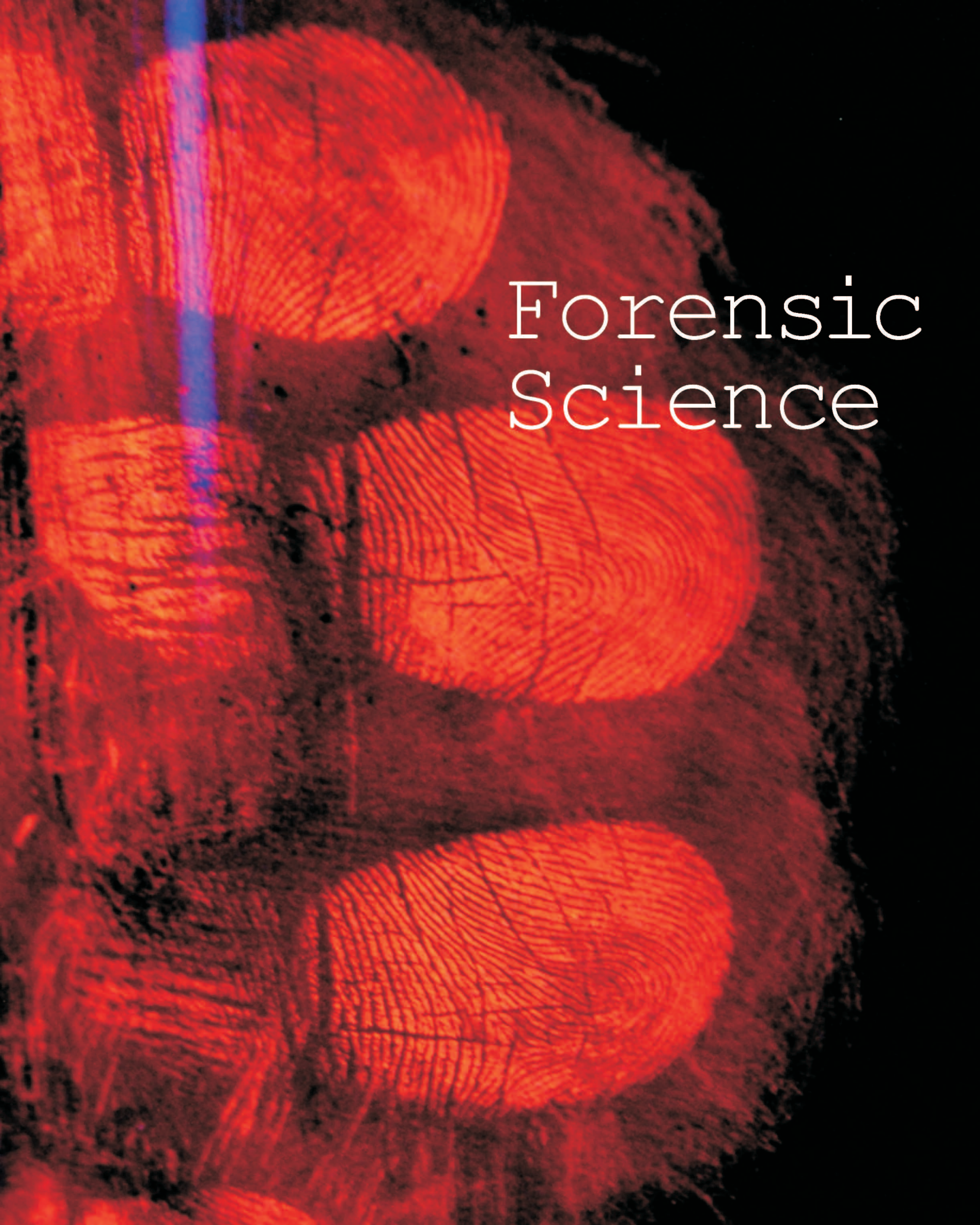

Forensic Science

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Forensic Science

Volumes 1 - 3

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Publisher's Note

This entirely new and comprehensive reference work, *Forensic Science*, addresses the rapidly growing academic and public interest in the application of the sciences to criminal investigations. The extent of this interest can be measured by the expansion of academic courses on forensics and criminal justice in schools and colleges and by the proliferation of popular television programs, both dramatic and documentary, on crime scene investigations. Articles in *Forensic Science*'s three volumes cover many topics that figure prominently in the media; however, the set's basic approach to forensic science is factual, and it lays great stress on offering up-to-date material on hard topics in this rapidly advancing field.

Often called simply "forensics" within the legal world, forensic science is essentially the application of the natural sciences to the analyzing and interpreting of legal evidence, particularly in criminal cases. Since the beginning of the twenty-first century—and especially since the terrorist attacks on the United States of September 11, 2001—there has been an explosion of both public and academic interest in the use of forensic techniques to investigate criminal acts. American television audiences have developed a seemingly insatiable appetite for shows such as *CSI: Crime Scene Investigation* and *Bones* that go into the minutiae of forensic techniques. During the spring of 2008, as many as five such shows ranked among the fifteen top-rated television programs during any given week. However, while these shows tend to emphasize crimes of violence, particularly murder, the real-world applications of forensic science are far broader.

It is clear that the forensic sciences play a major role in investigations of murder and other violent crimes. However, they also play equally important roles in investigations into many other types of criminal and civil cases, ranging from arson fires and contract disputes to forgery, paternity suits, and war crimes. Forensic techniques are also often central to efforts to identify victims of major accidents and natural disasters. All these subjects are covered in detail within these volumes.

Scope of This Set

Forensic Science contains 460 articles arranged in alphabetical order that range in length from 500 to 3,000 words. The set approaches the forensic sciences from several different perspectives. The primary perspective is that of investigators in the diverse subspecialties that make up the forensic sciences. The impressive variety of these fields can be seen at a glance in the titles of articles such as Forensic accounting, Forensic anthropology, Forensic archaeology, Forensic botany, Forensic entomology, Forensic geoscience, Forensic nursing, Forensic odontology, Forensic palynology, Forensic pathology, Forensic photography, Forensic psychiatry, Forensic psychology, Forensic sculpture, and Forensic toxicology. Those topics are joined by Ballistics, Computer forensics, Cryptology and number theory, Living forensics, Parasitology, Physiology, Serology, Structural analysis, Taphonomy, Thanatology, Viral biology, and Wildlife forensics.

Attention is also given to the many professional organizations in forensic science fields, such as the American Academy of Forensic Sciences, the American Society of Crime Laboratory Directors, and the International Association of Forensic Toxicologists. In addition to the core articles on subspecialties and allied fields, the set has articles on 30 specific types of investigations, ranging from Alcohol-related offenses, Arson, and Art forgery to Ritual killing, Sports memorabilia fraud, and Suicide.

More than 100 articles focus on investigative techniques and procedures. These include overviews of general subjects such as accident investigation and reconstruction, crime scene investigation, and quantitative and qualitative analysis of chemicals, along with more specialized techniques and procedures, such as autopsies, chromatography, crime scene photography, fingerprint analysis, and polygraph analysis. More than 35 articles examine specialized equipment, such as biodetectors and other detection devices, protective gear, and chemical reagents.

A second broad perspective in *Forensic Science* might be called the scene of the crime. Particularly important within this category are articles on types of evidence, such as fire debris, fibers and filaments, glass, soil, and bloodstains. Other articles cover both general and specific aspects of chemical and biological agents, such as biotoxins, carbon monoxide, illicit drugs, and a variety of poisons. At the center of crime scenes are the participants—the offenders, victims, and witnesses. More than 40 articles cover diverse diseases, medical conditions, and injuries, including various kinds of wounds.

A third broad perspective in *Forensic Science* is the role of the forensic sciences in the American legal system. The set includes brief articles on some of the most important federal laws applying to controlled substances, such as the Harrison Narcotic Drug Act of 1914, the Controlled Substances Act of 1970, and the Anabolic Steroid Control Act of 2004, as well as such international agreements as the Chemical Weapons Convention of 1993. Articles on selected U.S. Supreme Court decisions, including *Miranda v. Arizona*, and a variety of important legal principles, such as habeas corpus and *mens rea*, also help to illuminate the legal dimensions of the forensic sciences. Law-enforcement bodies and government investigative units covered in the set include the U.S. Drug Enforcement Administration, the Federal Bureau of Investigation, and the U.S. Secret Service as well as the Environmental Measurements Laboratory and the National Transportation Safety Board.

A fourth perspective of *Forensic Science*—and one that should have wide appeal to many readers—is its extensive coverage of specific historical subjects. These range from overviews of ancient criminal cases and crime mysteries and ancient science to examinations of such high-profile modern criminal cases as the O. J. Simpson murder trial, the Unabomber case, and criminal cases involving celebrities. The set also includes articles on such subjects as the Lindbergh baby kidnapping case, the exhumations of the remains of U.S. presidents Zachary Taylor and Abraham Lincoln, and mysteries surrounding the deaths of the French emperor Napoleon I and composer Ludwig van Beethoven. These historical topics serve as fascinating case studies in the practical application of forensic science.

Finally, *Forensic Science* makes a special effort to address depictions of forensics in the media. Long overview articles examine misconceptions fostered by the media and the treatment of forensic science in television, literature, and journalism. Briefer articles cover such iconic individual television programs as *CSI*, *Cold Case*, and *Forensic Files*. A special appendix offers brief descriptions of many other television programs.

Organization and Format

The set's alphabetical arrangement—which includes headnote cross-references of alternative terms (such as "Lie detectors. *See* Polygraph analysis")—makes topics easy to find. As in Salem's other encyclopedic reference works, articles in *Forensic Science* contain helpful top matter that defines the topics and offers compact summaries of their relevance to forensic science. Every article also contains a "Further Reading" section, followed by a generous list of cross-references to related topics within the set. The text of the articles is supplemented by more than 250 photographs and more than 180 maps, charts, graphs, and illustrative sidebars.

The appendixes in volume 3 include a guide to Internet resources, a directory of television shows in which forensic science figures prominently, a biographical directory of key figures in the history of the field, a time line of major events, an annotated bibliography of general works, and a glossary. Additional finding aids include a general subject index at the end of volume 3, the complete list of the set's contents at the beginning of each volume, and a list of topics by category at the end of each volume.

Acknowledgments

Salem Press would like to thank the 172 scholars who contributed original articles to *Forensic Science*. Their names and affiliations are listed in the pages that follow here. This publication is especially indebted to its editors, Dr. Ayn Embar-Seddon of Capella University and Dr. Allan D. Pass of National Behavioral Science Consultants.

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A

Accelerants

Definition: Any substances, most commonly ignitable liquids, used intentionally to increase the rate and spread of fires.

Significance: In a fire investigation, the primary goal is to identify whether the fire was accidental or intentional. The presence of an accelerant at a fire scene is often indicative of an intentional fire, or arson. Accelerants can be identified from fire debris through conventional forensic analysis.

Accelerants are commonly used in arson fires because they provide additional fuel in areas where the items present may not burn easily. Arsonists often pour accelerants over the areas they want to burn to ensure that their fires spread as much as possible to maximize damage and destruction. Common accelerants are commercially available ignitable liquids—such as gasoline, lighter fluid, and kerosene—that are readily accessible to the arsonist. The identification of an accelerant is significant evidence in a fire investigation because it suggests that the fire was set intentionally.

Identification at the Fire Scene

The identification of accelerants at fire scenes is often a challenge for investigators. Examination of the fire debris by various techniques can be useful in identifying the origin of a fire and any areas of potential accelerant use. After the preliminary identification of a potential accelerant source, samples can be collected and taken back to the forensics laboratory for further analysis.

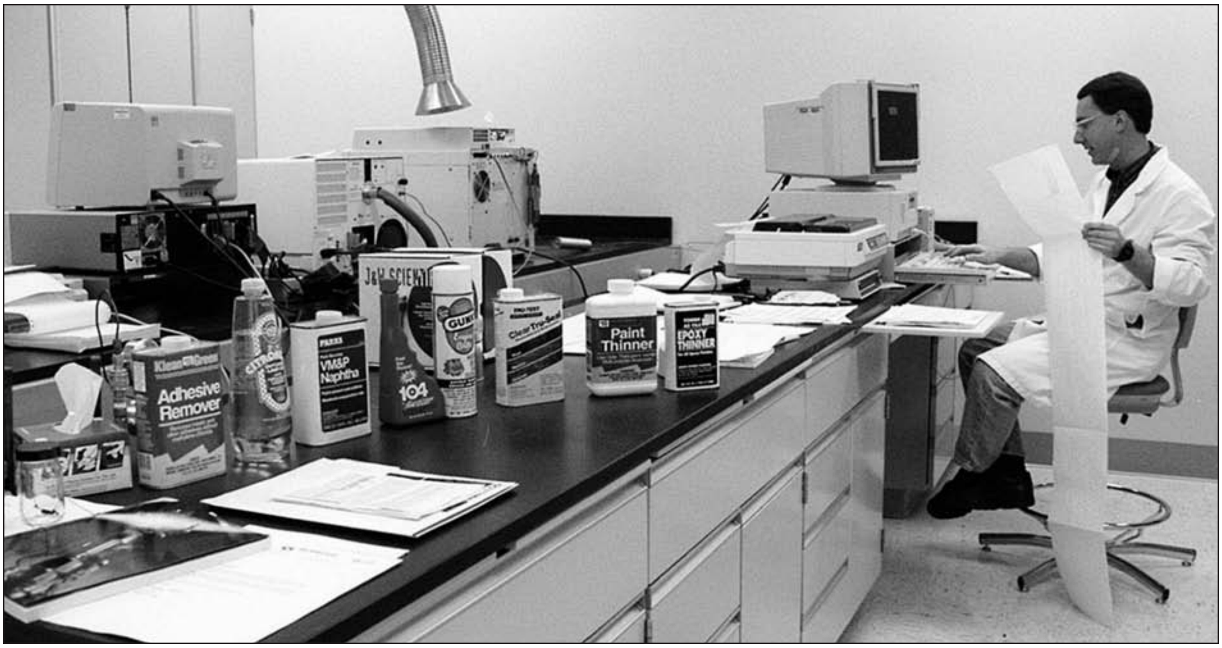
The types of fire debris most likely to contain sufficient accelerant residue for analysis are porous materials, such as wood and carpet, which can trap residual liquid. Accelerant residue can also pool in the cracks in floors, where it is somewhat protected from the fire. Investigators should collect and store any debris suspected to contain accelerant residue in airtight containers, preferably metal paint cans with friction lids, to eliminate the possibility of the loss of the volatile components within the samples.

Extraction Techniques

Gas chromatography coupled with mass spectrometry is the most common technique used for the analysis of accelerants from fire debris. Before fire debris evidence can be analyzed using the dual instrument known as the gas chromatograph-mass spectrometer (GC-MS), however, the accelerant residue must first be extracted from the debris that was collected. Several techniques can be used to perform this extraction, and each has its own advantages and disadvantages.

In a solvent extraction, the fire debris is washed with a solvent that will dissolve the accelerant residue but not the debris, such as carbon disulfide. The extract can then be injected directly into the GC-MS. A drawback of solvent extraction is that large amounts of potentially hazardous solvents are required to perform an efficient extraction; in addition, this method does not concentrate the accelerant residue effectively. Although solvent extraction was at one time a popular method, it has generally been replaced by quicker, more efficient preconcentration techniques.

In passive headspace extraction, the metal paint can used to collect the debris is heated so that any accelerant present is vaporized and becomes saturated within the area above the debris in the can, which is known as the headspace. A small hole is made in the top of the can and a gastight syringe is used to draw up a sample of the vapor in the headspace, which can then be injected into the GC-MS. Passive headspace extraction is biased toward the more volatile components, but it minimizes the capacity for cross-contamination of the evidence because the accelerant residue is extracted from the same container in which the debris was collected.



A forensic scientist who specializes in arson study analyzes data from an arson scene in the Kentucky State Police Crime Lab in Franklin County. Arrayed on the counter to his left are several substances that are used as accelerants in arson fires. *(AP/Wide World Photos)*

A variation of the passive headspace extraction technique is adsorption/elution, in which the debris is heated in the can with a strip of activated charcoal suspended in the headspace. The accelerant vapor is trapped on the strip, from which it is dissolved by a solvent for injection into the GC-MS. Adsorption/elution is affected by the same volatility bias as the passive headspace method, but because the vapor is concentrated onto the charcoal strip, adsorption/elution greatly decreases the potential loss of low-volatility compounds.

The solid-phase microextraction (SPME) technique employs a coated fiber that is housed in a retractable apparatus. The can containing the debris is heated, and this fiber is subjected to the headspace of the can, where the accelerant vapor adsorbs onto the fiber. One advantage of SPME is that the fiber apparatus can be placed directly into the injection port of the GC-MS. The heat of the injection port causes the accelerant trapped on the fiber to desorb from the fiber so that it can be carried into the instrument for analysis. Another advantage of SPME is its potential use for on-site accelerant collection. An investigator can use the SPME fiber apparatus to adsorb accelerant vapor at the fire scene; with the fiber retracted into the apparatus, it is protected from the environment and can be transported directly to the laboratory for analysis.

Instrumental Analysis

Although many techniques have proven useful in accelerant identification, gas chromatography (GC) is by far the most commonly used technique in the forensics laboratory for fire debris analysis. GC is a separation technique that is capable of isolating the numerous individual compounds present in typically complex accelerants. The result of a GC analysis is a chromatogram, which is essentially a chart in which all the components are represented as individual peaks. The pattern of these peaks does not change for a substance and thus is characteristic of that substance. Therefore, when an accelerant residue is examined by GC, its peak pattern can be matched to the peak pattern of a known sample of the same accelerant analyzed for comparison.

When GC is coupled with mass spectrometry (MS), the chemical composition of a sample can be identified conclusively. The pairing of GC and MS allows the identification of individual peaks within the peak pattern and thus is the standard convention for accelerant identification. It should be noted that accelerant identification is considered class evidence because it cannot be individualized to one source. For example, if an accelerant is identified to be gasoline, the pump or even the service station from which it was purchased cannot be determined because of the inherent variation in the process of refining crude oil.

The American Society for Testing and Materials (ASTM), an organization that generates and maintains standards for procedures and materials in a wide array of fields, has developed standard accelerant classes for the identification of accelerants in court. The ASTM classification system for ignitable liquids provides a standardized method of accelerant description for forensic scientists. In this system, nine classes of ignitable liquids are subdivided into three boiling point ranges (light, medium, and heavy). The nine classes—gasoline, petroleum distillates, isoparaffinic products, aromatic products, naphthenic-paraffinic products, normal alkane products, dearomatized distillates, oxygenated solvents, and a final miscellaneous grouping—and their subdivisions provide standard guidelines for the identification of ignitable liquids based on chemical composition.

Difficulties in Identification

Although chromatographic pattern matching is the convention for the identification of accelerants in a forensics laboratory, some factors can alter chromatographic patterns and make it difficult for investigators to identify conclusively any accelerant that may be present. Most common accelerants contain refined petroleum products, which are mixtures of hydrocarbons, and several of these hydrocarbons are found in everyday household products. For example, basic carpeting such as that found in many homes contains compounds similar to those found in common accelerants. This overlap presents a problem for a scientist attempting to identify an accelerant that soaked into a carpet before it was burned.

An efficient extraction technique, such as adsorption/elution or SPME, can separate an accelerant from the fire debris itself. Investigators can also use a data-processing technique called extracted ion chromatography (EIC)—in which specific characteristic peaks can be isolated from other peaks—to understand the data more fully. Because of the potential problem of interference, fire investigators should collect several debris samples, including samples in which no accelerant is expected to be found, in order to understand which chromatographic peaks correspond to the debris and which peaks correspond to an actual accelerant.

Lucas J. Marshall

Further Reading

Almirall, José R., and Kenneth G. Furton, eds. *Analysis and Interpretation of Fire Scene Evidence*. Boca Raton, Fla.: CRC Press, 2004. Presents comprehensive information about fire scene investigation and the chemical analysis of fire debris.

DeHaan, John D. *Kirk's Fire Investigation*. 6th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007. Detailed volume covers the physical nature and chemistry of fire and also discusses the various types of fires.

Nic Daéid, Niamh, ed. *Fire Investigation*. Boca Raton, Fla.: CRC Press, 2004. Compilation provides material on the basics of fire investigation with emphasis on laboratory reconstruction and analytical techniques.

Redsicker, David R., and John J. O'Connor. *Practical Fire and Arson Investigation*. 2d ed. Boca Raton, Fla.: CRC Press, 1997. Presents extensive information on the various undertakings of the fire investigator, from scene investigation to courtroom testimony.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007. Textbook discusses the different forensic science fields, including arson investigation.

Tilstone, William J., Kathleen A. Savage, and Leigh A. Clark. *Forensic Science: An Encyclopedia of History, Methods, and Techniques*. Santa Barbara, Calif.: ABC-CLIO, 2006. General reference work covers a broad range of topics in forensic science.

See also: Arson; Bureau of Alcohol, Tobacco, Firearms and Explosives; Burn pattern analysis; Column chromatography; Fire debris; Gas chromatography; Mass spectrometry; National Church Arson Task Force.

Accident investigation and reconstruction

Definition: Collection and analysis of evidence at the scenes of transportation accidents to create models explaining what happened.

Significance: In determining responsibility for motor vehicle and other kinds of transportation accidents, forensic scientists attempt to reconstruct what happened during these events by analyzing the available evidence. The testimony of accident investigators often plays a role in criminal and civil proceedings that stem from accidents.

In the United States, transportation accident investigation and reconstruction are usually carried out by police departments. Some accident investigations, however, fall under federal jurisdiction. The National Transportation Safety Board (NTSB), formed in 1967 as part of the U.S. Department of Transportation, replaced the Civil Aeronautics Board and expanded the role of the federal government in accident investigation and reconstruction. The NTSB became an independent agency in 1975; its duties include the investigation of all civil aviation accidents in the United States as well as all major railroad, highway, marine, and pipeline accidents and any transportation accidents that involve the release of hazardous materials. Private companies also offer accident investigation and reconstruction services.

Accident Investigators

When transportation accidents occur, law-enforcement agencies, insurance companies, manufacturers of the vehicles involved, and the persons involved, including those injured, all have interests in understanding the causes of the accidents and in assigning responsibility. Police officers normally are the first individuals to investigate traffic accidents. Typically, when a serious accident has taken place, the police deal first with any injured people and any hazardous situations created by the accident; they then record information that will allow them to assess how the accident occurred. Most police officers in the United States receive at least brief training in accident investigation; some receive additional specialist training. The accuracy and completeness of the evidence collected by the police at an accident scene affects the degree of accuracy of the accident reconstruction.

In accidents that fall under the jurisdiction of the NTSB, the NTSB becomes the lead investigative agency. In such a case, the role of the local police department initially is to handle any casualties and hazards caused by the accident and then to preserve the scene to the greatest degree possible. NTSB specialists are experienced investigators with strong academic backgrounds in forensic science, physics, structural engineering, aeronautical engineering, and similar fields. NTSB investigators are qualified to serve as expert witnesses in court.

Insurance companies often have their own accident investigators. These investigators, as well as independent investigators hired by attorneys and other interested parties, often enter the accident and reconstruction process after much of the debris from the accident has been cleared away. They may have the opportunity to examine the damaged vehicles, but in attempting to reconstruct the accident they usually must depend on other evidence collected by the police at the accident scene.

Some disagreement exists among experts in accident reconstruction concerning the degree of training and education necessary to qualify an individual as an accident and reconstruction specialist and as an expert witness. Since 1991, the Accreditation Commission for Traffic Accident Reconstruction (ACTAR) has promoted voluntary standards for traffic accident investigators in order to encourage accuracy, consistency, and professionalism in accident investigation and reconstruction. These standards have not been universally adopted, however.

At the highest level, accident reconstruction specialists hold university degrees in engineering, mathematics, physics, or similar fields and have years of experience related to crash analysis and reconstruction. In the United States, the National Academy of Forensic Engineers is empowered by the Council of Engineering and Scientific Specialty Boards to certify accident investigation and reconstruction specialists as "diplomate forensic engineers." This is the highest level of certification, the engineering equivalent of being a board-certified medical specialist. The International Institute of Forensic Engineering Sciences also awards diplomate status to qualified forensic engineers and forensic science professionals.

At the other end of the spectrum, individuals who do not even have high school diplomas can enroll in vocational training programs that focus on accident investigation and reconstruction. These programs call their graduates "certified accident reconstructionists," although many lack the background to do necessary mathematical analyses of accident scenes. Some courts in the United States have begun to reject certified accident reconstructionists as expert witnesses, requiring those who provide expert testimony on accidents to have higher levels of education and expertise.

The Investigation Phase

After immediate needs involving injuries and hazards have been attended to at the scene of an accident, the investigation phase begins. In collecting evidence at an accident scene, the investigators perform some or all of the following tasks: taking witness statements, photographing damage to vehicles and property, measuring and recording tire (skid) marks, recording paint

Crime novelist Patricia Cornwell examines the remains of a small plane dropped from a helicopter during an accident investigation exercise for crime scene investigator trainees at the University of Tennessee's National Forensic Academy in 2005. A best-selling author, Cornwell writes mostly about cases involving a fictional medical examiner, Dr. Kay Scarpetta. *(AP/Wide World Photos)* and gouge marks, recording the postcrash locations of all vehicles involved, and recording the positions of all pieces of debris from the accident with photographs and measurements. Using this information, the investigators create a grid map of the crash scene that shows, with measurements, where each skid mark, vehicle, and piece of collision debris and damaged property is located in relation to all others.

Primary accident investigators also use a Haddon matrix to record situational evidence relative to the accident. This tool, developed around 1970 by Dr. William Haddon, the first head of what later became the National Highway Traffic Safety Administration, is a grid on which investigators record information about various conditions before, during, and after the accident at the accident scene. The most common Haddon matrix used for traffic accidents has three rows and three columns, creating nine cells. The rows represent events occurring before the crash, during the crash, and after the crash, respectively, and the columns identify the following factors that could have affected the accident in each time period: human factors (for example, impaired vision, precrash alcohol consumption, speeding, failure to wear a seat belt), vehicle and equipment factors (for example, failed brakes, nonfunctioning lights, malfunctioning air bags, poorly designed fuel tanks that leaked or exploded), and physical, social, and economic factors (for example, missing road signs, nonfunctioning traffic signals, absence of or poorly designed guardrails, cultural attitudes toward alcohol consumption or speeding, interference with or delayed emergency services response).

The Reconstruction Phase

During the reconstruction phase, accident investigators apply their knowledge of the laws of physics to the evidence to determine such elements as the speeds of the vehicles involved, the angle of initial impact, the occurrence of secondary impacts, mechanical failures that may have caused the accident, and environmental factors that may affect responsibility for the accident. Damage-based reconstruction is one of the oldest and simplest forms of accident reconstruction. In this approach, the reconstructionist looks at the damage done by and to vehicles and property.

By using information from vehicle manufacturers and applying knowledge of the laws of physics and structural analysis, the reconstructionist is able to determine the approximate rates of speed of the vehicles and their angle of impact. Damage-based reconstruction requires many assumptions and simplifications. For example, car manufacturers provide the results of crash tests for reconstruction engineers, but in using such results, a reconstructionist must assume that the vehicle involved in the accident had the same structural properties as a new vehicle of the same model that was used in the crash tests.

Ideally, damage-based reconstruction should be done in conjunction with trajectory-based reconstruction, which is based on the principle that momentum (speed multiplied by mass) is conserved in a crash. Starting

Electronic Evidence Improves Precision and Confidence

Many new automobiles are equipped with event data recorders, also known as black boxes. These boxes store data about cars' speed and handling that can provide crucial evidence in accident cases. In November, 2004, Danny Hopkins was convicted of second-degree manslaughter for causing the death of Lindsay Kyle in a car accident. The event data recorder in Hopkins's car had shown that the vehicle was traveling at 106 miles per hour just four seconds before it crashed into the back of Kyle's car, which was stopped at a red light. If Hopkins's car had not been equipped with an event data recorder, a forensic investigation of the physical evidence, such as skid marks and crash damage, could have been used to estimate the speed of the car. The recorder's data evidence, however, provided better precision, increasing the investigators' confidence that the driver's speed was 106 miles per hour at the time of impact.

Linda Volonino

with where the vehicles and debris ended up after a crash, reconstructionists work backward to determine the speed of each vehicle at impact. This method must also take into account forces such as friction of tires on the road, which reduces momentum, and whether the road was wet or dry. The mathematics required to perform trajectory-based reconstruction can be complex, and software programs are available to help with these calculations.

Ultimately, the reconstruction of an accident is only as good as the original information provided by those who measured and recorded the accident scene. All reconstructions involve assumptions, simplifications, and interpretations. Good reconstruction engineers are able to explain their analyses and provide scientific justifications for their conclusions that will stand up to expert examination in a court of law.

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Further Reading

Andrews, Dennis R. "Accident Reconstruction from the Outside in." *Claims* 54 (June, 2006): 18-22. Presents a nontechnical explanation of the information that can be gained from traffic accident reconstruction.

Hermance, Richard. *Snowmobile and ATV Accident Investigation and Reconstruction*. 2d ed. Tucson, Ariz.: Lawyers & Judges Publishing, 2006. Focuses on the investigation of accidents involving off-road vehicles.

Palmer, Scott. "Fighting Fraud with Forensic Intelligence." *Claims* 55 (September, 2007): 54-59. Explains how accident reconstruction can be useful in the investigation of insurance claims.

Rivers, R. W. *Evidence in Traffic Crash Investigation and Reconstruction: Identification, Interpretation, and Analysis of Evidence, and the Traffic Crash Investigation and Reconstruction Process*. Springfield, Ill.: Charles C Thomas, 2006. Comprehensive volume addresses all aspects of the investigation of traffic accidents, including preservation of evidence and accident reconstruction.

Wheat, Arnold G. *Accident Investigation Training Manual*. Clifton Park, N.Y.: Thomson/Delmar Learning, 2005. Provides an extensive introduction to accident investigation, including reconstruction techniques.

See also: Crime scene measurement; Crime scene reconstruction and staging; Cross-contamination of evidence; Direct versus circumstantial evidence; Flight data recorders; Hit-and-run vehicle offenses; ValuJet Flight 592 crash investigation.

Acid-base indicators

Definition: Substances that show the acidity or alkalinity of solutions within a narrow range.

Significance: Among the tools forensic scientists use to identify unknown substances are acid-base indicators, also known as pH indicators. Such indicators can also enable scientists to detect the presence of contaminating chemicals in solutions, and their use in the analysis of human tissues can provide clues to cause of death.

The acidity or alkalinity of a substance is indicated by its pH, which is a measure of the concentration of hydrogen ions (H^+) in a solution. The pH scale is logarithmic and ranges from 0 to 14. The lower the pH, the more acidic the solution, and the higher the pH, the more alkaline, or basic, the solution; pH 7.0 is neutral and is the pH of pure water.

Acid-base indicators are organic dyes that change color depending on the concentration of hydrogen ions present in a solution. The change does not become visible at a precise point; rather, it happens within a fairly narrow pH range. Many different acid-base indicators are available, and they change colors within different pH ranges. For example, phenolphthalein is colorless at a pH of 8.2 but turns red at a pH of 10. Methyl orange is red at a pH of 3.2 but turns yellow at a pH of 4.4.

The most common acid-base indicator is litmus paper. It comes in two forms, red and blue. When dipped into a solution, blue litmus paper turns red if the pH of the solution is 4.5 or below, indicating the solution is acidic. If the pH of the solution is 8.2 or above, blue litmus paper remains its original blue color. Conversely, red litmus paper remains red when dipped into an acidic solution but turns blue when dipped into a basic solution.

Most often, acid-base indicators are used with a technique called titration. Titration allows analytical chemists to make quantitative determinations of how much acid or alkaline material is in a solution. In the titration of an acid solution, a known quantity of base is added until the correct acid-base indicator changes color. The chemist then measures how much base was used and can calculate how much acid is in the solution. The procedure is reversed with a basic solution.

When investigating an unknown substance such as a confiscated drug, a forensic technician may dissolve a small amount of the substance in water and then test its pH. Conversely, if the substance has been identified and the pH of that substance in pure form is known, the technician may dissolve a small amount of the substance in water to see if the pH varies from the known pH. If it does, this suggests that the substance is contaminated with another chemical.

Acid-base indicators are useful but crude analytical tools. To complete most chemical analyses, forensic scientists usually need to employ more precise analytical tools.

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Further Reading

Blei, Ira. and George Odian. *General, Organic, and Biochemistry: Connecting Chemistry to Your Life*. 2d ed. New York: W. H. Freeman, 2006.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005.

Oxlade, Chris. *Acids and Bases*. Chicago: Heinemann Library, 2007.

See also: Crime scene screening tests; Quantitative and qualitative analysis of chemicals; Reagents.

Old-fashioned chemist's kit containing a series of litmus papers capable of measuring different pH ranges. *(© iStockphoto.com/Oliver Bogler)*

Actuarial risk assessment

Definition: Formation of judgments and predictions regarding dangerous behavior through the application of formulas to particular variables and statistics in preparation for the adoption of necessary preventive measures.

Significance: Forensic psychologists use numerous factors to evaluate the likelihood that particular persons will be involved in violent and dangerous behavior. Predictions based on actuarial risk assessment influence many decisions made in the criminal justice system.

Actuarial risk assessment is one of the many tools that forensic psychologists use to evaluate the likelihood of future violent and dangerous behavior on the part of certain persons. Other methods include clinical predictions, which are based on evidence derived from counseling and experience, and anamnestic predictions, in which psychologists analyze the behavior of specific persons in the past in similar situations. The scientific community has demanded greater reliability in predictions than either clinical or anamnestic methods can provide, and an outcome of this demand has been the use of mathematical formulas to make predictions of risk. Actuarial risk assessment thus employs many of the tools of statistical analysis.

Uses of Risk Assessment

Many people and organizations rely on forensic psychologists and similar experts to make predictions of human behavior. For example, officials in the U.S. criminal justice system rely on risk assessment in making decisions concerning sentencing—for example, in deciding whether to impose probation as a sentence instead of incarceration or whether to sentence a violent offender to death rather than life in prison. A psychologist's prediction concerning a given individual's risk of violent or inappropriate behavior could support the issuance of a restraining order in a domestic dispute or abuse case. Risk assessment may also be used in child-custody decision making and in decisions concerning whether child visitation by a parent should be supervised. Some companies use risk assessment to evaluate the potential for violent behavior in the workplace by terminated employees, and some educational institutions use risk assessment to predict the likelihood of school violence.

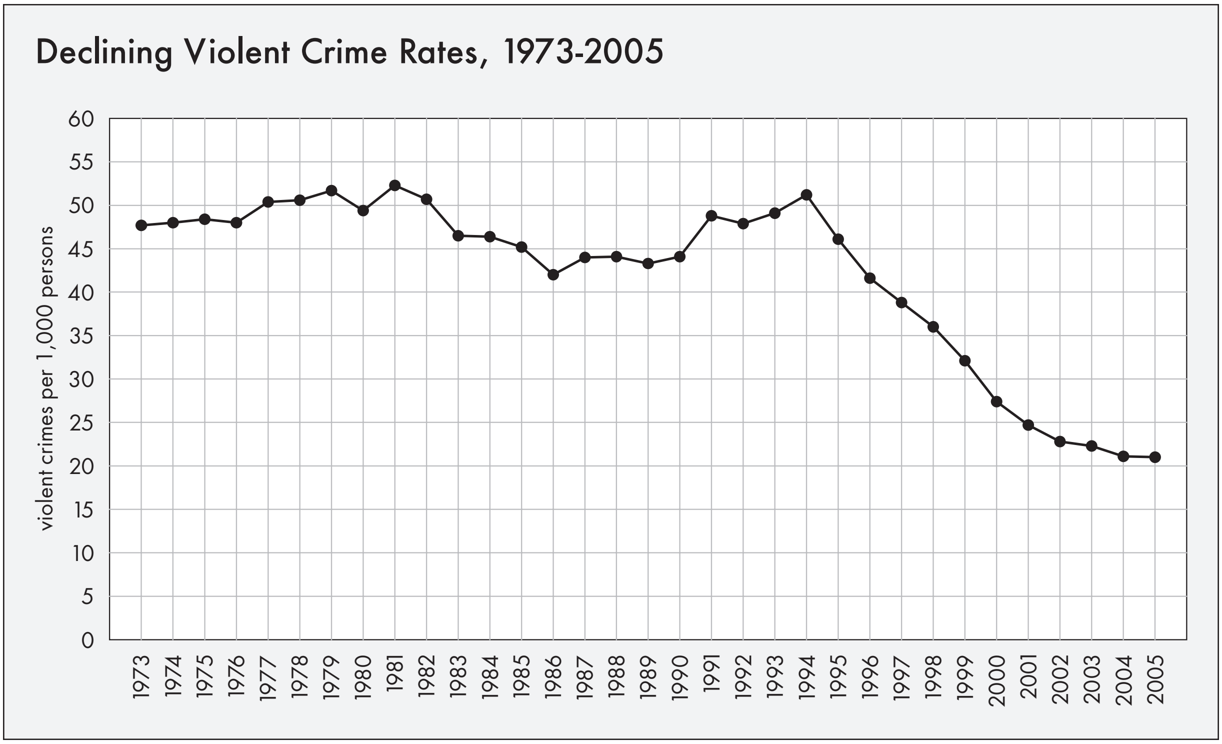
Experts also use actuarial risk assessment to predict the potential for recidivism in determining whether to parole prisoners from correctional facilities and in considering the release of offenders who have been confined to mental health facilities. One area of risk assessment that has seen substantial growth concerns the prediction of sexual offending. Predictions in this area may influence whether particular released prisoners must register as sex offenders with their local communities.

Forensic psychologists may also be called upon to predict the likelihood that certain persons will attempt suicide. In addition, psychologists may have a legal obligation to warn others of any potential danger of harm from any persons they are treating. In some cases, the goal of risk assessment is to determine whether to commit persons to mental health facilities involuntarily because of the likelihood that they may cause serious harm to themselves or others. Risk assessment is also used to decide whether persons who have been involuntarily confined to mental health facilities have become stable enough in their behavior that they are no longer dangerous and can be released.

Risk Assessment Factors

Actuarial risk assessment involves looking at statistical relationships between variables to make judgments and predictions about future behavior. Risk assessment involves a delicate balance between protecting society from physical harm and ensuring that the rights and liberties of the persons subjected to risk assessment are not unduly restricted. Forensic psychologists look at various behavioral characteristics and other factors to increase the accuracy of their scientific approaches to risk assessment. These factors are derived from research involving large groups of people who have exhibited risky or violent behavior in the past and from data gathered by professional clinicians. Some of the factors or variables considered in risk assessment are specifically associated with one behavior, whereas others are predictive across the entire array of potentially risky or dangerous behaviors.

One of the most significant factors considered in risk assessment is the presence or absence of a history of violent behavior. Other risk factors include static predictors such as psychological and physiological characteristics of the person and the person's personal and family history. Higher risk is associated with relationship and employment instability, education maladjustment, a history of drug and alcohol abuse, and being young. Dynamic characteristics—that is, characteristics that change over time—that are associated with higher risk include a lack of insight about personal behavior, the inability to control hostile and impulsive behavior, negative emotions in response to treatment, and ongoing psychotic symptoms such as hallucinations. Finally, in assessing risk, the person's potential living environments and social networks must be considered, as well as the person's ability to harm others in the future.



Source: U.S. Bureau of Justice Statistics, 2008. Data represent aggregate violent victimization rates for murder, rape, robbery, and assault.

Research has found that actuarial risk assessment is more accurate than clinical assessment. Jurors, however, tend to believe the testimony of clinicians over that of actuarial experts, as jurors perceive that clinicians have stronger relationships with and thus more knowledge of the persons being assessed. Despite the scientific basis of actuarial risk assessment by forensic scientists, the prediction of human behavior is very difficult, and significant criticism has been directed toward actuarial risk assessment. Research has shown that a person's behavior changes over time and that actuarial prediction has an accuracy rate of little more than 50 percent.

Actuarial risk assessment continues to gain acceptance among members of the scientific and legal communities, however, and as risk factors and formulas are enhanced through research, the accuracy rates of this technique should also improve in the future.

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Further Reading

Freeman, Naomi J. "Predictors of Rearrest for Rapists and Child Molesters on Probation." *Criminal Justice and Behavior* 34, no. 6 (2007): 752-768. Compares the recidivism rates of former prisoners who were convicted of rape with those of former prisoners who were convicted of child molestation.

Gran, Martin, and Niklas Langstrom. "Actuarial Assessment of Violence Risk: To Weigh or Not to Weigh?" *Criminal Justice and Behavior* 34, no. 1 (2007): 22-36. Addresses the validity of using risk factors in actuarial formulas for the purpose of predicting violent criminal behavior.

Prins, Her. *Will They Do it Again? Risk Assessment and Management in Criminal Justice and Psychiatry*. New York: Routledge, 1999. Using statistics and discussion of real cases, compares and contrasts the low risk of public harm posed by the mentally ill with society's perception of a high risk of harm. Provides recommendations for managing risky behavior on the part of mentally ill persons.

Webster, Christopher D., and Stephen J. Hucker. *Violence Risk: Assessment and Management*. Hoboken, N.J.: John Wiley & Sons, 2007. Focuses on violent offenders and provides suggestions for protecting the rights of these offenders when they are released from mental health facilities and prisons while also protecting the public from harm. Includes a list of variables that should be considered in the process of risk assessment.

See also: Alcohol-related offenses; Child abduction and kidnapping; Child abuse; *Daubert v. Merrell Dow Pharmaceuticals*; Forensic psychology; Psychological autopsy; Sexual predation characteristics; Suicide; *Tarasoff* rule.

Adipocere

Definition: Naturally occurring substance produced by dead bodies under certain conditions from the hydrolysis of body fat and a sufficient amount of water or moisture.

Significance: Also called grave wax, corpse wax, and mortuary wax, adipocere is commonly formed by the bodies of human beings or animals with sufficient body fat when they lie under wet or moist conditions. The presence of this substance on a human body may help or hinder forensic scientists in estimating the postmortem interval.

The production of adipocere by a body generally requires an anaerobic surrounding (that is, one without free oxygen), a sufficient quantity of body fat (that is, adipose containing connective tissue with lipids present), and any of a variety of bacteria that take oxygen away from other compounds and thus assist in the hydrolysis of the fats. The material was first recognized and described in the seventeenth century, when Sir Thomas Browne wrote in *Hydriotaphia, Urne Buriall* (1658) of encountering the substance while relocating previously buried individuals from an English cemetery. The process of adipocere formation is called saponification, which literally means “soap making” (in times past, soap was made with a combination of animal fat, water, and lye, which produced a grayish-white material that was similar to adipocere in appearance and texture). Because adipose, or body fat, can be either white or brown, adipocere may appear grayish-white or tan in color. It was not until the use of microscopes became widespread during the seventeenth century that scientists began to understand the chemical process of saponification.

Adipocere is an artifact of the decomposition process, and because its formation requires that lipids (fats) be present, it is more commonly seen among animal remains containing comparatively high levels of fat. Among humans, this means that adipocere is found most frequently on the bodies of women, infants, and obese individuals of either sex. In addition, fatter individuals contain more moisture, and fats contain fatty acids that have an affinity to attach to sodium or potassium from the environment. Water assists in this process, and, indeed, adipocere is most often found among tissues that have been kept damp or moist, or even submerged.

It has been suggested that the formation of adipocere on a body may be useful as a guide for forensic scientists in estimating the length of time since death (the postmortem interval, or PMI), much like the appearance of algor, rigor, and livor mortis. However, because adipocere results from a chemical process, the speed with which the substance is formed is temperature-dependent, and, as is true for all other PMI indicators, the rate of formation varies. It appears that the formation of adipocere is speeded up by warmth, but temperature extremes, whether too warm or too cold, impede formation. In addition, because saponification produces a more durable substance than do other processes associated with decomposition, the formation of adipocere can result in a body’s retaining facial and other anatomic features well after death.

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Further Reading

Gill-King, Herrell. "Chemical and Ultrastructural Aspects of Decomposition." In *Forensic Taphonomy: The Postmortem Fate of Human Remains*, edited by William D. Haglund and Marcella H. Sorg. Boca Raton, Fla.: CRC Press, 1997.

O'Brien, Tyler G., and Amy C. Kuehner. "Waxing Grave About Adipocere: Soft Tissue Change in an Aquatic Context." *Journal of Forensic Sciences* 52, no. 2 (2007): 294-301.

Spitz, Werner U., ed. *Spitz and Fisher's Medicolegal Investigation of Death: Guidelines for the Application of Pathology to Crime Investigation*. 4th ed. Springfield, Ill.: Charles C Thomas, 2006.

See also: Algor mortis; Decomposition of bodies; Forensic entomology; Livor mortis; Mummification; Rigor mortis; Taphonomy.

Air and water purity

Definition: Extent to which natural water and air supplies are free of harmful forms of contamination.

Significance: Various forms of chemical and biological contaminants that pollute air and water supplies are responsible for death, disease, climate shifts, and the alteration of fragile ecosystems around the world. Techniques used to investigate the nature and causes of pollution are allied with forensic toxicology.

Although challenges to air and water purity have always existed, the assault has taken on forbidding aspects since the advent of the industrial age. So ubiquitous are the sources of air and water pollution that they have become woven into the fabric of everyday modern life. However, it is important to note that although much pollution comes from the processes of industry and commerce, pollution is also a product of natural biological and geographic processes. It should also be kept in mind that purity and pollution are relative. For example, although oxygen is necessary to animal life, it is highly toxic to certain organisms that flourish in an atmosphere of methane, which would be lethal to human beings.

Human-made pollutants come from the combustion of fuels that power ships, aircraft, motor vehicles, factories, and power-generating plants. Natural pollutants come from the discharges of wildfires and volcanoes. Pollutants also come from chemical discharges and landfill outgassing as well as military operations that generate nuclear fallout, pathogens, and toxic gases. Pollutants even ride the wind in the form of dust.

A notorious example of the damage inflicted when human activities alter the air's chemistry comes in the form of chlorofluorocarbons (CFCs), which find wide applications as refrigerants, insulating foams, and solvents. CFCs eventually make their way into the stratosphere, where the ultraviolet (UV) rays of sunlight break the CFCs' chemical bonds and release their chlorine atoms. As one chlorine atom is capable of breaking apart 100,000 ozone molecules, damage to Earth's ozone layer is great. The ozone layer protects Earth's surface from the damaging UV rays of the sun; without its protection, human beings are vulnerable to immune disorders, skin cancer, and cataracts. Additionally, increased UV radiation can reduce crop yields and cause serious dislocations in the marine food chain.

Water Quality

The quality of naturally occurring freshwater may be degraded through natural sources such as bedrock salts or sediment containing organic material. Additional degradation of water quality may be caused by human manipulation, such as fertilizers and petroleum products. When water pollution comes from a single source such as a sewage-outflow pipe, it is called point-source pollution; when the exact source of pollution is not as clear, as in agricultural or urban runoff, it is called non-point-source pollution.

The principal water polluters are industry and agriculture. Rain helps to cleanse air of pollutant emissions from motor vehicles, factories, and heating boilers, but the pollutants ultimately find their way into groundwater and streams. More direct forms of water pollution come from industrial discharges, construction detritus, and agricultural runoff. All these forms of pollution change the chemistry of water, changing its acidity, conductivity, and temperature. Nitrogen runoff fertilizes water, causing it to be choked with new vegetation.

The consequences to human society of impure water are alarming. Intractable diarrhea is a leading cause of death around the world among children under five, and its main cause is degraded drinking water. Cholera, a potentially deadly bacterial infection that plagues much of the underdeveloped world, requires only clean drinking water and proper sanitation to be eliminated as a problem. Contaminated drinking water is responsible for up to fourteen thousand deaths every day in developing countries.

Health Effects of Contaminated Drinking Water

The U.S. Environmental Protection Agency (EPA) provides this information on acute and chronic health effects related to contaminants in drinking water.

EPA has set standards for more than 80 contaminants that may occur in drinking water and pose a risk to human health. EPA sets these standards to protect the health of everybody, including vulnerable groups like children. The contaminants fall into two groups according to the health effects that they cause. . . .

Acute effects occur within hours or days of the time that a person consumes a contaminant. People can suffer acute health effects from almost any contaminant if they are exposed to extraordinarily high levels (as in the case of a spill). In drinking water, microbes, such as bacteria and viruses, are the contaminants with the greatest chance of reaching levels high enough to cause acute health effects. Most people's bodies can fight off these microbial contaminants the way they fight off germs, and these acute contaminants typically don't have permanent effects. Nonetheless, when high enough levels occur, they can make people ill, and can be dangerous or deadly for a person whose immune system is already weak due to HIV/AIDS, chemotherapy, steroid use, or another reason.

Chronic effects occur after people consume a contaminant at levels over EPA's safety standards for many years. The drinking water contaminants that can have chronic effects are chemicals (such as disinfection by-products, solvents, and pesticides), radionuclides (such as radium), and minerals (such as arsenic). Examples of the chronic effects of drinking water contaminants are cancer, liver or kidney problems, or reproductive difficulties.

Sources of water pollution include sewage, industrial discharges, surface runoff from farms and construction sites, underground storage tank leakage, and acid rain. It is convenient to categorize water contaminants into subgroups: microorganisms, disinfectants, disinfection byproducts, inorganic chemicals, organic chemicals, and radionuclides. The U.S. government's Environmental Protection Agency (EPA) lists eighty-six specific water contaminants, along with their sources and potential health effects.

Examples of specific pollutants include alachlor, an herbicide used in row crops that increases human risks of cancer and can also cause eye, liver, and kidney disease. Cadmium, which reaches water supplies from corroded galvanized pipes and discharges from metal refineries, can cause kidney damage. Dioxin is a chemical discharge from factories that causes cancer and reproductive disorders. *Giardia lamblia* is a protozoan parasite found in human and animal waste that often causes gastrointestinal disturbances. Toxaphene, an active ingredient in insecticides used in cotton farming and cattle production, increases cancer risk and can cause kidney, liver, and thyroid problems. Vinyl chlorides from plastics manufacturing discharges and leaching from polyvinyl chloride pipes also increase cancer risks.

Air Quality

Air pollution not only threatens the health of human beings but also compromises the well-being of animal and plant life. It degrades bodies of freshwater, thins the atmosphere's protective ozone layer, and creates haze that shrouds the beauty of nature. The EPA attempts to sus-

A sign at a Sturgeon Bay, Wisconsin, park warns beachgoers of a possible *Escherichia coli* contamination in the water. The local county government by this inlet of Lake Michigan routinely tests the water for possible contaminants and posts warnings when hazards reach certain levels. When health hazards are especially great, the county closes down the beaches. *(AP/Wide World Photos)*

tain reasonable levels of air purity through regulatory enforcement and voluntary programs, such as Energy Star and Commuter Choice. Through the federal Clean Air Act of 1990, the EPA restricts the amounts of specific pollutants allowed into the atmosphere to help protect public health.

Under the surveillance of the EPA are these broad categories of atmospheric pollutants: aerosols, asbestos, carbon monoxide, chlorofluorocarbons, ground-level ozone, hazardous air pollutants, hydrochlorofluorocarbon refrigerants, lead, mercury, methane gas, nitrogen oxides, particulate matter, propellants, radon, refrigerants, sulfur oxides, and volatile organic compounds. The EPA is armed with government regulations. Through a cooperative effort that involves private industry and state and local governments, the agency calls for the discontinuation of ozone-depleting substances, the elimination of specified toxic chemicals, and the treatment of polluted areas.

To assess air quality, the EPA's Office of Air Quality Planning and Standards (OAQPS) monitors specific pollutants that can harm human health, the environment, and property. All common throughout the United States, these pollutants include sulfur dioxide, particulate matter, nitrogen dioxide, lead, and carbon monoxide. Based on national ambient air quality standards, geographic areas are designated as attainment or nonattainment areas. OAQPS gives the standards more meaning by subdividing them into primary and secondary standards. Primary standards are about issues of health, whereas secondary standards consider damage to crops, vegetation, or buildings. Further, they assess the health effects for their potential long- or short-term damage.

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Further Reading

Friedlander, Sheldon K. *Smoke, Dust, and Haze: Fundamentals of Aerosol Dynamics*. 2d ed. New York: Oxford University Press, 2000. Written by a prominent authority on aerosols, this textbook designed for advanced undergraduates and graduate students covers basic concepts, lab techniques, and many practical applications.

Godish, Thad. *Air Quality*. 4th ed. Boca Raton, Fla.: Lewis, 2004. Up-to-date and comprehensive overview, appropriate for both undergraduate and graduate students, covers a wide variety of issues affecting air quality, with attention to atmospheric chemistry and the impact of polluted air on human health and the environment. Also covers public policy issues and risk assessment.

Heinsohn, R. J., and R. L. Kabel. *Sources and Control of Air Pollution*. Upper Saddle River, N.J.: Prentice Hall, 1998. Engineering textbook offers broad coverage of both natural and human-made sources of air pollution and methods for preventing or reducing pollution.

Nathanson, Jerry A. *Basic Environmental Technology: Water Supply, Waste Management, and Pollution Control*. 5th ed. Upper Saddle River, N.J.: Prentice Hall, 2007. Provides a clearly written introduction to water supply, waste management, and pollution control that is ideal for students with limited background in the hard sciences and engineering.

Novotny, Vladimir. *Water Quality: Diffuse Pollution and Watershed Management*. 2d ed. Hoboken, N.J.: John Wiley & Sons, 2003. Useful textbook focuses on all types of water-pollution problems. Especially strong on regulatory laws and judicial decisions.

Viessman, Warren, and Mark J. Hammer. *Water Supply and Pollution Control*. 7th ed. Upper Saddle River, N.J.: Prentice Hall, 2004. Authoritative standard textbook on modern water management issues stresses applications of scientific methods to problems that include pollution.

See also: Biodetectors; Biological Weapons Convention of 1972; Biosensors; Chemical Weapons Convention of 1993; Choking; Decontamination methods; Environmental Measurements Laboratory; Food and Drug Administration, U.S.; Forensic toxicology; International Association of Forensic Toxicologists; Lead; Mercury; Mycotoxins; Pathogen transmission.

Airport security

Definition: All legal measures, law-enforcement activities, regulations, and forensic science applications needed to maintain the safety and security of passengers and operational facilities—including aircraft, terminals, and transportation facilities—associated with airline commerce.

Significance: As rates of world travel have increased and the threat of international terrorism has grown, airport security measures have evolved to keep pace. Forensic science has contributed a number of technologies and methodologies to the effort to keep airports safe.

Airport security measures have been operative since commercial airline traffic began during the 1920's. Initial measures included the establishment of rules for luggage, boarding, and other aspects of air travel intended to provide safe passage. As the volume and complexity of air traffic increased, so did the emphasis on rules and regulations governing air passengers, aircraft, and airport security. The most basic of these took the form of regulations regarding movement of passengers and their baggage within airports and their access to airport facilities, the airplanes, and the flight tarmac.

As airports grew larger and volumes of freight and passenger traffic increased during and following World War II, the movements of passengers within airport terminals and their access to operational infrastructure of air terminals were further restricted. Luggage restrictions and weight restrictions became routine, as did requirements concerning passenger identification and boarding passes, but these rules were established to protect passengers from harm and to ensure airport efficiency rather than as deterrents to perceived threats.

The first important changes in airport security followed several incidents in the 1950's in which bombs were planted on aircraft to destroy them in flight for insurance purposes. These were followed with additional security measures taken in the 1960's in response to a number of high-profile hijackings, some of which led to the destruction of aircraft and crews as well as to passenger injuries and deaths. Airlines, agencies, and various governments around the world, including that of the United States, took the (at that time) extraordinary measure of instituting a program of sky marshals to fly on board aircraft. Sky marshals were armed and were charged with identifying and arresting potential menaces as well as with preventing incidents during flight.

Although the sky marshal program was well conceived and well designed for that time, it never received adequate funding to place marshals on every airplane. Hijackings continued to occur, necessitating additional airport security programs. In response, the U.S. Federal Aviation Administration (FAA) required that all passengers and their luggage be thoroughly screened beginning in January, 1973. The airlines contracted this work to private security companies that supplied equipment and trained personnel. The airlines maintained operational control over their airport and aircraft facilities, and the private security companies controlled the screening of carry-on baggage at designated checkpoints prior to passenger entry to the airport waiting rooms, all under the general oversight of FAA officials.

The terrorist attacks on the World Trade Center in New York City and on the Pentagon on September 11, 2001, precipitated immediate and drastic changes in airport security matters that have remained in place. Immediately following the attacks, the federal government mandated that the highest-priority emphasis be placed on the safety and security of passengers, airport facilities, and aircraft at all airports in the United States and most around the world as well. Dramatically increased levels of security were initially reflected in the presence of armed security guards, uniformed local police officers, and even National Guard and active-duty military personnel in some terminals. The military presence was discontinued after a few months; although some passengers were comforted by the open display of weapons, others had expressed alarm.

Post-9/11 Airport Security

Long-term airport security measures that remain in place since the changes brought about after 9/11 include dramatically increased scrutiny of passengers and their carry-on luggage. This has led to the implementation of a number of measures aimed at passenger behavior. First, people are no longer permitted to leave cars unoccupied at terminals or to leave luggage unattended. Passengers must wait in long lines in which they and their luggage are checked with scanners, metal detectors, and, in some cases, substance-detection dogs. Each individual must present some form of personal identification with a photograph, such as a driver's license or passport, and must agree to extensive searching of luggage. These strictures sometimes lead to long waiting times and travel delays, all of which have been sanctioned by federal authorities; most such measures have met with general passenger approval.

Behind-the-scenes changes in airport security have been equally dramatic. Each airport, similar to a small town, now has a dedicated police force hired specifically to maintain airport security. Depending on locality, the airport force may be a private policing agency or a part of the local police force with a police station maintained at the airport. Most airport police forces also include dogs that have been trained to detect explosives and drugs.

Airports have tested and purchased a number of technologically advanced and very expensive apparatuses that permit rapid scanning of baggage and passengers. These include X-ray backscatter scanners that can detect hidden weapons and explosives on passengers as well as automated explosive detection system (EDS) machines that are able to scan hundreds of pieces of luggage per hour. New and improved

Baggage-Screening Technology

The Transportation Security Administration (TSA), a component of the U.S. Department of Homeland Security, is responsible for the security of the nation's transportation systems, including highways, railroads, buses, mass-transit systems, ports, and airports. The TSA provides this description of one of the security measures in place at American airports.

Ever wonder what happens to your bag once you check it with your airline? We screen every bag—100% of all bags—placed on an airplane, whether taken as carry-on or checked with an airline. With nearly 2 million people flying each day, it's a Herculean task.

We are able to meet this requirement by relying on Explosive Detection System (EDS) machines, which work like the MRI machines in your doctor's office. Through a sophisticated analysis of each checked bag, the EDS machines can quickly determine if a bag contains a potential threat or not. If a weapon or explosive is detected, the machines alert our security officers so they can manage the bag appropriately. In some cases, the alarm is quickly resolved and in others law enforcement and the bomb squad may be called in.

computed axial tomography (CAT) scanners have been developed that provide three-dimensional images, thereby more effectively detailing luggage contents; this advancement promotes rapid and accurate identification of hidden weapons, bombs, and packets of chemicals.

A Transportation Security Administration agent at George Bush Intercontinental Airport in Houston, Texas, screens checked baggage for dangerous or suspicious contents using an X-ray machine. *(AP/Wide World Photos)*

Forensic Applications in Airport Security

Airlines and airline facilities must be protected from all forms of terrorism, including bombs planted in luggage, airplane hijackers, and attacks using chemical or biological weapons. Since September 11, 2001, the U.S. government has poured millions of dollars per year into improving airport security, but security breaches still occur. For the most part, these involve identity fraud, drug trafficking, possession of explosives or weapons, or possession of international contraband, harmful chemicals, or biotoxins. Forensic science plays an important role in the prevention and investigation of such security breaches.

The first line of defense against terrorist threats to airport security involves a system of enclosure and screening that prevents access to aircraft and tarmacs. All airports in the United States are surrounded by tall fences or walls, making it nearly impossible for anyone to sneak in. In addition to constant video surveillance throughout airports, security personnel watch every checkpoint, entry, and exit. Upon entrance, both persons and luggage pass through metal detectors. Luggage is also exposed to X rays and may be searched. Individuals are also required to agree to noninvasive searches if asked to do so. Any person who is deemed a threat is subject to more intensive searches.

Modern airport security measures also involve more clandestine operations, such as profiling and the comparison of passenger names and identifications against lists of known terrorists. Airport security profiling involves generalizations about the personality types and physical characteristics of persons who may pose threats to other passengers. Security personnel are urged to be on the lookout for particular “types.” Therefore, while random baggage and clothing checks are conducted, owing to the nature of many international terrorist attacks, ethnic profiling may also occur. Passengers on flights into the United States from overseas are also subject to profiling and comparison against terrorist “watch lists.” If it is discovered that the passenger list of an inbound aircraft includes a known or suspected terrorist, the plane may be turned back, diverted to land at a designated high-security airport, or refused landing permission anywhere in the United States.

Anyone found to be carrying a weapon in an airport is immediately apprehended and the weapon removed. Forensic scientists then confirm and attest in court that the object was cause for the subject’s arrest. In the case of gun possession, firearms analyses are performed in a laboratory to determine the model of the weapon and to recover the serial numbers if removed.

Hidden explosives may be detected using modern explosive detectors that use chromatography to detect volatile gases given off by explosive mixtures. Drug-detection and bomb-sniffing dogs are led by specialized teams at customs checkpoints and often can be seen roaming common rooms in airports as well. If a suitcase or other device is suspected of containing harmful material, it is often further tested with a mechanical "chemical sniffer." If hazardous material is found, be it illegal drugs, explosive material, chemicals, or other toxins, the individual is apprehended and held until forensic scientists can conduct toxicological and chemical composition tests to determine the identity of the substance. If the substance is determined to be an illicit one, the individual is further detained to face charges of possession of an illegal substance.

The detection of possible biological weapons is much more difficult than detection of other kinds of harmful substances. However, if airport security authorities are concerned, they can seize any suspicious substance and submit it for forensic analysis to determine what it is. Unfortunately, no standard procedure yet exists among airline or FAA officials for dealing with possible biological weapons.

A valid driver's license is sufficient identification for a person flying within the United States; a passport is needed to fly internationally. Both these forms of identification, however, provide merely photographs and some additional personal information about the appearance, age, and residence of the individual. The future of individual identification in respect to airport security is likely to involve screening systems based in biometrics—that is, human recognition based on physical traits, such as fingerprints. Biometric identification systems include fingerprint scanning, iris and retina scanning, and facial recognition technologies. In some cases, handwriting and voice recognition are also used to confirm identities.

Among the airport security measures that have been put in place in the United States since September 11, 2001, those involving biometric technologies have become particularly controversial. Some feel comforted by the prospect of being identified by their own fingerprints or retinal images, whereas others feel that these methods of identification are invasive and violate personal privacy. Also, many fear the damage that could be done if hackers or identity thieves gain access to the databases in which biometric data are stored.

Above all other matters related to airport security, Americans are often frustrated with the long lines, personal questions, baggage and clothing searches, and other time-consuming measures they are subject to when they fly. Many believe, however, that these inconveniences are a small price to pay for increased passenger safety. With increasing technological capabilities, the U.S. Department of Homeland Security and Department of Defense are working on measures to expedite the security process while ensuring efficiency, effectiveness, and accurate personal identification. The next decision that Americans who fly commercially will probably have to make is whether they would rather put up with the waiting and frustration or have their fingerprints and retinal scans stored in government databases.

Dwight G. Smith

Further Reading

Bullock, Jane, and George Haddow. *Introduction to Homeland Security*. 2d ed. Boston: Butterworth-Heinemann, 2006. Provides a basic introduction to the operations of the U.S. Department of Homeland Security. Outlines certain types of threats and their prevention, addresses responses to threats, discusses the uses of communication and other technologies in security measures, and speculates on the future evolution of such measures in the United States. Appendixes include a number of related legal documents.

Sweet, Kathleen M. *Aviation and Airport Security: Terrorism and Safety Concerns*. Upper Saddle River, N.J.: Pearson Prentice Hall, 2004. Provides a historical overview of aviation terrorism and discusses the changes in security measures through the years, particularly after September 11, 2001.

Thomas, Andrew R. *Aviation Insecurity: The New Challenges of Air Travel*. Amherst, N.Y.: Prometheus Books: 2003. An aviation security expert details the shortcomings of airport security systems from the days preceding September 11, 2001, through the implementation of changes following that terrorist attack.

Wilkinson, Paul, and Brian M. Jenkins, eds. *Aviation Terrorism and Security*. Portland, Oreg.: Frank Cass, 1999. Collection of essays includes a review of past incidents of aviation terrorism and discussion of the trends seen in security responses. Other chapters address the politics of aviation terrorism and security in the United States and the probable directions of global air security in the future.

See also: Biological terrorism; Biological weapon identification; Biometric eye scanners; Canine substance detection; Closed-circuit television surveillance; Facial recognition technology; Improvised explosive devices; Metal detectors; Racial profiling; September 11, 2001, victim identification.

Alcohol-related offenses

Definition: Violations of the law in which consumption of alcohol is a fundamental component.

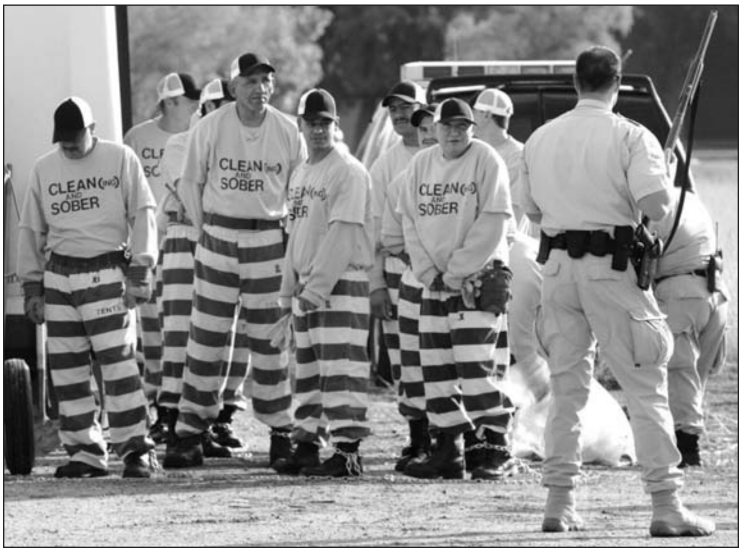
Significance: Alcohol is a legally available drug that has significant impairing effects on a number of aspects of human cognition and performance. Given that alcohol is used pervasively among the general population, alcohol consumption is a significant element in a wide range of criminal cases. Alcohol may play a contributory role in a variety of offenses, even when the presence of alcohol at concentrations associated with significant intoxication does not form the basis of the offenses.

Ethanol, commonly referred to as alcohol, is a drug whose effects include depression of the function of the central nervous system (CNS). As is true for other CNS depressants, the severity of alcohol's effects increases with dose, potentially causing significant impairment of psychomotor skills (such as those required for safe driving) and, ultimately, fatal respiratory depression or circulatory collapse.

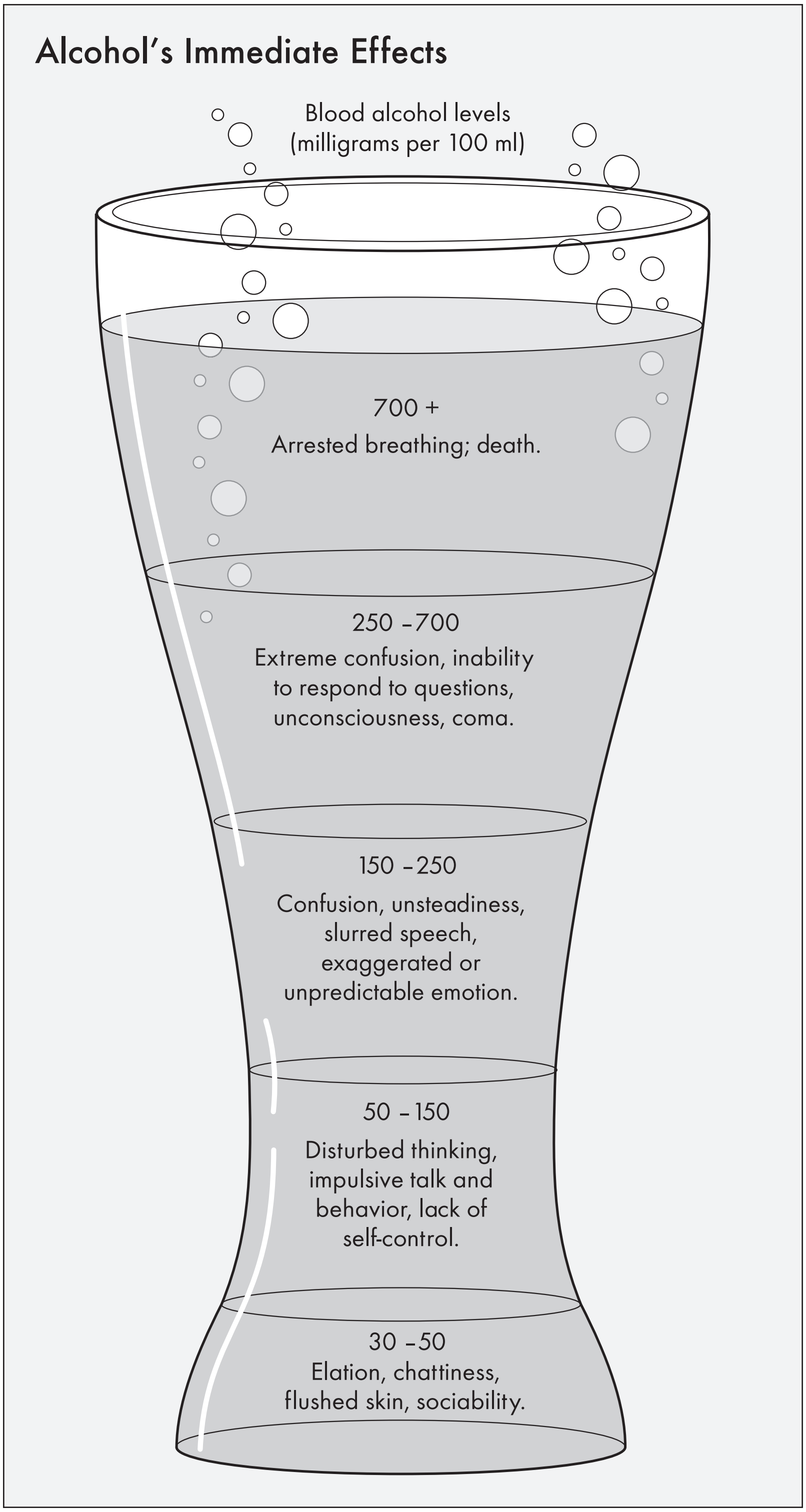
Effects of Alcohol

At low blood alcohol concentrations (BACs), the effects of alcohol consumption include euphoria, talkativeness, and reductions in anxiety and inhibitions. At progressively greater BACs, speech may become slurred, and dizziness or a significant loss of coordination may be observed. Further increases to BAC may be accompanied by drowsiness, emotional lability, confusion, and loss of consciousness. Uncontrolled overdose can result in fatal respiratory depression.

In addition to these relatively obvious symptoms, alcohol causes BAC-dependent impairment to a number of faculties related to psychomotor performance, including the ability to divide attention over multiple tasks, reaction time, risk or hazard perception, and motor coor-



In an innovative program designed to deter drunk driving by publicly humiliating drivers convicted of driving under the influence of alcohol, Arizona's Maricopa County created special chain gangs. Convicted offenders are required to do roadwork while wearing bright pink shirts and black-and-white striped pants. Chain gang members are also required to perform burials of people who die of alcohol abuse. *(AP/Wide World Photos)*



The presence of 30-50 milligrams of alcohol per every 100 milliliters of blood, which represents the effects of an average drink (a glass of beer or wine or an ounce of hard liquor), has immediate effects; as the amount increases, the effects progress toward death.

dination. All these faculties are essential for the safe operation of a motor vehicle. Consequently, one of the most obvious offenses directly related to alcohol consumption is impaired driving, or operation of a motor vehicle with a BAC in excess of the legal limit. Despite the fact that the impairing effects of alcohol on the ability to drive safely have been studied extensively and publicized widely through various public education programs, the incidence of impaired driving offenses remains high in many jurisdictions.

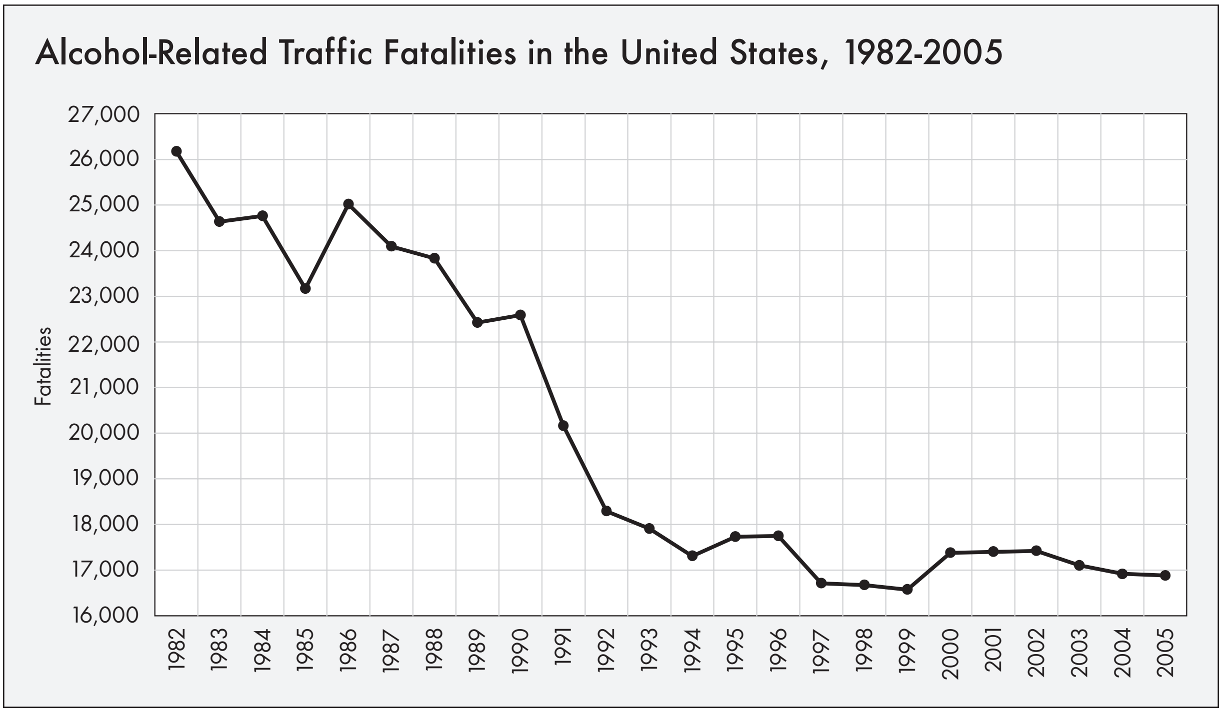
Driving under the influence of alcohol is an example of an offense for which the consumption of alcohol and the associated intoxication form the basis of the offense. In some jurisdictions, other legal offenses are also premised specifically on alcohol consumption; these include public intoxication and the consumption of alcohol by minors.

The consumption of alcohol may also be associated with an increased probability of occurrence of a number of other kinds of offenses. One such offense is sexual assault. A significant amount of research has examined the incidence of the use of drugs and alcohol in cases of sexual assault, especially those in which surreptitious drug administration (so-called drink spiking) is suspected. Over a significant number of jurisdictions worldwide, the most common finding in such studies has been the presence of significant amounts of alcohol in the complainants. In cases of sexual assault, the consumption of alcohol by both complainant and assailant may be important. From the perspective of the complainant, alcohol suppresses behavioral inhibitions, possibly influencing decision-making skills or risk perception. Furthermore, excessive alcohol consumption often leads to substantial impairment and perhaps even unconsciousness, which can place an individual under considerable risk for attack. From the perspective of the assailant, alcohol's suppression of behavioral inhibitions may also be dangerous, but further complications may take the form of alcohol's interference with the perception of social cues.

Forensic Analysis and Interpretation of Evidence

Forensic analysis of the role of alcohol in a particular case typically requires an understanding of the extent of intoxication or impairment, which, in turn, is reflected by the BAC at the time of the incident. In practice, measurement of BAC involves the collection of blood samples or breath measurements, depending on the type of offense (for example, breath analysis is typically done in driving-related offenses, whereas blood sampling is generally done in the course of the examination of victims of sexual assault). Breath alcohol analysis uses instrumentation specifically designed for that particular purpose; analysis of blood samples is generally done by enzymatic methods or gas chromatography. Once a BAC measurement is made, a correction is usually applied to account for the amount of alcohol eliminated from the blood through metabolism and other processes between the time of the incident and the time of sample collection. This provides an estimated BAC range at the time of the incident from which the likely extent of intoxication or impairment may be interpreted.

CNS function is enhanced when other depressant drugs are used in combination with alcohol, with potentially fatal consequences. Additionally, the combination of alcohol with other drugs not associated with CNS depression (such as cocaine or cannabis) may lead to significantly enhanced impairment or unexpected symptoms



Source: National Center for Statistics and Analysis. Fatality Analysis Reporting System, 2008.

that may nonetheless contribute to some kinds of offenses. Consequently, more comprehensive forensic toxicological analysis may be warranted in some cases.

James Watterson

Further Reading

Baselt, Randall C. *Drug Effects on Psychomotor Performance*. Foster City, Calif.: Biomedical Publications, 2001. Comprehensive reference work presents information on the impairing effects of a wide range of therapeutic and illicit drugs.

Brunton, Laurence L., John S. Lazo, and Keith L. Parker, eds. *Goodman and Gilman's The Pharmacological Basis of Therapeutics*. 11th ed. New York: McGraw-Hill, 2006. Authoritative advanced textbook explains basic pharmacological principles and the specific pharmacological features of therapeutic agents. Includes some discussion of illicit agents.

Garriott, James C., ed. *Medical-Legal Aspects of Alcohol*. 4th ed. Tucson, Ariz.: Lawyers & Judges Publishing, 2003. Comprehensive work covers all aspects of forensic alcohol toxicology, including analysis of biological samples, and alcohol pharmacology, including the physiological and psychomotor effects of alcohol consumption and the time course (pharmacokinetics) of alcohol within the body.

Karch, Steven B., ed. *Drug Abuse Handbook*. 2d ed. Boca Raton, Fla.: CRC Press, 2007. Describes the pharmacological, physiological, and pathological aspects of drug abuse in general, and individual chapters address specific compounds, such as alcohol, as well as specific issues related to drug abuse, such as workplace drug testing.

Levine, Barry, ed. *Principles of Forensic Toxicology*. 2d ed., rev. Washington, D.C.: American Association for Clinical Chemistry, 2006. Introductory textbook describes the analytical, chemical, and pharmacological aspects of a variety of drugs of forensic relevance.

See also: Actuarial risk assessment; Analytical instrumentation; Breathalyzer; Drug and alcohol evidence rules; Forensic toxicology; Gas chromatography; Halcion; Toxicological analysis.

Algor mortis

Definition: Cooling of the body after death.

Significance: Because the temperature of the human body begins to cool at the moment of death, observation of algor mortis is one of the ways in which forensic scientists attempt to estimate the postmortem interval.

Investigators of homicides use various techniques to estimate the length of time since death, or the postmortem interval (PMI). It is likely that before the techniques employed by modern investigators gained wide acceptance, early hunters and gatherers distinguished the same stages of decomposition following death. Such stages include the fresh, bloat, active, and advanced decay stages versus the stage at which remains become dry or skeletonized. However, the indicators that modern forensic investigators consider classic for suggesting PMI are those of algor mortis (cooling of the body), rigor mortis (stiffening of the body), and livor mortis (discoloration of the body from gravitational blood seepage).

Because decomposition reflects chemical processes and all chemical processes are temperature-dependent, the acquisition of many of the conditions noticed after death is affected by temperature. That is, higher temperatures generally speed chemical reactions, and lower temperatures slow them. In algor mortis (the term derives from the Latin words *algor*, meaning "coolness," and *mortis*, meaning "death"), the body is expected to cool until its temperature matches that of the surrounding environment.

If a body cools at a uniform rate, the measure of its temperature decrease following death can assist in the accurate determination of the elapsed time since death. The formula used for making such an estimate, known as the Glaister equation, is based on the notion that a dead body is expected to lose 1.5 degrees Fahrenheit per hour. Because the metabolic processes associated with maintaining life among humans generates a normal body temperature of nearly 98.4 degrees Fahrenheit, the Glaister equation estimates the approximate postmortem interval in hours by subtracting the body temperature (measured in degrees Fahrenheit at the rectum or deep within the liver) from 98.4 degrees and dividing the result by 1.5. Thus, if a decedent's temperature is found to be 90.2 degrees Fahrenheit at the time of the body's discovery, the decedent would be suggested to have died approximately 5.5 hours earlier.

After death, a body cools by radiation, conduction, and convection, so many physical factors can influence algor mortis. One of these is ambient temperature, or, more precisely, the difference between ambient and body temperatures. If, for example, a body were to be discovered in a warm sauna, it might not have cooled at all. Furthermore, the body temperature of the decedent might not have been normal at the time of death owing to the effects of exercise, illness, or infection. Additionally, the amount of subcutaneous fat present, the lightness or heaviness of any clothing worn at the time of death, and any number of insulating coverings can alter the rate at which a body might be expected to cool. Any such variables can alter the effectiveness of employing the Glaister equation to estimate the postmortem interval.

Turhon A. Murad

Further Reading

Randall, Brad. *Death Investigation: The Basics*. Tucson, Ariz.: Galen Press, 1997.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007.

Spitz, Werner U., ed. *Spitz and Fisher's Medicolegal Investigation of Death: Guidelines for the Application of Pathology to Crime Investigation*. 4th ed. Springfield, Ill.: Charles C Thomas, 2006.

See also: Adipocere; Body farms; Decomposition of bodies; Forensic pathology; Livor mortis; Rigor mortis; Taphonomy.

ALI standard

Definition: Statement of the insanity defense that has become widely accepted in federal and state jurisdictions throughout the United States.

Significance: The American Law Institute's carefully formulated insanity defense standard was created to overcome the shortcomings of earlier tests of insanity, such as the M'Naghten rule and the irresistible impulse rule.

During the 1950's and early 1960's, the American Law Institute (ALI) developed the Model Penal Code, the 1962 draft of which contained a statement of the insanity defense composed by a panel of judges, legal scholars, and behavioral scientists. It stated:

> A person is not responsible for criminal conduct if at the time of such conduct as a result of mental disease or defect he lacks substantial capacity either to appreciate the criminality (wrongfulness) of his conduct or to conform his conduct to the requirements of law. . . . the terms "mental disease or defect" do not include an abnormality manifested only by repeated criminal or otherwise antisocial conduct.

In the 1972 case of *United States v. Brawner*, the U.S. Court of Appeals for the District of Columbia adopted the ALI rule, and it became the standard used in almost all federal courts and in twenty-two U.S. state jurisdictions.

The ALI standard is considered a more precisely worded amalgam of two earlier insanity tests, namely, the M'Naghten rule and the irresistible impulse rule. The M'Naghten rule, developed in Great Britain in 1843, was the first formal test of legal insanity. As a test of legal insanity, it focused on whether the defendant's insanity deprived the defendant of a certain kind of cognitive ability, that of knowing what he or she was doing or knowing the difference between right and wrong. The ALI standard uses the broader term "appreciate" instead of "know" yet still retains the key idea of cognitive impairment.

Many jurisdictions had augmented the

M'Naghten test with the irresistible impulse rule to allow for cases in which mental disease or defect impedes a person's power to choose. The ALI standard replaces the somewhat narrow and misleading phrase "irresistible impulse" with the person's not being able "to conform" his or her "conduct to the requirements of law," thus capturing the underlying idea of volitional impairment. In the federal Insanity Defense Reform Act of 1984, the volitional impairment part of the ALI standard was eliminated as part of the definition of the insanity defense.

The ALI rule was also drawn in such a way as to avoid the looseness of two similar legal insanity tests, the New Hampshire rule and the Durham rule. Both tests framed the issue of legal insanity in terms of whether the criminal act was a product of mental disease. They were criticized on the grounds that in practice they resulted in "undue dominance of experts" in the courtroom, specifically, that the testimony of forensic psychiatrists carried too much weight and encroached on the proper role of the jury.

Mario Morelli

Further Reading

Moore, Michael. *Law and Psychiatry: Rethinking the Relationship*. New York: Cambridge University Press, 1984.

Rogers, Richard, and Daniel W. Shuman. *Fundamentals of Forensic Practice: Mental Health and Criminal Law*. New York: Springer, 2005.

See also: Forensic psychiatry; Guilty but mentally ill plea; Insanity defense; Irresistible impulse rule; Legal competency; *Mens rea*.

American Academy of Forensic Sciences

Date: Formed in 1948

Identification: Nonprofit professional organization created to improve, administer, and achieve justice through the application of science to the legal system.

Significance: With a membership made up of forensic scientists from all the field's major specialties, the American Academy of Forensic Sciences represents forensic science and its professionals to the public, offers credibility for their expert court testimony through board certification, and promotes educational and research opportunities for members.

In 1948, a small group of pathologists, psychiatrists, criminalists, and lawyers formed the American Academy of Forensic Sciences (AAFS) to apply science to the law. The AAFS has become the primary organization for professional forensic scientists, representing some six thousand members from across the United States, Canada, and more than fifty other countries. The society represents all the major forensic science disciplines, with sections including Criminalistics, Digital Forensics, Engineering Sciences, General, Odontology, Pathology/Biology, Physical Anthropology, Psychiatry and Behavioral Science, Questioned Documents, and Toxicology. AAFS members include physicians, pathologists, dentists, toxicologists, physicists, engineers, physical anthropologists, attorneys, and other forensic science specialists.

Functions of the society (in association with the Forensic Sciences Foundation) include the promotion of forensic science education through the publication of newsletters, symposia, and the flagship peer-reviewed journal the *Journal of Forensic Sciences*, which was launched in 1956, and through sponsorship of an annual meeting each February. The AAFS also administers board certification exams, continuing education credit (for physicians, dentists, chemists, nurses, and attorneys), and training seminars for members to advance their scientific accuracy and credibility. The AAFS offers job placement, scholarship, and grant opportunities for its members as well as career information for all persons interested in forensic science; the academy also supports research in the forensic science fields and provides ethical oversight in the practice of forensic science.

The AAFS oversees the Forensic Science Education Programs Accreditation Commission, known as FEPAC, which is dedicated to enhancing the quality of college-level academic forensic science education through a formal evaluation and recognition process. FEPAC sets quality standards for undergraduate and graduate forensic science programs and administers their accreditation.

Categories of membership in the AAFS are student affiliate, trainee affiliate, associate member, member, and fellow. The academy's stringent membership requirements include (for associate member and higher) proof of active engagement in and significant contributions to the field of forensic science as well as a minimum education of a baccalaureate degree from an accredited college or university. Each section within the AAFS also has its own additional requirements for membership. Applications for membership are approved only at the annual meeting each February.

Donna C. Boyd

Further Reading

Gaensslen, R. E., Howard A. Harris, and Henry C. Lee. *Introduction to Forensic Science and Criminalistics*. New York: McGraw-Hill, 2008.

Houck, Max M., and Jay A. Siegel. *Fundamentals of Forensic Science*. Burlington, Mass.: Elsevier Academic Press, 2006.

See also: American Society of Crime Laboratory Directors; Ethics; European Network of Forensic Science Institutes; Expert witnesses; Federal Bureau of Investigation Forensic Science Research and Training Center; Forensic Science Service; International Association for Identification; International Association of Forensic Nurses; International Association of Forensic Sciences; Training and licensing of forensic professionals.

American Law Institute standard. *See* ALI standard

American Society of Crime Laboratory Directors

Date: Founded in 1974

Identification: Organization of forensic laboratory professionals that provides a forum for the discussion of laboratory management issues and promotes improvements in forensic techniques and services.

Significance: Through their interaction in the American Society of Crime Laboratory Directors, forensic laboratory managers advanced the standards of labs in North America and internationally and also secured public recognition for the need to require accredited laboratory analysis of forensic evidence.

Dr. Briggs Johnston White (1911-1994), a chemist who served as director of the Laboratory Division of the Federal Bureau of Investigation (FBI), envisioned forming the American Society of Crime Laboratory Directors (ASCLD) to encourage local, state, and federal managers of U.S. forensic laboratories and forensic science programs to share their experiences and suggestions for reinforcing the professionalism of forensic laboratories. In December, 1973, approximately thirty crime laboratory directors participated in a symposium at the FBI Academy in Quantico, Virginia, to discuss White's ideas. In fall, 1974, the laboratory directors returned to Quantico to organize ASCLD, designating White as chairman.

Officers and a board of directors oversee ASCLD administration, with committees addressing specific needs. North American and international forensic professionals who oversee crime laboratories or associated scientific, educational, or legal work qualify for ASCLD membership categories. The ASCLD code of ethics outlines members' accountability to their profession and the public, and the organization's "Guidelines for Forensic Laboratory Management Practices" lists lab managers' duties, including the evaluation of employees and procedures.

ASCLD hosts meetings every year at which members and other forensic professionals can participate in workshops and discussions on topics relevant to the management of crime laboratories, such as personnel and accreditation. Also addressed are scientific and technological advances in forensic tests and techniques used to evaluate evidence in laboratories. Since 1994, ASCLD has presented the Briggs White Award annually to recognize notable forensic science laboratory leaders.

The association also distributes several publications, including *ASCLD News*, *Crime Laboratory Digest*, and *Crime Lab Minute*, which is posted on the ASCLD Web site. ASCLD guides outline forensic laboratory management practices for individual topics such as arson, and the association's laboratory accreditation manuals specify current standards. ASCLD established the National Forensic Science Technology Center (NFSTC) to improve laboratories by aiding crime laboratory directors and personnel to gain proficiency in forensics work.

In 1981, the association's Committee on Laboratory Evaluation and Standards became the ASCLD Committee on Laboratory Accreditation and began evaluating U.S. state police laboratories. By 1993, the autonomous American Society of Crime Laboratory Directors/Laboratory Accreditation Board (ASCLD/LAB) was focused on examining North American and foreign laboratories because of complaints concerning inferior forensic work. The FBI Laboratory Division received accreditation from ASCLD/LAB in September, 1998. Approximately 350 laboratories, including other U.S. federal forensic laboratories, had secured accreditation by late 2006. Several states have passed legislation making the accreditation of government forensic laboratories a requirement for representatives of those labs to present evidence in courts.

As members of the Coalition of Forensic Science Organizations, ASCLD and ASCLD/LAB supported the National Forensic Science Improvement Act, which was enacted in December, 2000. This federal law provides for the distribution of federal funds to state and local crime laboratories.

Elizabeth D. Schafer

Further Reading

Dao, James. "Lab's Errors in '82 Killing Force Review of Virginia DNA Cases." *The New York Times*, May 7, 2005, p. A1.

Lueck, Thomas J. "Sloppy Police Lab Work Leads to Retesting of Drug Evidence." *The New York Times*, December 4, 2007, p. B1.

St. Clair, Jami J. *Crime Laboratory Management*. San Diego, Calif.: Academic Press, 2002.

See also: American Academy of Forensic Sciences; Courts and forensic evidence; Crime laboratories; DNA fingerprinting; Ethics; European Network of Forensic Science Institutes; Federal Bureau of Investigation Laboratory; Forensic Science Service; Quality control of evidence; Training and licensing of forensic professionals.

Amphetamines

Definition: Members of a class of drugs that contain an amphetamine base. These drugs are classified as stimulants, meaning they increase energy levels, reduce fatigue, and cause psychological exhilaration.

Significance: Despite intense effort on the part of both legislative and law-enforcement personnel, the number of users of amphetamines continues to rise. The popularity of these drugs is an ongoing concern because chronic use of amphetamines can produce severe mental and physical problems. These drugs are of particular interest to law enforcement because clandestine methamphetamine laboratories pose a threat to neighborhoods, the environment, and investigating officials.

In the United States, the use of controlled substances is governed at the federal level by the Controlled Substances Act of 1970. The most strongly controlled substances are listed in Schedule I of the act, and those under the least control are listed in Schedule V. Amphetamines,

An agent for the North Dakota Bureau of Criminal Investigations holds a bag containing about 50 grams of methamphetamine. Behind the bag are some common household ingredients used to make methamphetamine. *(AP/Wide World Photos)*

along with cocaine, morphine, and phencyclidine (PCP), are listed in Schedule II. Drugs in this class have a high potential for abuse and also have accepted medical uses within the United States (with severe restrictions). Abuse of Schedule II drugs may lead to severe psychological dependence, physical dependence, or both.

Amphetamines are easy to produce, cheap to buy, and cause effects in the body similar to those of cocaine. Most illicit, or "street," amphetamines are actually methamphetamine, which is particularly potent and has long-lasting effects. Street names for amphetamines and methamphetamine include meth, crank, krank, crystal, glass, ice, pep pills, speed, uppers, peanut brittle, and tweak. These names often reflect particular ways the drugs appear; for example, ice is a very pure form, whereas peanut brittle is less so. The street price for one gram of methamphetamine ranges from twenty to three hundred dollars.

Manufacture

The high demand for methamphetamine, along with significant profit potential, has resulted in the production of the drug in thousands of clandestine laboratories, or "clan labs." "Super labs" are clan labs that are capable of producing seventy-five to one hundred pounds of methamphetamine in each production cycle. In comparison, "stove-top labs" typically produce only one to four ounces per batch. Production of one pound of the drug can result in from five to seven pounds of hazardous waste. Most of this waste ends up dumped on the ground or flushed into streams or sewage systems.

The synthetic route by which methamphetamine is prepared is widely known, and the required chemicals are readily available. The three most common production routes are the P2P (phenyl-2-propanone) amalgam method, the hydroiodic acid and red phosphorus reduction method, and the Birch reduction method. Ephedrine and pseudoephedrine, which can be found in many over-the-counter cold remedies, are key starting materials in the production of methamphetamine. Depending on the synthetic pathway, other important materials include iodine, red phosphorus, hydrogen chloride gas, and anhydrous ammonia. The U.S. government has regulated the sale and use of some of these chemicals in an effort to curb production of methamphetamine.

Routes of Ingestion

Amphetamines may be smoked, snorted, injected, or taken orally in pill form. Methamphetamine is often smoked; the drug is placed in a glass pipe, heat is applied to the bowl, and the vapors are inhaled through the stem. Snorting the drug tends to cause irritation to the nasal lining. Heavy, long-term users generally prefer to inject the drug. Like cocaine, amphetamine can be dissolved in water and cooked to prepare it for injection.

The route of ingestion determines the onset of the drug's effects. Effects from oral ingestion are felt within thirty to sixty minutes. When snorted, the drug produces effects within five to twenty minutes. Injecting and smoking the drug both result in an intense "rush" within seconds of ingestion. The intensity of the effects, which can last from six to twelve hours, is related to both the dose of the drug and its purity. Regardless of the route of ingestion, tolerance to the drug may develop quickly, so that the user requires larger and larger doses of amphetamines to produce the desired effect. Whereas medical doses of amphetamines rarely exceed 100 milligrams per day, a super user on a binge may ingest more than 15,000 milligrams every twenty-four hours.

Forms

The appearance of amphetamine and methamphetamine depends on the synthetic process and quality control used in their production. High-quality street meth is generally a white crystalline powder. The color of lower-quality meth may range from dark yellow to brown. The drug may be crystalline, granular, or solid block, and it may have a sticky consistency. It may be packaged in plastic bags, paper bindles, or glass vials.

Ice is a very pure form of methamphetamine with an appearance similar to that of broken glass. It is usually in-

Scope of Methamphetamine Abuse

A 2006 research report from the National Institute on Drug Abuse provides this information on methamphetamine use in the United States.

According to the 2005 National Survey on Drug Use and Health, an estimated 10.4 million people age twelve or older (4.3 percent of the population) have tried methamphetamine at some time in their lives. Approximately 1.3 million reported past-year methamphetamine use, and 512,000 reported current (past-month) use. Moreover, the 2005 Monitoring the Future survey of student drug use and attitudes reported 4.5 percent of high school seniors had used methamphetamine within their lifetimes, while eighth-graders and tenth-graders reported lifetime use at 3.1 and 4.1 percent, respectively. However, neither of these surveys has documented an overall increase in the abuse of methamphetamine over the past few years. In fact, both surveys showed recent declines in methamphetamine abuse among the nation's youth.

In contrast, evidence from emergency departments and treatment programs attests to the growing impact of methamphetamine abuse in the country. The Drug Abuse Warning Network, which collects information on drug-related episodes from hospital emergency departments (EDs) throughout the nation, reported a greater than 50 percent increase in the number of ED visits related to methamphetamine abuse between 1995 and 2002, reaching approximately 73,000 ED visits, or 4 percent of all drug-related visits, in 2004.

Treatment admissions for methamphetamine abuse have also increased substantially. In 1992, there were approximately 21,000 treatment admissions in which methamphetamine/amphetamine was identified as the primary drug of abuse, representing more than 1 percent of all treatment admissions during the year. By 2004, the number of methamphetamine treatment admissions increased to greater than 150,000, representing 8 percent of all admissions.

gested by smoking, and the effects can last up to fourteen hours. The price of one gram of ice ranges from two hundred to four hundred dollars.

Effects

As stimulants that act on the central nervous system, amphetamines reduce fatigue and the need to sleep, increase confidence and energy levels, and in general cause psychological and physical exhilaration. These effects are identical to those of cocaine, but the effects of cocaine last from twenty to eighty minutes, whereas those of amphetamines last for four to twelve hours. New users can rapidly develop psychological dependence on amphetamines.

Common effects displayed by people under the influence of amphetamines include alertness, anxiety, euphoria, reduced appetite, talkativeness, and teeth grinding. Chronic abuse of the drug can produce severe mental and physical problems, including delusions, visual and auditory hallucinations, and violent behavior. Long-term high-dose users of amphetamines may experience formication, which is the feeling that bugs are crawling under the skin. People in this state can severely injure themselves while trying to dig or cut the imagined bugs from their skin.

Megan N. Bottegal

Further Reading

Gano, Lila. *Hazardous Waste*. San Diego, Calif.: Lucent Books, 1991. Provides a good discussion of the health risks of the hazardous wastes generated by clandestine labs in the production of methamphetamine.

Hicks, John. *Drug Addiction: "No Way I'm an Addict."* Brookfield, Conn.: Millbrook Press, 1997. Focuses on drug-abuse treatment strategies, with an emphasis on amphetamine addiction.

Laci, Miklos. *Illegal Drugs: America's Anguish*. Detroit: Thomson/Gale, 2004. Comprehensive guide to illegal drugs in the United States includes discussion of the origins, uses, and effects of drug abuse. Of particular interest is the section on drug trafficking.

Menhard, Francha Roffé. *Drugs: Facts About Amphetamines*. Tarrytown, N.J.: Marshall Cavendish, 2006. Provides information on the characteristics, legal status, history, abuse, and treatment of addiction to amphetamines and methamphetamine.

Pellowski, Michael. *Amphetamine Drug Dangers*. Berkeley Heights, N.J.: Enslow, 2000. Discusses stimulant drugs in general and amphetamines in particular. Topics of interest include the signs and symptoms of amphetamine abuse.

See also: Club drugs; Controlled Substances Act of 1970; Drug abuse and dependence; Drug classification; Drug confirmation tests; Drug Enforcement Administration, U.S.; Drug paraphernalia; Meth labs; Stimulants.

Anabolic Steroid Control Act of 2004

Date: Enacted on October 22, 2004

The Law: Federal legislation designed to clarify definitions of anabolic steroids, to provide for research and education activities relating to steroids and steroid precursors, and to expand regulatory and enforcement authority.

Significance: The Anabolic Steroid Control Act of 2004 represented an attempt by the U.S. government to address the growing problem of the use of anabolic steroids, particularly by young people. The law strengthened legal penalties for distribution and possession of these drugs while also encouraging increased education about their dangers for children and adolescents.

Anabolic steroids are synthetic chemicals that mimic the action of the hormone testosterone in the body. They originally found a valued use in maintaining tissue integrity in sufferers of chronic disease. Athletes, however, soon discovered that the muscle-promoting activity of anabolic steroids could enhance performance and give them decided advantages over other athletes in competition, and the use of these drugs became pervasive throughout the sporting world. When they found a place among American male teenagers craving larger muscles and better athletic performance, the U.S. Congress took note.

Congress first criminalized the nonmedical use of anabolic steroids by passing the Anabolic Steroid Control Act of 1990, which made it clear that anyone illegally possessing these drugs was subject to arrest and prosecution. Under the 1990 act, a first offense of simple possession was punishable by up to one year in prison, a minimum fine of $1,000, or both. The penalties increased for those with previous convictions related to narcotics crimes. The act reserved the most severe penalties for individuals who distributed or dispensed steroids. These activities carried a penalty of up to five years in prison, a fine of $250,000, or both. Penalties were higher for repeat offenders, and fines could rise to $1,000,000 for defendants that were other than individuals.

Although the 1990 act was an improvement over previous legislation, it did not go far enough. For example, the 1990 act listed only twenty-seven controlled substances; the Anabolic Steroid Control Act of 2004 act more than doubled that number in addition to stiffening penalties and providing for research and education regarding anabolic steroids. The 2004 act significantly increased the maximum term of imprisonment, fine, and length of supervised release for the manufacture or distribution of anabolic steroids. It also broadened the definition of an anabolic steroid to encompass any drug or hormonal substance chemically related to testosterone. The act specifically excluded estrogens, progestins, corticosteroids, and dehydroepiandrosterone from that list while designating fifty-nine specific drugs as anabolic steroids. Finally, the act encouraged the use of federal grants to carry out science-based education programs in elementary and secondary schools to highlight the harmful effects of anabolic steroids.

Although a great deal of debate continues regarding the negative effects of anabolic steroids, proponents of the 2004 legislation took their lead from studies that had found that these drugs may damage the liver, kidney, heart, and sexual organs. In addition, research has indicated that the use of anabolic steroids by children could prevent them from reaching their full height, and use of the drugs has been associated with outbursts of anger and violence (often referred to as "roid rage"). In recognition of anabolic steroids' potential for damage, U.S. president George W. Bush called for a "get-tough approach" to steroid abuse in his 2004 state of the union address. The Anabolic Steroid Control Act of 2004 was a step in that direction.

Richard S. Spira

Further Reading

Aretha, David. *Steroids and Other Performance-Enhancing Drugs*. Berkeley Heights, N.J.: Enslow, 2005.

Gray, James. *Why Our Drug Laws Have Failed and What We Can Do About It: A Judicial Indictment of the War on Drugs*. Philadelphia: Temple University Press, 2001.

Monroe, Judy. *Steroids, Sports, and Body Image: The Risks of Performance-Enhancing Drugs*. Berkeley Heights, N.J.: Enslow, 2004.

Yesalis, Charles E. *Anabolic Steroids in Sport and Exercise*. Champaign, Ill.: Human Kinetics, 2000.

See also: Athlete drug testing; Drug confirmation tests; Drug Enforcement Administration, U.S.; Forensic toxicology; Performance-enhancing drugs; Toxicological analysis.

Analytical instrumentation

Definition: Tools used during the chemical and physical investigation of physical evidence to identify components and their associated concentrations.

Significance: The scientific evaluation of forensic samples provides information that can be useful to law-enforcement investigators. The instruments employed by forensic scientists are designed to detect and measure small quantities and fine details, thus enabling comparisons of samples that can link suspects to crime scenes or eliminate persons from suspicion.

Advances in analytical instrumentation have significantly changed how forensic investigations are completed. Forensic scientists use many different types of analytical instruments, but all these tools serve the purpose of enabling the scientists to obtain more information on forensic samples. Analytical techniques have the ability to change a sample from one that was thought to have only class characteristics to one that has individual characteristics, making it more valuable in an investigation. This ability to detect individual characteristics is one reason analytical instrumentation has become an important part of forensic investigations.

Analytical instruments can be grouped according to the types of chemical and physical properties they measure. The analytical techniques most commonly used by forensic scientists are microscopy, chromatography, electrophoresis, spectrometry, and spectroscopy.

Microscopy

Light microscopy, or the use of light microscopes, allows forensic analysts to magnify samples so the fine details can be viewed and evaluated. Light microscopes have the ability to magnify up to around 1,500× (that is, 1,500 times normal size). Light microscopy is useful for comparisons of samples and in the evaluation of specimens for similarities and differences. Common light microscopes used in forensic science include the compound microscope, the stereo microscope, and the comparison microscope. A comparison microscope allows an analyst to view two samples side by side, so they can easily be compared; fiber samples and bullets are among the kinds of forensic evidence often compared in this way.

An electron microscope uses a beam of electrons to probe a sample and allows a forensic scientist to view a sample at a greater magnification than is possible with a light microscope. A common type of electron microscope used in forensic applications is the scanning electron microscope (SEM), which can reach a magnification of 100,000× or greater. Another advantage of the SEM is that it enables the scientist to probe the elemental composition and elemental distribution of specimens using the X-ray fluorescence property of the microscope.

Chromatography and Electrophoresis

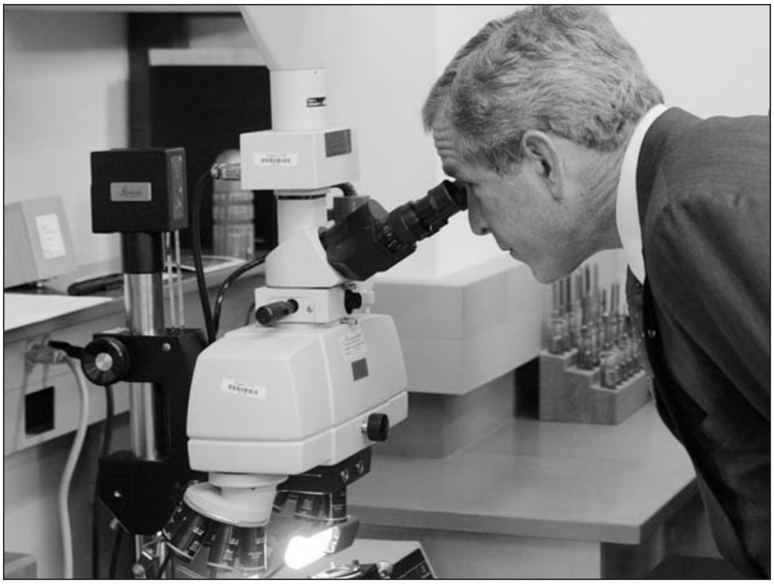
Forensic scientists use chromatography and electrophoresis to analyze complex mixtures of chemicals. The term "chromatography" is used to refer to a range of techniques that allow the separation of the individual components of chemical mixtures through the use of either a gas or a liquid moving phase. Chromatographic analysis can be used to determine all the different chemical components that make up a sample and how much of each component is present.

The main types of chromatography used in forensic investigations are gas chromatography (GC) and high-performance liquid chromatography (HPLC). GC separates, detects, and quantifies volatile species (atoms, molecules, or ions) or chemical compounds that can be converted to the gas phase by heating. Once in a gas phase, species move at different rates through a column, which results in a physical separation between components. This technique is very useful for arson investigations, in which fire accelerants often need to be evaluated. HPLC involves the analysis of mostly organic samples (molecules containing carbon) in a liquid state. The samples are dissolved in a suitable liquid solvent, such as water or an alcohol. This technique can be used to identify and determine the amounts of different drugs in samples collected at crime scenes.

Capillary electrophoresis is a technique used by forensic scientists to separate charged chemical species such as proteins and peptides. It uses an electric potential to cause positive and negative charged species to migrate and separate into components. The main forensic application of this technique is in DNA (deoxyribonucleic acid) analysis.

Spectrometry and Spectroscopy

Forensic scientists use molecular spectrometry and spectrophotometry to look at the molecular or organic structure of chemical compounds. Techniques such as Fourier transform infrared (FTIR) spectrometry, ultraviolet and visible spectrometry (UV-Vis), and mass spectrometry (MS) allow analysts to classify and identify chemicals by their molecular spectra. FTIR spectrometry uses infrared light, and UV-Vis uses visible and ultraviolet light. A forensic scientist might compare an FTIR spectra of a forensic sample such as a white powder found at a crime scene with a spectral library of known compounds in order to identify the powder. FTIR can also be attached to a microscope to create a microspectrophotom eter, which enables examination of the molecular structure of a sample. MS is often carried out in conjunction with gas or liquid chromatography to provide more detailed identification of components in a forensic sample.



President George W. Bush looks through a comparison microscope in the ballistics room of the Federal Bureau of Investigation Laboratory in Quantico, Virginia. *(AP/Wide World Photos)*

Elemental spectroscopy is accomplished by techniques that measure the elemental composition and concentration in a sample. Atomic absorption (AA), inductively coupled plasma (ICP), X-ray fluorescence (XRF), X-ray diffraction (XRD), and neutron activation analysis (NAA) are typical instruments used in inorganic analysis. XRF can be used to determine the presence of lead and barium in gunshot residue. ICP can be used in finding out what elements are in a metal sample, such as a bullet; this allows the scientist to determine the alloy type, which then may be traced to a manufacturer.

Dwight Tshudy

Further Reading

Bell, Suzanne. *Forensic Chemistry*. Upper Saddle River, N.J.: Pearson Prentice Hall, 2006. Chemistry-focused text presents discussion of the use of analytical instrumentation.

Girard, James E. *Criminalistics: Forensic Science and Crime*. Sudbury, Mass.: Jones & Bartlett, 2008. Textbook includes sections in which instruments and their uses are described.

Houck, Max M., and Jay A. Siegel. *Fundamentals of Forensic Science*. Burlington, Mass.: Elsevier Academic Press, 2006. Good general textbook includes a well-presented section on analytical tools.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005. Covers analytical instrumentation in a section on forensic science in the laboratory.

Johll, Matthew. *Investigating Chemistry: A Forensic Science Approach*. New York: W. H. Freeman, 2007. Textbook designed for nonscience majors presents simple explanations of analytical instruments and their uses.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007. Introductory text describes and explains the uses of various analytical instruments and techniques.

See also: Atomic absorption spectrophotometry; Chromatography; Column chromatography; Crime laboratories; Electrophoresis; Fourier transform infrared spectrophotometer; Gas chro-

matography; High-performance liquid chromatography; Homogeneous enzyme immunoassay; Mass spectrometry; Microspectrophotometry; Scanning electron microscopy; Spectroscopy.

Anastasia remains identification

Date: Began in July, 1991

The Event: After Bolshevik revolutionaries executed the members of the Russian imperial family in 1918, rumors persisted—and the notion was popularized in books and films—that two of the czar's children, Anastasia and Alexei, survived. Numerous pretenders came forward claiming to be the missing Princess Anastasia. Beginning in 1991, forensic science was put to use in attempts to clarify which members of the family were in fact executed.

Significance: The forensic investigation undertaken to identify the remains of the Russian royal family, the Romanovs, was the first to employ both short tandem repeats and mitochondrial DNA for the identification of historical figures, portending the application of the same techniques in the identification of the remains of both well-known and obscure persons in future investigations.

On July 17, 1918, Czar Nicholas II of Russia, his family members (Czarina Alexandra, their four daughters—Olga, Tatiana, Maria, and Anastasia—and only son, Alexei), the family physician, and three servants were herded into a basement and executed by firing squad or by stab wounds from bayonets. Eyewitness accounts stated that most of the bodies were then placed in a shallow pit, and sulfuric acid was added to impede identification; the remains of Alexei and an unidentified daughter were burned separately.

In 1991, the Russian government authorized an investigation at the burial site. The July, 1991, exhumation of the grave near Yekaterinburg revealed that it contained nine corpses. A Russian forensic team did extensive work in determining the sexes of the bodies, in estimating ages, and in employing odontology and computer-assisted facial reconstruction to attempt identification, although the latter tests were limited because the facial areas of the skulls were destroyed. The scientists determined that the grave contained the remains of the czar, the czarina, three of the daughters, the physician, and the servants. However, a disagreement about the identification of the daughters developed between the Russian scientists and an American team of forensic anthropologists who had been hired by the city of Yekaterinburg. Relying on the same evidence, the Russian researchers argued that the missing daughter was Maria, whereas the Americans thought her to be Anastasia. No evidence of the allegedly burned children's bodies was found at the site or nearby.

To bolster the authenticity of the identification, a joint team of British and Russian scientists evaluated the remains using three DNA (deoxyribonucleic acid) tests. The first confirmed that the mass grave contained five female and four male bodies. The second test was a short tandem repeat (STR) analysis; this type of test can establish whether individuals are closely related to one another. The second test showed that the remains included parents and three children. The third test was mitochondrial DNA (mtDNA) sequencing, which can be employed for identification even when the related persons are separated by many generations; mtDNA is passed directly from mothers to their children. DNA from the body believed to be that of the czar was compared with DNA samples from two of the czar's maternal grandmother's descendants; DNA from the czarina and the children was compared with DNA from Prince Philip, duke of Edinburgh, whose maternal grandmother was the czarina's sister. In both instances, matches were positive.

The researchers reported a 98.5 percent probability that the remains were those of the imperial family based on the anthropological, historical, and scientific evidence. They de-

The children of the last czar of Russia (from left): Tatiana, Maria, Anastasia, Olga, and Alexei. This photograph was taken sometime around 1916, approximately two years before the members of the Romanov family were executed. *(Library of Congress)*

clined, however, to confirm the individual identities of the daughters. Both American and German authorities tested the DNA of Anna Anderson, the best known of the Anastasia pretenders, using STR analysis, and the DNA was not a match to the royal family.

In 2007, Russian archaeologists announced that they believed they had found the remains of the two missing children of the imperial family near the site where Nicholas, Alexandra, and the other three daughters were found. In April, 2008, Russian forensic scientists who had performed analyses on DNA extracted from teeth, bones, and other fragments of those remains announced their findings: The last two of the Romanov children, Alexei and Maria, had been identified. The remains found in the mass burial site examined beginning in 1991 thus included those of Anastasia.

Susan Coleman

Further Reading

Gill, Peter, et al. “Identification of the Remains of the Romanov Family by DNA Analysis.” *Nature Genetics* 6 (February, 1994): 130-135.

Jobling, Mark A., and Peter Gill. “Encoded Evidence: DNA in Forensic Analysis.” *Nature Reviews Genetics* 5 (October, 2004): 739-751.

Klier, John, and Helen Mingay. *Quest for Anastasia: Solving the Mystery of the Lost Romanovs*. Secaucus, N.J.: Carol, 1997.

Rudin, Norah, and Keith Inman. *An Introduction to Forensic DNA Analysis*. 2d ed. Boca Raton, Fla.: CRC Press, 2002.

See also: Anthropometry; DNA analysis; Forensic odontology; Louis XVII remains identification; Mass graves; Mitochondrial DNA analysis and typing; Nicholas II remains identification; Short tandem repeat analysis; Skeletal analysis.

Ancient criminal cases and mysteries

Significance: Many ancient humans engaged in illegal behaviors, ranging from theft to murder, that share elements with crimes that have been encountered by centuries of law-enforcement personnel, who in turn developed effective forensic investigation techniques. Intrigued by certain unsolved ancient crimes, some modern investigators have applied the latest forensic methods and tools to the evaluation of the available evidence in those cases, and their work has sometimes led to improvements in modern forensic analysis.

In ancient times, legal systems and procedures were not standardized; they functioned distinctly in diverse locales and during various periods. Biblical accounts, particularly in the Old Testament, depict many crimes, beginning with Cain's killing of Abel. Ancient historians, including Herodotus (c. 484-425 B.C.E.) and Tacitus (c. 56-120 C.E.), recorded incidents of crime based on anecdotes they heard from contemporaries. The historical veracity of many of these accounts is questionable, however. Information regarding ancient crimes is often inconsistent, vague, and greatly distanced from eyewitnesses. Biased chroniclers often excluded information that countered their own beliefs or those of their patrons or incorporated incorrect details. In addition, wars and other disasters led to the loss of records that described crimes.

Ancient Laws

The crimes committed in the ancient world were similar to the malicious actions humans have pursued in all eras. Ancient people robbed, raped, abducted, and murdered much as modern people do, prompted by greed, revenge, and other motives. Rulers shaped most early laws to define crimes and establish punishments. The first known law code was issued by Hammurabi during his reign as king of Babylon, from approximately 1792 to 1750 B.C.E. The behaviors defined as crimes in ancient times were those that violated the moral and social beliefs valued by the leaders who made the laws; these behaviors were often directed against royalty, governments, or temples, and they had negative impacts on communities. People were often considered criminal for disobeying rules and customs, especially those related to religious practices, as ancient theology and politics were often linked. Many ancient people perceived blasphemy to be a criminal activity.

Laws in particular areas changed as the ruling powers changed with invasions and wars, and the laws that were enforced varied depending on rulers' agendas, attitudes, and tolerance for criminality. Ancient philosophers, including Aristotle (384-322 B.C.E.) and Plato (c. 427-347 B.C.E.), contemplated the role of crime and punishment in societies and the need for justice. The punishments for criminal behavior in ancient times included seizure of property, imprisonment, forced labor, mutilation, exile, and execution. Individuals usually dealt with personal crimes, such as embezzlement and extortion, by seeking compensation.

Just as the laws varied, the courts of the ancient world operated differently in different places and times. Most of the courts of ancient Rome were conducted by praetors, or magistrates, who chose the cases that would be heard. Juries came to decisions of acquittal, condemnation, or not proven after hearing cases in which alleged criminals were pitted against their accusers; in these courts, oratorical evidence was offered and witnesses testified. In ancient Greek courts, citizen juries, often consisting of several hundred men, ruled on the cases presented; both prosecutors and defenders in these cases used oratory rather than evidence to sway jurors' decisions.

Murder

Ancient people committed homicide for many of the same reasons modern people do. Some murders were intentional, committed out of jealousy, rage, or vengeance; others were the unintentional result of other crimes, such as theft or assault. Assassinations of rulers occurred frequently throughout ancient history. Although most of the homicides that took place in ancient times remain anonymous, at least one is widely known in the modern world: the assassination of the Roman ruler Julius Caesar (100-44 B.C.E.), whose political actions provoked his rivals to conspire to kill him.

After he attained power in 49 B.C.E., Caesar instituted reforms that outraged his enemies, who feared losing the power and prestige that had been accorded their families for generations. On March 15, 44 B.C.E., Caesar went to the Theatre of Pompey, where the Roman senate was meeting. A group of senators led by Marcus Junius Brutus swarmed around Caesar and slashed him with knives. A physician who later examined Caesar's corpse noted that he had twenty-three stab wounds. Roman officials ordered that Caesar's assassins be apprehended and slain.

Other notorious ancient assassinations targeted Roman and Egyptian leaders. On September 18, 96 C.E., Roman emperor Domitian was assassinated. Tired of Domitian's oppression, his chamberlain had devised a plot against him, involving Domitian's guards as accomplices. A steward named Stephanus fatally stabbed Domitian, whose supporters avenged his death by killing the assassins. In ancient Egypt, women living in the pharaoh's harem plotted to remove Ramses III from power in 1153 B.C.E. A judicial papyrus dating from that time indicates that numerous people were arrested for actions related to the crime, of whom twenty-four were declared guilty and probably executed.

Poisoning

During ancient times, scientific techniques to detect poisons in bodies were nonexistent. This inability to trace toxins to fatalities benefited many people who relied on poisoning as the most effective method of eliminating enemies and rivals. Ancient poisoners derived toxins from organic sources, both plants and animal venoms, to contaminate food and drink or create deadly lotions. Arsenic, which was used to season foods and was incorporated in pharmaceuticals, proved lethal when concentrated in bodily tissues.

Among the notorious poisoners in ancient Rome (around 74 B.C.E.) was a man named Oppianicus, whose criminal acts included poisoning but failing to kill Cluentius, whose stepfather Oppianicus had killed so he could marry Cluentius's mother, Sassia. Oppianicus schemed to acquire Cluentius's belongings, which his mother would inherit after his death. At Oppianicus's trial for attempting to kill Cluentius, his defense tried to discredit Cluentius by claiming that Cluentius had bribed judges. The tactic did not work, and Oppianicus was exiled. Sassia and Cluentius's sister later sought prosecution of Cluentius for allegedly attempting to poison Oppianicus, and Cluentius was acquitted. When Oppianicus was subsequently murdered, Cluentius, who was accused of the crime, benefited from the defense oratory of Roman statesman and philosopher Cicero. Cicero's strategy was not to stress Cluentius's innocence but to focus on the crimes Oppianicus had committed to suggest that his death was justified. Cicero's persuasive statements resulted in Cluentius's exoneration.

Another ancient Roman poisoner, Locusta, was so well-known for her herbal expertise that prominent Romans sought her out for her poisoning services. Her influential clients included the wife of Emperor Claudius (10 B.C.E.-54 C.E.), Agrippina the Younger, who schemed for her son from an earlier marriage, Nero, to succeed Claudius as emperor rather than Britannicus, Claudius's son by a previous wife. Deciding to kill Claudius first, Agrippina contacted Locusta, who served Claudius a meal containing poisonous mushrooms. The physician who attended Claudius when he became ill was allied with Agrippina; he gave the emperor a poisonous enema, ensuring his death. Although Locusta was incarcerated for that murder, Nero, the new emperor, released her so that she could kill Britannicus with tainted wine.

Theft and Civic Crimes

Theft was a common crime in ancient communities. Thieves picked pockets, stole goods from markets and homes, and embezzled. Papyrus records from ancient Egypt describe such notable heists as the Great Tomb Robbery. Royal tombs at Thebes were particularly vulnerable to robbery. Some corrupt officials aided thieves or stole from religious and royal sites. Records describe the plundering of the Karnak temple complex by a guard.

An example of the view of some ideas as criminal according to ancient law is found in the trial of the philosopher Socrates (470-399 B.C.E.) in Athens. Many ancient communities deemed behavior that ignored or denounced tradition as criminal. Trials contemplated whether people should be punished for such sacrilegious acts as vandalizing statues related to gods. In 399 B.C.E., three prominent citizens of Athens—a poet, an artisan, and a politician—initiated prosecution against Socrates, asserting that his crime was suggesting that people reject the city's gods. Also, Socrates had prompted Athenians, particularly young men, to examine their leaders' rules and conduct critically.

Because of his views, Socrates had alienated many Athenians who considered his behavior criminal and sought his conviction. Some people despised Socrates for criticizing their professions and demeaning them personally. A group of 280 jurors, out of a jury of approximately 500 men, declared Socrates guilty and sentenced him to death. They stressed that Socrates had endangered Athenians with his erratic religious views and his arguments that citizens should scrutinize their leaders. Socrates carried out his own execution by consuming hemlock.

Zahi Hawass, head of the Egyptian Supreme Council for Antiquities, oversees a computed tomography (CT) scan of the mummy of King Tutankhamen in an attempt to learn more about how the young pharaoh died. *(AP/Wide World Photos)*

Death of Tutankhamen

The mysterious death of Eighteenth Dynasty Egyptian pharaoh Tutankhamen has intrigued people since Howard Carter and his archaeological team located the tomb of the "boy king" in 1922. The objects in the tomb, including the pharaoh's mummy, provoked speculation regarding why and how Tutankhamen died in 1323 B.C.E. at the age of eighteen. The tomb's small size and arrangement were inconsistent with the stature accorded to other royal figures, suggesting that Tutankhamen's death was unexpected and required expeditious arrangements. In addition to suggesting that Tutankhamen may have succumbed to illness, archaeologists and historians have speculated that he may have been the victim of assassination by a rival.

For several decades, scientists lacked sufficiently effective forensic methods and tools to evaluate hypotheses regarding Tutankhamen's premature demise. In 1968, Ronald Harrison, head of the Anatomy Department at the University of Liverpool, X-rayed Tutankhamen's mummy. He noted damage to the skull that suggested the pharaoh may have sustained a violent blow to the head. Harrison also observed that some of Tutankhamen's ribs and his breastbone were absent. Murder theorists identified four people who might have slain Tutankhamen to seize power: his adviser Ay, who became the next pharaoh; army commander Horemheb, who succeeded Ay and purged monuments of Tutankhamen references; his treasurer, Maya; or his wife, Ankhesenamun.

Investigation and speculation regarding Tutankhamen's death continued, and in January, 2005, Zahi Hawass, Egypt's chief archaeol-

A researcher at the South Tyrol Museum of Archaeology prepares to take samples from the corpse known as Ötzi the Iceman. Scientists have determined that the body is more than five thousand years old. *(AP/Wide World Photos)*

ogist, oversaw a full digital evaluation of Tutankhamen's mummy through the use of a computed tomography (CT) scan. The approximately seventeen hundred images generated in the scan indicated that the pharaoh had been healthy and probably had not suffered fatal trauma, intensifying the mystery regarding his death. The scan revealed a fractured left femur (thighbone), causing scientists to ponder whether the bone had been broken before or after the pharaoh died. Many forensic experts interpreted the evidence provided by the CT scan as proof that Tutankhamen was probably not murdered, but many scientists have continued to seek definitive information that can point to the exact cause of his death.

Unresolved Cases

Several ancient murders have intrigued modern forensic investigators, some of whom have applied their techniques, tools, and knowledge to efforts to understand what happened. Discoveries of the preserved corpses of ancient persons, such as Kennewick man, discovered in the Pacific Northwest in 1996, and related artifacts have allowed scientists to gain insights into ancient lifestyles and communities. Although forensic methods have helped scientists to develop plausible interpretations regarding specific ancient bodies, in cases where they have suspected murder they have been unable to learn conclusively why particular individuals died or who might have killed them. Those crimes remain mysteries, although each advancement in forensic science offers continuing hope for resolution.

In September, 1991, mountain climbers found a frozen male corpse on a glacier in the Ötztal Alps near the border between Austria and Italy. When the clothing on the body and items adjacent to it were examined, the authorities realized the remains were ancient. The corpse, which later became known as Ötzi the Iceman, and the objects found with it were shipped to Innsbruck, Austria, where they were evaluated at the Forensic Medical Institute by Konrad Spindler, an archaeologist. Radiocarbon dating indicated that the remains were approximately 5,300 years old.

Scientists employed numerous methods, including CT scans, in attempting to solve the mystery of Ötzi's demise and whether it was criminal or accidental. In 1998, Ötzi was transported to Bolzano, Italy, where forensic pathologist Peter Vanezis studied the skull and performed a facial reconstruction. During June, 2001, Paul Gostner, a radiologist at Bolzano General Hospital, X-rayed the body and found that an arrowhead was lodged in Ötzi's shoulder. Stating that Ötzi had been murdered, forensic experts suggested various ways in which the death might have taken place. Some speculated that Ötzi may have been killed during warfare, that he may have been the victim of rival hunters, or that he may have been a human sacrifice.

Similarly preserved ancient bodies found in northern Europe have also stimulated forensic analysis. Bodies immersed in peat bogs for centuries have retained evidence useful for forensic examination. Investigators have hypothesized that the so-called bog bodies were those of ancient murder victims, people whose lives were sacrificed to gods, or executed criminals. Radiometric dating has shown that some of those found in the bogs lived during the British Iron Age (seventh century B.C.E. to fifth century B.C.E.). Forensic scientists have evaluated their garments, wounds, and physical characteristics using techniques similar to those employed in the assessment of Ötzi. The evidence they have found, including fingerprints and preserved injuries, indicates that many of these ancient people met violent deaths—strangled with ropes, drowned, stabbed, or decapitated.

Profiting from Ancient Crimes

The appeal of enigmatic ancient crimes, particularly mysteries associated with royalty, has abetted criminal activity in later centuries. Obscure information regarding historic individuals has often enabled criminals to carry out fraudulent schemes involving the deception of antiquities collectors.

In October, 2000, for example, information accompanying a mummy that was seized from the dwelling of a Karachi, Pakistan, chieftain stated that the remains were those of Rhodugune, young daughter of Persian king Xerxes I, who had lived in the fifth century B.C.E. Investigators noted the sloppy mummification procedures evidenced by the body and the odd usage of the Greek version of the princess's Persian name, Wardegauna. Scientists conducted X-ray and CT scans of the mummy at Pakistan's National Museum, and the results, along with further forensic examination, revealed that the mummy, although unusually short, was that of an adult woman in her twenties, not a child, and radiocarbon dating revealed she had died in 1996. Given that the woman's spine was fractured, authorities feared she had been murdered by people engaged in the marketing of counterfeit ancient mummies.

Elizabeth D. Schafer

Further Reading

Emsley, John. *The Elements of Murder: A History of Poison*. New York: Oxford University Press, 2005. Presents details about how killers have used poisons throughout history. Features chapters on arsenic, lead, and other toxins.

Hawass, Zahi. *Tutankhamun: The Mystery of the Boy King*. Washington, D.C.: National Geographic Society, 2005. Egyptian archaeologist describes his experiences with forensic investigations regarding Tutankhamen's death. Features CT images.

Redford, Susan. *The Harem Conspiracy: The Murder of Ramesses III*. De Kalb: Northern Illinois University Press, 2002. Archaeologist describes the women who plotted to kill the Egyptian king and their motivations based on temple and papyri resources.

Wilson, Emily. *The Death of Socrates*. Cambridge, Mass.: Harvard University Press, 2007. Examines how Socrates' ideas were considered criminal in ancient Athens and how the philosopher's trial and execution influenced thought and culture.

Woolf, Greg. *Et Tu, Brute? The Murder of*

Caesar and Political Assassination. Cambridge, Mass.: Harvard University Press, 2007. Presents comprehensive discussion of Caesar's death and the role of assassins in ancient history. Includes photographs of artifacts and artworks that portray the crime and its participants.

See also: Ancient science and forensics; Arsenic; Art forgery; Assassination; Food poisoning; Forensic archaeology; Homicide; Kennewick man; Knife wounds; Mummification; Peruvian Ice Maiden.

Ancient science and forensics

Significance: Although ancient scientific techniques lacked the sophistication of modern forensic methods, individual examples of people applying science and technology to legal issues foreshadowed some of the basic concepts that forensic scientists recognized and developed centuries later.

The introduction of scientifically collected and examined evidence in legal proceedings is a relatively modern development. In ancient times, evidence presented in legal proceedings was generally limited to the oral arguments that prosecutors and defenders presented in courts. No concept of "forensic science" existed. Prosecutors and defenders relied primarily on words to convince officials and juries of the correctness of their cases. Most ancient legal personnel did not consider seeking such evidence as fibers, fingerprints, and hair or have techniques to evaluate them.

The levels to which the hard sciences were developed varied among different ancient civilizations. Scientists typically shaped their pursuits to please patrons and rulers. Many people associated science with superstitions and magic, especially with the ancient world's fascination with the pseudoscience of alchemy, which sought to transform other elements into gold. Religious beliefs frequently influenced ancient science. Nevertheless, some people did pursue science for practical reasons, such as measuring land.

Before Forensic Science

The absence of standardized forensic science practices throughout the ancient world aided criminals in escaping punishment. Without the input of scientifically collected and examined evidence, criminal investigations typically relied on force to secure confessions from suspects. In court trials, the only evidence that was usually considered was the testimonies of witnesses and the arguments of prosecutors and defenders. In rare instances, descriptions of the symptoms displayed by victims of poisoning or the physical damage inflicted by assaults might be presented.

As scientific knowledge expanded, some people began applying common sense to evident connections between physical evidence and crimes. Some records of ancient legal proceedings include records of practices that resemble modern forensic techniques. However, many people were probably unaware of the scientific bases behind their methods. They tended to rely on common sense and practical approaches to solving problems related to problems they considered criminal or threatening. For example, a passage in the Bible's book of Judges describes a technique foreshadowing modern voice identification. Jephthah insisted people say the word *shibboleth* so he could identify his allies and detect enemy Ephraimites who pronounced the word differently. Originating in this passage in the Bible, the ancient Hebrew word for stream, *shibboleth*, came to be used in English as a word or saying that might be used as a kind of password for a group while lacking any true meaning.

Forensic Foreshadowing

Some early forensic scientific methods were based on accidental discoveries, or epiphanies, achieved while pursuing solutions to other problems. For example, the third century B.C.E. Greek mathematician and inventor Archimedes was challenged to prove that a goldsmith had cheated King Hieron II of Syracuse by mixing inferior metals with the pure gold he had been given to make a crown for the king. Archimedes' investigation was constrained by the requirement that he not damage the royal crown in any way. According to legend, while Archimedes was taking a bath, he noticed that his body displaced an amount of water equal to his own weight. Drawing on that observation, he submerged both King Hieron's crown and an amount of gold equivalent to what the goldsmith was supposed to have used for the crown in water. When he determined than the crown displaced less water than the control sample, he proved that the goldsmith had committed fraud.

Poisons had a special fascination for ancient scientists. However, physicians had a difficult time proving that apparent victims of poisoning crimes were actually poisoned, as the symptoms of poisoning and natural seizures were similar. Their attempts to devise methods to prove victims had been poisoned were simplistic compared to later toxicology developments. Around 200 B.C.E., the Middle Eastern physician and poet Nicander of Colophon studied poisons and their antidotes and wrote two books on the subject. *Alexipharmaca* describes many types of poisonings by animals, plants, and inanimate agents and suggests antidotes and other treatments. *Theriaca* deals more narrowly with poisonings caused by animal bites, stings, and scratches. Nicander had a strong reputation during his time, but his books were not published in print until 1499, when a joint edition appeared in Venice.

The modern forensic science of odontology, which is used to identify bodies of victims by their teeth, has at least one ancient precursor. In 49 C.E., the Roman emperor Nero's mother, Agrippina, sent for the head of her enemy Lollia Paulina after the woman reportedly committed suicide so that Agrippina could verify her death. The dead woman's face was distorted beyond easy recognition, but when Agrippina looked at the teeth in the head, she recognized a distinctively colored front tooth that she had previously noticed in Lollia Paulina's mouth.

Voice Identification in the Bible

These verses from the Bible's book of Judges describe a technique that might be viewed as foreshadowing modern voice identification:

12:4 Then Jephthah gathered together all the men of Gilead, and fought with Ephraim: and the men of Gilead smote Ephraim, because they said, Ye Gileadites are fugitives of Ephraim among the Ephraimites, and among the Manassites.

12:5 And the Gileadites took the passages of Jordan before the Ephraimites: and it was so that when those Ephraimites which were escaped said, Let me go over; that the men of Gilead said unto him, Art thou an Ephraimite? If he said, Nay;

12:6 Then said they unto him, Say now Shibboleth: and he said Sibboleth: for he could not frame to pronounce it right. Then they took him, and slew him at the passages of Jordan: and there fell at that time of the Ephraimites forty and two thousand.

Detecting Fraud

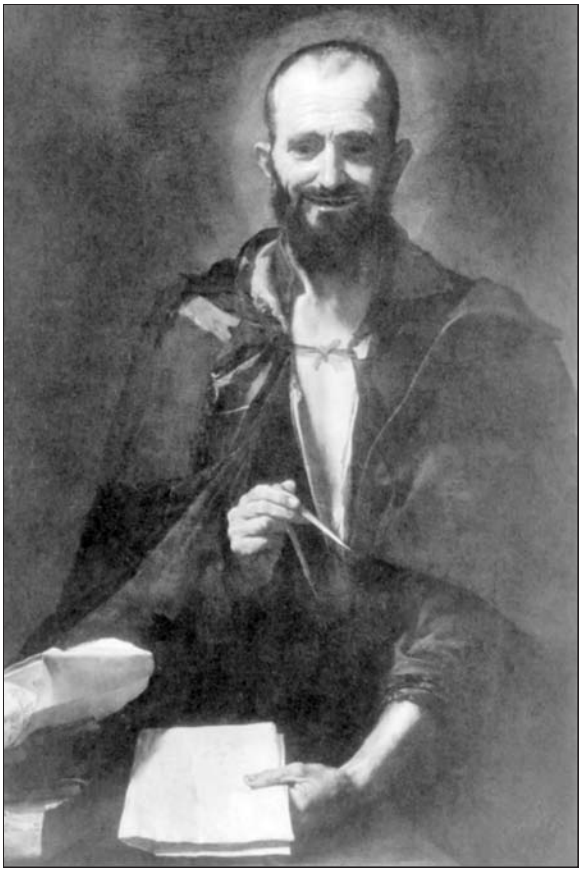
Documents were frequently forged in ancient times, when most people were illiterate, so government officials sought effective methods to detect fraudulent wills, deeds, and contracts. In ancient Rome, legal officials used people considered to be experts in handwriting analysis to evaluate documents by comparing writing styles of known and suspect scribes

Seeking ways to detect lies, some ancients created primitive polygraph techniques. In contrast to modern polygraphs, which measure physiological responses, the techniques of the ancients were based solely on observations of the suspects' behavior, even though psychology was not yet an established scientific field. For example, around 500 B.C.E., priests in India tested people accused of thievery by placing them in darkened tents with donkeys whose tails were coated in soot. The priests would tell the suspected thieves to tug the animals' tails because the donkeys would bray when touched by thieves. Suspects who left the tents with their hands unsoiled by soot were considered guilty. Ancient Arabs conducted similar tests using grease instead of soot on the animals' tails.

Ancient Chinese officials devised a different kind of lie-detecting test. They placed dried rice in the mouths of criminal suspects, whom they told to spit out the grains. Suspects with rice still sticking on their tongues were exposed as liars. This test actually had some scientific validity, as human bodies often respond to stress by being unable to produce the saliva necessary to spit. Because guilty suspects were more likely than the innocent to feel stress, they were less likely to be able to spit the rice out of their mouths.

Prints

Throughout human history, every individual person has had fingerprints, palm prints, and footprints that are unique. These prints have always offered the potential for identifying criminal suspects but had to wait for a time when their forensic value was understood. The ancients were aware that the lines on their palms and fingertips formed distinct patterns and may have even recognized that those patterns were unique. However, they did not comprehend how prints left on objects could be used to identify criminal who touched things such as murder weapons and stolen items. They used fingerprints primarily to identify objects and documents, not for criminal investigations. Various hand and fingerprints were used for signatures that were recognized in courts and business dealings. In Babylonia, for example, fingerprints were used to mark tablets related to business activities at least as early as 2000 B.C.E. In East Asia, ancient Chinese and Japanese officials and traders used thumbprints to distinguish legal seals and documents, and handprints were often used to sign divorce documents.



Portrait of the ancient Greek mathematician Archimedes by the early seventeenth century Spanish painter Jusepe de Ribera. All depictions of Archimedes are fanciful, as no contemporary pictures or sculptures of him are known to exist. *(Library of Congress)*

A court case in which print evidence did prove significant occurred in Rome during the first century C.E., when a Roman attorney named Quintilian defended a man accused of killing his mother. A talented speaker, Quintilian combined his oratorical skills with some scientific knowledge to build his legal strategy. He showed that a bloody palm print that had dried at the site of the murder was not compatible in size with the hand of his client. He went on to argue that the print had been placed at the crime scene by someone who wished to frame the murdered woman's son. Thanks to his comparison of handprints, he won his client's acquittal; however, the true murderer was never identified.

Medical Evidence

Many ancient rulers and physicians recognized the importance of medical knowledge to legal systems. The eighteenth century B.C.E. Babylonian king Hammurabi included laws relevant to medicine in the famous law code that he formulated. The early fourth century B.C.E. Greek physician Hippocrates recommended that medical practitioners learn how to recognize injuries and poisonings inflicted by criminal assailants.

Ancient physicians were often involved in investigations of crimes because of their specialized knowledge and their connections with rulers and officials. Medical autopsies go back at least as far as the early third millennium B.C.E. As in modern times, they were performed to determine causes of deaths. However, members of many ancient societies opposed invasive examinations of dead people because they believed that bodies had to be intact for their transition to the afterlife.

The word "autopsy" itself comes from ancient Greek, in which it means seeing with one's own eyes, even though the ancient Greeks seldom performed autopsies. During the third century B.C.E., the Greek physicians Erasistratus and Herophilus of Chalcedon performed autopsies in Alexandria, Egypt, and may have explored how evidence of poisoning and injuries were linked to crimes.

Perhaps the most notable autopsy in ancient history was that of the Roman ruler Julius Caesar, who was stabbed to death by assassins on March 15, 44 B.C.E., at the Forum of Rome. The physician who afterward examined Caesar's body reported to Roman officials that the second stab wound Caesar received was the fatal one. The word "forensic" comes from the Latin word *forum*. Some historians believe that the connection between the two words goes back to the autopsy performed after Caesar was killed at the Roman Forum.

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Further Reading

Evans, Colin. *Murder Two: The Second Casebook of Forensic Detection*. New York: John Wiley & Sons, 2004. Discusses ancient efforts to detect liars, identify corpses, and determine cause of death through methods with scientific elements.

Gagarin, Michael. *Antiphon the Athenian: Oratory, Law, and Justice in the Age of the Sophists*. Austin: University of Texas Press, 2002. Provides examples of the forensic speeches, not scientific evidence, that ancient Greeks used strategically to win in court.

Ramsland, Katherine. *Beating the Devil's Game: A History of Forensic Science and Criminal Investigation*. New York: Berkley Books, 2007. Discusses several significant uses of science in ancient Greek and Roman legal settings.

Ricciuti, Edward. *Science 101: Forensics*. New York: HarperCollins, 2007. Illustrations and text highlight early forensic precursors by ancient peoples, placing those achievements in context with later developments.

Riggsby, Andrew M. *Crime and Community in Ciceronian Rome*. Austin: University of Texas Press, 1999. Describes court procedures and verdict options for various ancient crimes. Explains that oratory was the primary evidence utilized.

See also: Ancient criminal cases and mysteries; Autopsies; Crime scene investigation; Document examination; Epidemiology; Forensic odontology; Forgery; Handwriting analysis; Knife wounds; Medicine; Poisons and antidotes; Ritual killing.

Animal evidence

Definition: Organic materials from nonhumans, excluding insects, analyzed by forensic scientists for use in legal cases.

Significance: With advancements in DNA fingerprinting of dogs, cats, and other domesticated and wild animals, animal evidence has become much more useful in criminal and civil court cases than it was in the past, when individual animals, breeds or even species could not be identified.

The animal evidence involved in cases of crimes against humans most often consists of shed hairs and traces of blood, other body fluids (including saliva and urine), and excrement from either dogs or cats. Given that in the United States about 40 percent of households include at least one dog and 30 percent include at least one cat, crime scene investigators frequently encounter this kind of evidence.

Animal Hair

In relation to crimes against humans, the most commonly analyzed type of animal evidence is shed hair. Research has shown that it is almost impossible for a person to enter a house where a dog or cat lives and not have some of the animal's hair transferred to his or her skin, shoes, or clothing. Criminal perpetrators who live with dogs or cats can thus transfer the hair of their animals to victims or crime scenes. Perpetrators can also pick up animal hairs from crime scenes, from victims' clothing, from household items, or directly from victims' pets.

In 1994, white hairs from a cat named Snowball were used to help convict a Canadian man of murdering his wife. Police investigators found the hairs on the husband's black leather jacket. This was the first evidentiary use of nonhuman DNA (deoxyribonucleic acid) to help solve a crime. In this case, the DNA analysis used feline microsatellite markers mapped by English geneticist Alec Jeffreys. Scientists have concluded that both feline and canine microsatellite markers are almost as discriminating as their human counterparts, not very much diminished by the inbreeding often seen in canines.

Because shed hair lacks a viable root, it usually does not contain enough nuclear DNA to allow short tandem repeat (STR, or microsatellite) fingerprinting of individuals. Instead, criminalists extract and amplify mitochondrial DNA (mtDNA) from the hair shaft, which contains thousands of mitochondria. This type of DNA identification of dogs and cats is most often used to add a layer of evidence rather than to provide a strong association to a particular animal, given that only a single locus is used for mtDNA profiling. In 2002, however, canine mtDNA was admitted into court during the prosecution of David Westerfield in the abduction and murder of seven-year-old Danielle van Dam, whose family owned a pet Weimaraner. This was the first trial in the U.S. to admit canine mtDNA analysis as evidence.

Forensic scientists also analyze the morphological (structural) characteristics of animal hair using compound light microscopy. Characteristic patterns of scales on the cuticle covering the shaft, for example, can be used to determine a particular species. Also, the medulla inside the shaft is informative for the identification of different species; for instance, the medullae of feline hairs show a typical "string of pearls" pattern. These features, among others, are usually used in conjunction with DNA profiling to identify particular animals.

Other Types of Animal Evidence

Animal blood found at crime scenes usually contains enough viable nuclear DNA for STR analysis, which can be used to identify an individual animal. As early as 1998, STRs obtained from dried canine blood linked a suspect to the murder of a Seattle couple and the killing of their dog. Although the suspect was convicted, the canine DNA evidence was not admitted at trial because canine DNA typing was not considered reliable at the time. Since then, the reliability of canine and feline STR profiling has been well established in the scientific literature, and dog and cat DNA evidence is regularly admitted in legal proceedings.

Both urine and excrement from dogs have also provided nuclear DNA to help solve crimes and convict criminals. One example of using DNA from animal fecal matter outside the legal justice system is the identification of the Canadian lynx from scat found near the large cat's paw prints in snow. This technique is being investigated as a way to track the health, distribution, and population densities of certain endangered animal species.

The National Fish and Wildlife Forensics Laboratory in Ashland, Oregon, is dedicated to the collection and analysis of evidence of crimes against wildlife. Law-enforcement agencies submit to the lab the types of animal evidence discussed above in addition to more unusual samples, such as hunting trophies (antlers), carved ivory, hides, furs, bones, teeth, leather goods, feathers, claws, talons, whole carcasses, stomach contents, and Asian medicinals, among other organic and inorganic materials usually investigated in criminal cases. Forensic experts at the facility extract and profile DNA from many of these items; they also employ other methodologies such as morphological and chemical analysis to determine whether samples come from particular species. Much of this work is concerned with supporting law-enforcement efforts to address crimes involving endangered species.

The emerging field of veterinary forensics is involved in identifying cases of animal abuse against domestic pets. In situations where abuse is suspected, veterinarians or veterinary pathologists most often obtain evidence from deceased whole animals, which are worked up in a manner similar to that employed during autopsies in homicide cases. These professionals look for specific patterns of injuries, telltale wounds, bullet holes, ballistic material, evidence of malnutrition or starvation, signs of torture, and incriminating human evidence (such as blood or hairs). Sometimes insects and maggots found on or in proximity to an animal carcass can be employed to determine the time of death or crime scene location.

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Further Reading

Cassidy, Brandt G., and Robert A. Gonzales. "DNA Testing in Animal Forensics." *Journal of Wildlife Management* 69 (October, 2005): 1454-1462. Discusses how animal DNA is being used to solve human crimes. Gives examples from specific legal cases and notes the potential pitfalls related to DNA processing and collection methods.

Cooper, John E., and Margaret E. Cooper. *Introduction to Veterinary and Comparative Forensic Medicine*. Ames, Iowa: Blackwell, 2007. Includes discussion of wildlife conservation and links between cruelty to animals and violence toward humans. Intended for veterinarians and law-enforcement officials but written at a level understandable by interested laypersons.

Dorion, Robert B. J., ed. *Bitemark Evidence*. New York: Marcel Dekker, 2005. Comprehensive collection of essays on all aspects of the study of human and animal bite marks. Well illustrated.

Merck, Melinda D. *Veterinary Forensics: Animal Cruelty Investigations*. Ames, Iowa: Blackwell, 2007. Readable work discusses the handling of suspected animal cruelty cases.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007. Classic introductory text includes discussion of animal-related evidence.

See also: Biological terrorism; Bite-mark analysis; Canine substance detection; Crime scene investigation; DNA analysis; DNA banks for endangered animals; Evidence processing; Forensic entomology; Hair analysis; Mad cow disease investigation; Trace and transfer evidence; Wildlife forensics.

Antemortem injuries

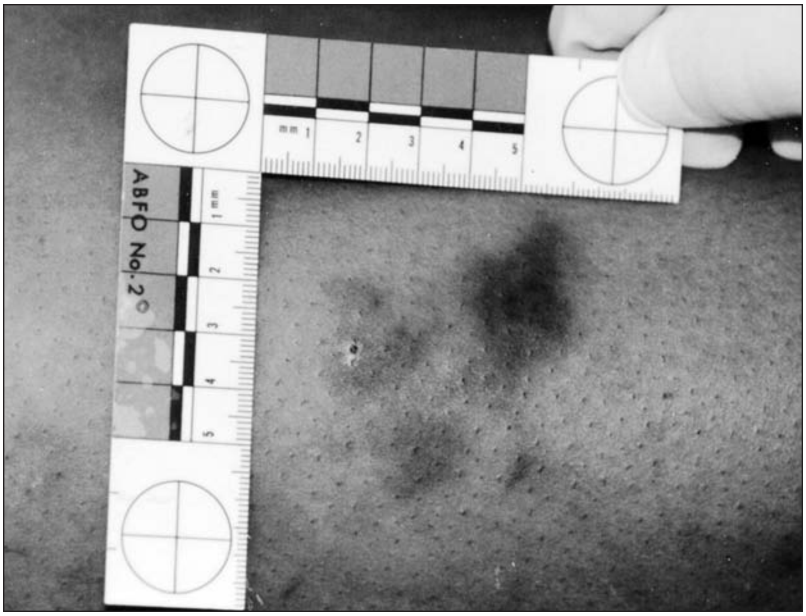
Definition: Injuries received before death.

Significance: In a death investigation, it is important to determine which injuries the person sustained before death as opposed to any injuries that occurred to the body postmortem (after death) because antemortem injuries may indicate the cause of death or factors that contributed to the death.

To determine cause of death accurately, a pathologist must distinguish between the injuries to a body that were received before death and those that were received after death. The pathologist must also determine whether the body shows evidence of any injuries that occurred well before death. The most difficult determination to make involves which injuries were received immediately prior to death and which occurred immediately after death.

One significant difference between antemortem and postmortem injuries is in the ways in which the wounds have bled or bruised. It is possible for bleeding to occur after death, and, depending on the type of death, it is possible for bruising or pooling of the blood to occur postmortem, but a pathologist can generally tell by the way a wound has bled or bruised whether it is an antemortem injury.

A pathologist also looks at the type of tissue damage associated with injuries to determine when the injuries occurred. Tissues from antemortem injuries contain leukotriene B4, which living tissues produce in a chemical response to inflammation. Tissues that have been damaged by postmortem injuries do not contain this chemical. This information provides another



Measurement of bruises on a corpse during an autopsy examination. *(Custom Medical Stock Photo)*

way for the pathologist to determine exactly when injuries occurred.

In a case in which the body has been in water, the pathologist examines lung tissue to determine whether the person drowned or the body was put into the water after death. This tissue can show signs of whether the person struggled to breathe and began coughing before death or whether the lungs simply filled with water after death had already occurred.

The pathologist must also determine which antemortem injuries were the cause of the death as opposed to injuries that may have been received days, months, or even years before the death occurred. To do this, the pathologist looks for evidence of healing, such as wounds that have begun to close or bones that have begun to knit together, to eliminate those injuries as factors contributing to the death. Such older injuries can be significant clues in the determination of cause of death. For example, in cases of deaths resulting from child abuse or domestic violence, bodies may evidence many injuries in various states of the healing process, showing a pattern that can help investigators establish the history of abuse. This pattern may also occur in victims who were tortured before death.

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Further Reading

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005.

Shkrum, Michael J., and David A. Ramsay. *Forensic Pathology of Trauma: Common Problems for the Pathologist*. Totowa, N.J.: Humana Press, 2007.

Timmermans, Stefan. *Postmortem: How Medical Examiners Explain Suspicious Deaths*. Chicago: University of Chicago Press, 2006.

See also: Autopsies; Blunt force trauma; Body farms; Defensive wounds; Forensic anthropology; Forensic pathology; Forensic sculpture; Living forensics; Oral autopsy; Osteology and skeletal radiology.

Anthrax

Definition: Deadly disease caused by the soil bacterium *Bacillus anthracis*.

Significance: Because anthrax is capable of debilitating and killing people and animals quickly, it is an attractive agent for use in biological warfare. The abilities to detect, treat, and neutralize anthrax efficiently are thus necessary to ensure public safety.

The bacterium *Bacillus anthracis* resides in soil, and, like other members of the bacterial genus *Bacillus*, can make a highly resistant resting cell known as an endospore. Endospores can withstand heat, desiccation, harsh chemicals, and ultraviolet radiation and can last in soils for centuries. Anthrax, the disease caused by *B. anthracis*, afflicts herbivorous animals, but human anthrax infections result from contact with infected animals or animal products.

Types of Anthrax Infections

Anthrax is caused by the inhalation or ingestion of *B. anthracis* endospores or, in the case of cutaneous anthrax, by contact between damaged skin and *B. anthracis*. Inhalation of endospores causes inhalation anthrax, which typically occurs among workers in textile or tanning industries who handle contaminated animal products such as wool, hair, and hides. The incubation period of inhalation anthrax ranges from one to six days, and the disease follows a two-stage progression. After infection, the patient develops a dry cough, muscle weakness, tiredness, fever, and pressure in the middle of the chest. The second stage begins with the onset of respiratory distress and typically culminates in death within twenty-four hours. Inhalation anthrax has a mortality rate of 95 percent if untreated.

Gastrointestinal anthrax results from the ingestion of undercooked, contaminated meat. Two to seven days after ingestion, abdominal pain and fever occur, followed by vomiting, nausea, and diarrhea. Gastrointestinal bleeding is observed in some severe cases, and dissemination of the disease throughout the body also results. Fluid loss can result in shock and kidney failure. Approximately 50 percent of cases of gastrointestinal anthrax are lethal.

Cutaneous anthrax results from invasion of the skin by *B. anthracis*. If the skin is damaged by scrapes, cuts, or insect bites, endospores can breach the outer layers of the skin and infect it. After an incubation period of two to five days, small solid and conical elevations of the skin devoid of pus called papules form; these papules then swell, rupture, and blacken. Without treatment, anthrax skin infections can disseminate to other systems, and death occurs about 20 percent of the time.

Detection of Anthrax

Growing *B. anthracis* from a blood sample is the best way to demonstrate an anthrax infection in patients who have not yet been given antibiotics. In patients who have begun antibiotic therapy, serological methods that detect antibodies made by the immune system against the bacterium are efficacious. Blood samples from a person who has died from anthrax should yield copious quantities of relatively large, rod-shaped bacteria that are encapsulated and easily visualized with polychrome methylene blue stains.

Automated detection systems (ADS's) can determine whether *B. anthracis* endospores have been released into a setting. The BSM-2000 (Universal Detection Technology), for example, continuously samples the air and heats it. Captured, heated spores release dipicolinic acid (DPA), a compound unique to bacterial endospores. DPA binds to terbium ions (Tb^{3+}), which, together, fluoresce green under ultraviolet light. Other ADS's use polymerase chain reaction (PCR) to test the air for DNA (deoxyribonucleic acid) sequences specific to *B. anthracis*.

Treatment and Prevention of Anthrax

Several antibiotics are effective in the treatment of anthrax infections. High-dose intravenous penicillin G, ciprofloxacin, and doxycycline are typically quite effective. Preventive treatments with oral ciprofloxacin or doxycycline for six weeks are also effective. Anyone exposed to anthrax should begin treatment immediately because the disease can become untreatable with the passage of time.

BioThrax (made by Bioport Corporation) is a vaccine against anthrax. It consists of an extract prepared from a non-disease-causing strain of *B. anthracis*. It is administered as three inoculations given under the skin at two-week intervals, followed by booster injections at six, twelve, and eighteen months, after which yearly boosters are necessary to maintain immunity. BioThrax vaccinations are 93 percent effective in preventing anthrax infections.

When bodies or clothes are contaminated with *B. anthracis* endospores, personal contact can spread the disease. Washing with antibacterial soap and water and treating the wastewater with bleach can rid contaminated bodies of all endospores. Burning contaminated clothing and the corpses of those who have died from anthrax is an effective means of liquidating anthrax from the environment. Burial does not kill endospores. Endospores of *B. anthracis* released into the air are easily removed by means of high-efficiency particulate air (HEPA) or P100 filters.

Decontamination of areas that have been exposed to *B. anthracis* presents several challenges because the bacterial endospores are rather difficult to destroy. Ethylene oxide, chlorine dioxide, liquid bleach, and a decontamination foam created by Sandia National Laboratories kill *B. anthracis* endospores slowly. A cleanup method approved by the Environmental Protection Agency (EPA) that utilizes liquid bleach, water, and vinegar requires contact with a surface for at least sixty minutes. If chlorine dioxide is used in combination with an iron-based catalyst, sodium carbonate, and bicarbonate, disinfection requires only thirty minutes.

Risks of Anthrax Contamination in the Workplace

After the deaths of postal workers contaminated by anthrax bacteria sent through the mail by terrorists in late 2001, the U.S. Department of Labor's Office of Safety and Health Administration (OSHA) developed a matrix to help employers and workers understand the risks of anthrax exposure and to offer suggestions for preventive measures to avoid contamination. OSHA's matrix identified three levels of risk:

- **Green Zone:** Workplaces in which the risk of anthrax contamination is unlikely. This category encompasses the vast majority of workplaces in the United States.
- **Yellow Zone:** Workplaces in which anthrax contamination is considered possible. This category includes places that handle bulk mail, places handling mail from facilities known to be contaminated or that are close to such facilities, and places likely to be targeted by bioterrorists.
- **Red Zone:** Workplaces that authorities know or suspect to be contaminated.

Anthrax as a Biological Weapon

Many nations have examined the potential of *B. anthracis* as a biological weapon. Growing *B. anthracis* is extremely easy, but processing the endospores into a form that is easily disseminated is extremely difficult. The first attempts to use anthrax as a biological weapon utilized rather crude methods. During World War II (1942), the British military experimented with anthrax on Gruinard Island. This experiment so thoroughly contaminated the site that it was quarantined for the next fifty years. Britain then manufactured some five million "N-bombs," which were anthrax-laced explosive devices, to attack German livestock, but the bombs were never used. In 1986, the British government hired a private company to disinfect the soil of Gruinard Island. The company first carted away the island's topsoil in sealed containers and then used 280 tons of formaldehyde mixed with 2,000 tons of seawater to disinfect the soil that remained. In 1990, the British defense minister declared the island safe.

At Fort Detrick in Frederick, Maryland, the U.S. Army developed a special form of anthrax endospores for use as a biological weapon. Such weaponized endospores lack the ionic charges that ordinarily cause them to stick together. Consequently, the spores are easily dispersed as a fine powder that can float for miles on the wind. On November 25, 1969, an executive order from President Richard M. Nixon outlawed offensive biological weapons research in the United States. All existing U.S. stockpiles of biological weapons were subsequently destroyed.

Despite the fact that it was a signatory to the international Biological Weapons Convention of 1972, which was intended to end the production of biological weapons, the Soviet Union produced extensive quantities of weapons-grade anthrax endospores. On April 2, 1979, more than one million people in Sverdlovsk (now Yekaterinburg), Russia, were exposed to an accidental release of anthrax organisms from the local biological weapons plant. More than sixty people died from inhalation anthrax. An extensive KGB-sponsored cover-up from 1979 to 1992 prevented the international community from learning the truth of what happened until Russian president Boris Yeltsin admitted Soviet involvement in this incident. In Africa, South African intelligence services helped the Rhodesian government of Ian Smith use anthrax against humans and the cattle of the black nationalists who were fighting against his government during the late 1970's.

Weaponized endospores were used in the United States during the final four months of 2001, when spores of *B. anthracis* were mailed within the continental United States. Eleven cases of inhalation anthrax and eleven cases of cutaneous anthrax resulted from these attacks, and five people died.

Anthrax and Microbial Forensics

Microbial forensics is concerned with the isolation and identification of any microbes used during bioterrorist attacks. Upon arrival at the site of an attack, the microbial forensics team must remove all persons from the site and decontaminate them. Sample collections taken from the air, vents, countertops, sinks, floors, and other surfaces can help the scientists to determine the source of the infection. All samples collected must be properly identified and stored in tamper-proof containers to preserve the chain of custody.

By identifying the exact strain of *B. anthracis* involved in an anthrax outbreak, experts can determine whether the disease has occurred as the result of a bioterrorism attack or as a naturally acquired infection. Various strains of *B. anthracis* show very little DNA sequence variation, but because the entire genome of this organism has been completely sequenced, scientists are able to use PCR to detect single base differences between strains, called single nucleotide polymorphisms (SNPs), and thus provide a fingerprint for each *B. anthracis* strain. If the strains found at the scene of an attack and in the infected individuals are the same, then the agent used in the bioterrorism attack is confirmed. This information can be used in determining both the source of the biological weapon employed and the best treatment options. Molecular forensics identified the strain used in the 2001 postal attacks on American soil as the Ames strain of *B. anthracis*, which was, ironically, developed at Fort Detrick.

Michael A. Buratovich

During the middle years of World War II, the British military experimented with explosive munitions containing anthrax spores on Scotland's Guinard Island. The island was so thoroughly contaminated that the government sealed it off from the public after the war. During the 1980's, decontamination work was begun, and in 1990 the quarantine was lifted. *(AP/Wide World Photos)*

Further Reading

Alibek, Ken, with Stephen Handelman. *Biohazard: The Chilling True Story of the Largest Covert Biological Weapons Program in the World—Told from Inside by the Man Who Ran It*. London: Hutchinson, 1999. Provides an insider's view of the extensive Soviet biological weapons program. Includes map and photographs.

Decker, Janet. *Anthrax*. New York: Chelsea House, 2003. Presents a detailed examination of the dynamics of anthrax epidemics and the influence that medical responses can have on them.

Guillemin, Jeanne. *Anthrax: The Investigation of a Deadly Outbreak*. Berkeley: University of California Press, 2001. Noted medical anthropologist discusses the Sverdlovsk anthrax tragedy in depth, including information on the Soviet Union's subsequent cover-up.

Holmes, Chris. *Spores, Plague, and History: The Story of Anthrax*. Dallas: Durban House, 2003. A medical epidemiologist surveys the historical effects of anthrax on human society.

Miller, Judith, Stephen Engelberg, and William Broad. *Germs: Biological Weapons and America's Secret War*. New York: Simon & Schuster, 2001. Three investigative journalists from *The New York Times* relate the deeply disturbing findings of their research into the history of biological weapons and the status of such weapons as of 2001.

Wheelis, Mark, Lajos Rózsa, and Malcolm Dando, eds. *Deadly Cultures: Biological Weapons Since 1945*. Cambridge, Mass.: Harvard University Press, 2006. Offers frank technical descriptions of the biological weapons programs of all the world's major countries.

See also: Anthrax letter attacks; Antibiotics; Bacteria; Bacterial biology; Bacterial resistance and response to antibacterial agents; Biological terrorism; Biological Weapons Convention of 1972; Centers for Disease Control and Prevention; Chemical Biological Incident Response Force, U.S.; Pathogen transmission; Polymerase chain reaction; U.S. Army Medical Research Institute of Infectious Diseases; Viral biology.

Anthrax letter attacks

Date: September-November, 2001

The Event: One week after the terrorist attacks on New York City and the Pentagon of September 11, 2001, the discovery of the bacterium that causes the deadly disease anthrax in letters mailed to various parties in New York, Florida, and Washington, D.C., triggered a forensic investigation.

Significance: Beyond their human toll, infecting twenty-two people overall and killing five, the anthrax attacks that took place in September, 2001, caused heightened panic at a time when the United States was reeling from the tragedy of the terrorist attacks on the World Trade Center and the Pentagon. The 2001 anthrax attacks led to a number of policy changes surrounding preparations to combat biological terrorism in the United States.

On September 11, 2001, the United States endured the largest act of terrorism it had ever experienced when highjackers flew commercial airliners into the towers of the World Trade Center in New York City and into the Pentagon in Arlington, Virginia. These attacks led to a change in ideology within the country that was just getting under way when the United States was attacked again, this time by an unknown assailant using the naturally existing bioterrorism source known as anthrax.

Anthrax

Anthrax is a life-threatening disease caused by the bacterium *Bacillus anthracis*. This bacterium is assiduous in that it turns dormant and into a spore stage when it does not have a host or is threatened by extreme temperatures, and it can survive in this state until it comes into contact with a new host. Then, even if it has been dormant for decades, it can spread very quickly.

Anthrax is most commonly found in agricultural areas, where it often infects cattle, sheep, goats, and other animals, but it can also occur among humans. Humans typically contract the disease through handling products from infected animals (cutaneous anthrax), by inhaling spores from contaminated products or animals (inhalation anthrax), or by eating the meat of infected animals (gastrointestinal anthrax). Anthrax is not known to spread from one person to another as do cold viruses; the large majority of people who become infected with anthrax experience cutaneous exposure. Anthrax outbreaks are rare in the United States, although they were more common in the eighteenth and nineteenth centuries; from the early twentieth

Recognizing and Handling Suspicious Packages

After the anthrax letter attacks in 2001, the Centers for Disease Control and Prevention developed the following guidelines for recognizing and handling suspicious packages.

Identifying Suspicious Packages and Envelopes

Some characteristics of suspicious packages and envelopes include the following:

Inappropriate or unusual labeling

- Excessive postage
- Handwritten or poorly typed addresses
- Misspellings of common words
- Strange return address or no return address
- Incorrect titles or title without a name
- Not addressed to a specific person
- Marked with restrictions, such as "Personal," "Confidential," or "Do not X-ray"
- Marked with any threatening language
- Postmarked from a city or state that does not match the return address

Appearance

- Powdery substance felt through or appearing on the package or envelope
- Oily stains, discolorations, or odor
- Lopsided or uneven envelope
- Excessive packaging material such as masking tape, string, etc.

Other suspicious signs

- Excessive weight
- Ticking sound
- Protruding wires or aluminum foil

If a package or envelope appears suspicious, DO NOT OPEN IT.

Handling of Suspicious Packages or Envelopes

- Do not shake or empty the contents of any suspicious package or envelope.
- Do not carry the package or envelope, show it to others or allow others to examine it.
- Put the package or envelope down on a stable surface; do not sniff, touch, taste, or look closely at it or at any contents which may have spilled.
- Alert others in the area about the suspicious package or envelope. Leave the area, close any doors, and take actions to prevent others from entering the area. If possible, shut off the ventilation system.
- WASH hands with soap and water to prevent spreading potentially infectious material to face or skin. Seek additional instructions for exposed or potentially exposed persons.
- If at work, notify a supervisor, a security officer, or a law enforcement official. If at home, contact the local law enforcement agency.
- If possible, create a list of persons who were in the room or area when this suspicious letter or package was recognized and a list of persons who also may have handled this package or letter. Give this list to both the local public health authorities and law enforcement officials.

century onward, anthrax has been most commonly encountered in developing countries.

Because anthrax kills humans through the multiplication of the *B. anthracis* bacterium within the body, it is most deadly when it reaches the lungs or the bloodstream. Cutaneous anthrax, the least dangerous form of the disease, typically results in blisters or ulcers on the skin. Indeed, more than three-fourths of people who contract cutaneous anthrax survive without medicinal treatment. Inhalation anthrax is the most dangerous of the three forms of the disease; more than half of those infected do not survive despite treatment. Treatment success is greatly influenced by how early the infection is uncovered and treated. People who come into contact with *B. anthracis* generally become sick within a week or ten days, but symptoms can take up to two months to appear.

Anthrax has been used in warfare since World War II, and a number of nations have developed biological weapons that include *B. anthracis*. Although some countries have destroyed their biological weapons facilities, others continue to test new strains of anthrax and conduct research seeking new antidotes for this disease.

The Attacks

On October 1, 2001, Claire Fletcher, an employee at the Columbia Broadcasting System

On October 16, 2001, during the height of concerns regarding anthrax spores sent through the U.S. mail to addresses in New York City, Florida, and Washington, D.C., a New York City Emergency Service police officer inspects a mailbox on Fifth Avenue for evidence of contamination. *(AP/Wide World Photos)*

(CBS) news division in New York City began to develop facial swelling and nausea. Her symptoms were confirmed as cutaneous anthrax, and she was provided antibiotics and later recovered. On October 4, Robert Stevens, an employee at the tabloid newspaper *Sun*, contracted inhalation anthrax and died the next day. *Sun* was published by American Media, Incorporated, located in Boca Raton, Florida

Although the first victim of the anthrax attacks was not identified until October 1, the attacks arguably began when the letters that contained the anthrax were first sent. Five such letters were postmarked in Trenton, New Jersey, on September 18, 2001, and sent to locations in New York City and Florida. Specifically, letters were sent to the news divisions of the American Broadcasting Company (ABC), the National Broadcasting Company (NBC), and CBS as well as the *New York Post* in New York City and to the *National Enquirer* and American Media in Boca Raton, Florida.

Two more letters containing anthrax were also postmarked in Trenton on October 9, 2001; these were addressed to the Washington, D.C., offices of Senator Tom Daschle of South Dakota and Senator Patrick Leahy of Vermont. After an aide at Daschle's office opened the letter, it was found to contain a more potent form of anthrax than had been used in the earlier mailings; initial news media reports referred to it as "weapons grade" anthrax. The U.S. government mail service was temporarily shut down in response to the attacks, and the letter addressed to Leahy was found a month later, on November 16, after it had been routed to the wrong ZIP Code and placed in an impounded mail bag.

In all, five people died as a result of the anthrax attacks and another seventeen were injured. Many of those who were injured continued to experience ill effects, including fatigue and memory loss, years later. Moreover, a few postal inspectors became ill during the massive cleanup effort that followed the attacks, which continued for two and one-half years. Including the costs of cleanup and replacement of equipment, as well as the investment of human resources, some estimates put the monetary figure for the total damage caused by the attacks at more than one billion dollars.

The Investigation

After 2001, the anthrax attacks became known as Amerithrax, the case name given to them by the Federal Bureau of Investigation (FBI). The investigation that ensued relied on a combination of investigative police work and forensic testing. Investigators from the FBI, U.S. Postal Service, and other governmental agencies worked on the case, but through the seven ensuing years, no suspects were arrested.

Investigators observed that the anthrax used in the attacks was not all of the same grade. That mailed to television networks and the newspaper was of a brown granular form that caused only cutaneous anthrax, while that mailed to the senators and to Florida was a higher grade that caused inhalation anthrax. However, both types came from the same Ames strain that had been distributed to biological research labs across the United States and overseas.

Investigators narrowed the origin of the letters to Princeton, New Jersey, after anthrax spores were found in a mailbox near Princeton University. Hundreds of mailboxes in the area were tested, and no others tested positive. After further testing of the anthrax used in the attacks, investigators backed away from referring to the higher-grade anthrax as "weapons grade." However, several scientists still thought that the anthrax spores had been combined with additives that rendered the material more easily inhaled. They argued that only someone with advanced expertise could have created such a mixture.

DNA (deoxyribonucleic acid) tests of the anthrax inhaled by the first victim, Robert Stevens, ruled out laboratories in England as the source of the anthrax. Later testing found a DNA match with the original Ames strain of anthrax produced at Fort Detrick in Frederick, Maryland. Testing also indicated that the anthrax had been made within the two years preceding the attack, using a water source in the northeastern United States.

The person most closely scrutinized by investigators was Dr. Steven Hatfill, an American virologist and bioweapons expert who consistently denied any involvement. U.S. attorney general John Ashcroft labeled Hatfill a "person of interest," and significant amounts of government time and resources were invested in looking into possible connections between him and the anthrax attacks. Hatfill later sued several newspapers and magazines for libel and the FBI and U.S. Justice Department for violating his constitutional rights. In June, 2008, he was exonerated when he won a large settlement from the U.S. government.

Meanwhile, the investigation was moving in a different direction, as the government built a case against Bruce Ivins, a veteran biological-weapon researcher for the U.S. Army who had worked on the type of anthrax used in the attacks. Ivins had a history of suspicious behavior around the time of the attacks. In July, 2008, as the Justice Department was preparing to present its case against him to a grand jury, Ivins committed suicide. In early August, a federal prosecutor announced that Ivins was the sole culprit behind the 2001 anthrax attacks. Ivins clearly had the means and opportunity to perpetrate the attacks. Less certain was the question of what his motive may have been. One theory was the possibility that he stood to profit from his patents for a powerful anthrax vaccine.

Brion Sever and Ryan Kelly

Further Reading

Cole, Leonard A. *The Anthrax Letters: A Medical Detective Story*. Washington, D.C.: Joseph Henry Press, 2003. Presents an in-depth examination of the anthrax attacks and the media frenzy they created as well as the government's response to the attacks. Emphasizes the difficulties that investigators and scientists faced in reacting to the attacks and discusses the continuing threat posed by anthrax.

Graysmith, Robert. *Amerithrax: The Hunt for* *the Anthrax Killer*. New York: Berkley Books, 2003. Uses evidence from the official FBI investigation to guide an analysis of the anthrax case. Contends that the anthrax-contaminated letter opened at American Media in Florida on September 19, 2001, is the key to solving the case.

Hasan, Tahara. *Anthrax Attacks Around the World*. New York: Rosen, 2003. Brief volume presents details on the various anthrax attacks that have occurred around the world. Provides useful context for the 2001 attacks in the United States.

Thompson, Marilyn W. *The Killer Strain: Anthrax and the Government Exposed*. New York: HarperCollins, 2003. Focuses primarily on the U.S. government's reactions to the 2001 anthrax attacks. Analyzes the responses of doctors, politicians, scientists, and law-enforcement personnel in responding to the threat in the immediate days and weeks following the attacks.

See also: Anthrax; Bacteria; Bacterial resistance and response to antibacterial agents; Biological terrorism; Biological warfare diagnosis; Biological weapon identification; Biological Weapons Convention of 1972; Chemical Biological Incident Response Force, U.S.; Viral biology.

Anthropometry

Definition: Systematic study of the dimensions of the human body and skeleton.

Significance: Anthropometry has a long history of use in criminalistics and medical sciences. Forensic anthropometry uses the methods and techniques of physical anthropology in a legal context to help law-enforcement agencies identify human remains specifically.

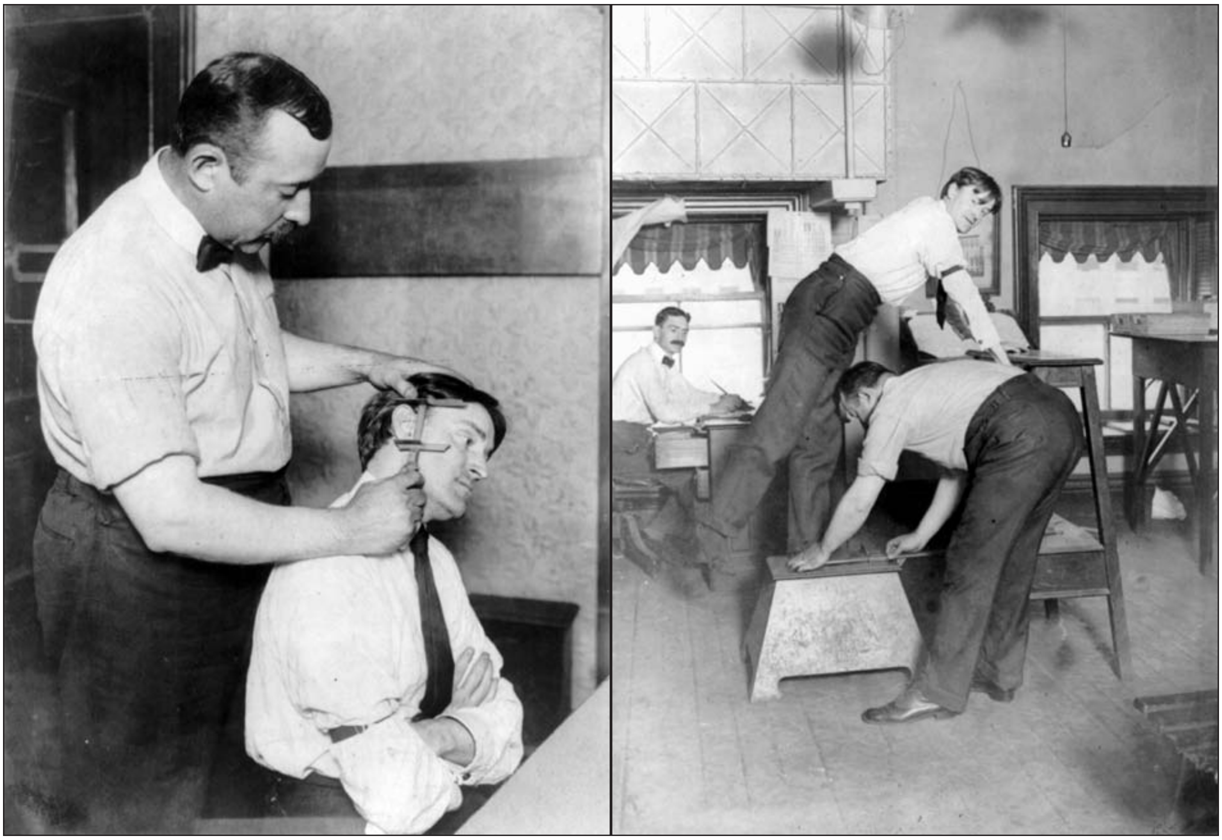
Anthropometry is the application of a quantified series of measures to the study of the human body with respect to origins, relationships, and individual identity. Forensic anthropometry is the application of anthropometrics to human remains—whether victims of accidents, catastrophes, or criminal acts—to identify characteristics and thus help establish personal identities. Anthropometry can be both objective and rigorous when conducted by trained scientists who are familiar with measurement techniques and their subsequent statistical interpretations.

Scientific Basis

The science of anthropometry is based on several premises. First, the body dimensions of each individual represent a subset of unique features that can be used, like fingerprints, for identification purposes. Second, body dimensions provide information regarding additional characteristics such as gender, stature, and, in some cases, ethnicity. Third, body dimensions shed light on health, size, and morphology of internal tissues and organs. Fourth, certain body dimensions and skeletal remains can provide a record of health, accidents, and diseases and permit determination of health at time of death. All of these elements may aid the identification process.

Anthropometry is divided into two subfields: somatometry and osteometry. Somatometry is the measurement of dimensions of the living body, the cadaver, or body fragments. The measurement of the head and face constitutes a special field within somatometry termed cephalometry. Osteometry is the measurement of the bones and distinctive features of bones such as heads of ball joints, protuberances, condyles, articulations, and bone density of the human skeleton. Systematic measurement of the skull is sometimes termed craniometry. Both somatometry and osteometry have been proven useful in the comparison and identification of geographic variation and patterns among human populations in different areas of the world. Anthropometry is especially useful in the sciences of physical anthropology and the paleontological study of human ancestors and hominid relationships.

Collectively, anthropometric analysis of somatometry and osteometry can provide important information about an individual. Depending on the extent of remains collected, anthropometrists can determine age, sex, stature, body shape, diet, work habits, and sometimes ancestry of an individual. Forensic



New York City Police Department personnel demonstrate the Bertillon measurement method of identification, an early use of anthropometry. These photographs, taken around 1908, show how measures were taken of two of the many body dimensions used in the Bertillon system, ears and feet. *(Library of Congress)*

anthropometry has proven especially useful in missing persons cases; the anthropometrics of discovered remains can be compared with information obtained from physicians, photographs, and other materials to determine the likelihood of a match between the remains and the missing person or persons. Anthropometric data on remains that do not match the missing persons of immediate interest are archived in an electronic database for future possible comparisons.

History

Anthropometry traces its roots to French criminologist Alphonse Bertillon (1853-1914), who reasoned that because no two persons are exactly alike, an individual could be identified on the basis of his or her body dimensions. Beginning in 1882, Bertillon systematically measured various dimensions on the bodies of criminals in Paris jails, including height, length of ear, and length of foot. He laboriously compiled a vast archive of measurements that was successfully used as a guide to identify repeat criminal offenders. The Bertillon system, or *bertillonage*, as it came to be called, was widely adopted in France and several other European countries.

English scientist Francis Galton (1822-1911) simplified the process originated by Bertillon by reducing the number of body dimensions measured. Galton also introduced the use of fingerprints to identify criminals. The reliability of fingerprints as a means of identification and the ease of fingerprinting were quickly recognized, and fingerprint analysis soon replaced Bertillon's laborious system of measuring body dimensions as a tool of the criminal justice system.

In the later years of the nineteenth century and well into the early years of the twentieth century, however, anthropologists adopted anthropometrics to compare human races. Although the method was useful at first, anthropometry took a darker turn as some used anthropometric data to suggest that morphological differences among groups of peoples implied superiority of some human groups over others. For example, anthropometry became a political tool in the eugenics policies of the Nazis, who used cranial measurements to distinguish Aryans from Jews. In a similar vein, social anthropologist William Herbert Sheldon contended that one could predict the mental, emotional, and social characteristics of a person, as well as personality and potential criminality, on the basis of the individual's body measurements alone. After the Holocaust, these schools of anthropometry went into decline, and the use of anthropometry to imply racial differences, personality traits, or criminal predisposition was largely discontinued.

Forensic Applications

Although the use of anthropometry in forensic science has been somewhat superseded by the use of DNA (deoxyribonucleic acid) analysis, anthropometry is still widely used to provide initial identification of human remains in cases of natural disasters, automobile accidents, and catastrophes such as airplane crashes or terrorist attacks. Anthropometry is also helpful in identifying remains that have been deliberately destroyed in an effort to make identification impossible.

Forensic anthropologists must be familiar with both field and laboratory techniques, as they are often among the first to arrive at a site to recover and gather remains for identification. These scientists combine expertise in comparative osteology, human osteology, craniometry, osteometry, and racial morphology as well as skeletal anatomy and function and skeletal proportions characteristic of different geographic areas. Forensic anthropologists work with other crime scene investigators, such as forensic pathologists, to reconstruct the biological nature of individuals at the time of postmortem examinations; they also provide expertise in criminal cases.

Depending on the amount and nature of remains, forensic anthropometry continues to be useful in providing such information as age, gender, health, past injuries, and injuries that may have caused death. Forensic anthropometry has proven especially useful in cases in which only partial remains have been recovered. Examples of successful uses of forensic anthropometry include the identification of remains from the Vietnam War and other past conflicts, identification of the remains of victims of the 2001 terrorist attack on the World Trade Center, and identification of the skeletal fragments of the last two members of the family of Russian czar Nicholas II, who were murdered nearly one hundred years ago in a field in Siberia.

Dwight G. Smith

Further Reading

Krogman, Wilton Marion, and Mehmet Yasar Iscan. *The Human Skeleton in Forensic Medicine*. 2d ed. Springfield, Ill.: Charles C Thomas, 1986. Updated and expanded version of Krogman's classic work, which was first published in 1962.

Pheasant, Stephen, and Christine M. Haslegrave. *Bodyspace: Anthropometry, Ergonomics, and the Design of Work*. 3d ed. Boca Raton, Fla.: CRC Press, 2005. Details the many different applications of anthropometrics.

Reichs, Kathleen, ed. *Forensic Osteology: Advances in the Identification of Human Remains*. 2d ed. Springfield, Ill.: Charles C Thomas, 1998. Collection of essays includes discussions of the history, scope, and specialized methodologies of forensic anthropology, including anthropometry.

Ulijaszek, S. J., and C. G. N. Mascie-Taylor, eds. *Anthropometry: The Individual and the Population*. New York: Cambridge University Press, 1994. Collection of essays by anthropologists, biologists, clinical scientists, and other experts describes the many ways in which anthropometry is used.

White, Tim D., and Pieter A. Folkens. *The Human Bone Manual*. Burlington, Mass.: Elsevier Academic Press, 2005. Compact volume offers critical information about skeletal

identifications and hundreds of illustrations and photographs. Intended for use by professional anthropologists, forensic scientists, and researchers.

See also: Autopsies; Biometric identification systems; Composite drawing; Crime scene investigation; Forensic anthropology; Forensic sculpture; Osteology and skeletal radiology; Sex determination of remains; Skeletal analysis.

Antianxiety agents

Definition: Group of medications that relieve tension, reduce activity, induce relaxation, and produce drowsiness.

Significance: The use of antianxiety agents is routinely associated with high risk for dependence and abuse that can be associated with criminal activity, drug-seeking behaviors, and suicide. In addition, sexual predators are increasingly using antianxiety agents to reduce the capacity of their victims to react against assault.

The drugs classified as antianxiety agents are frequently prescribed for patients complaining of tension, muscle strain, sleep problems, panic attacks, and phobias. Among the drugs' effects are drowsiness, impaired social or occupational functioning, slurred speech, rapid mood changes, and impaired judgment; these effects become more pronounced with increased dosage. Because of the negative impact on occupational functioning that abuse of antianxiety agents can produce, many employment settings have implemented urine testing of employees to screen for these drugs.

Benzodiazepines

The most commonly prescribed antianxiety agents are the benzodiazepines, which are classified as controlled substances by the U.S. Drug Enforcement Administration (DEA). These include such drugs as chlordiazepoxide (Librium), diazepam (Valium), alprazolam (Xanax), clonazepam (Klonopin), clorazepate (Tranxene), and lorazepam (Ativan). The benzodiazepines act on the central nervous system and produce intoxication and withdrawal symptoms. These drugs can produce physical and psychological dependence within two to four weeks of usage. The symptoms of withdrawal from antianxiety drugs can range form mild discomfort to severe reactions, including seizures. Some of the common symptoms include weakness, rapid pulse, tremor, insomnia, restlessness, nausea, hallucinations, and irritability. Sudden withdrawal from benzodiazepine dependence can lead to seizures and even death. Detoxification involves a gradual decrease of the drug over a period of weeks. Persons who are addicted to antianxiety medications often respond best to detoxification in residential treatment programs.

In medical practice, the benzodiazepines have replaced the usage of barbiturates for control of anxiety. Barbiturates were commonly used throughout the early to mid-twentieth century to induce relaxation, promote sleep, and quell tension, but they had a high abuse potential. Common barbiturates include amobarbital (Amytal), phenobarbital (Luminal), pentobarbital (Nembutal), seconbarbital (Seconal), and thiopental (Pentothal). Barbiturate drugs are still common among the chemical substances sold illegally. Colloquially they are frequently referred to as reds, red devils, yellow jackets, rainbows, downers, phennies, and nembies.

Abuse and Negative Impacts

Although antianxiety agents are legitimately prescribed for the treatment of psychiatric disorders associated with anxiety, a large number of individuals use the drugs illicitly for their mood-altering relaxation effects. Some use only benzodiazepines, but others often use them in conjunction with other controlled substances, including stimulants and hallucinogens, to diminish anxious feelings; some use benzodiazepines with cocaine to reduce withdrawal symptoms or with heroin as a way to enhance the euphoric feelings heroin causes. Benzodiazepine abusers, the majority of whom are under forty years of age, account for approximately one-third of all substance-abuse-related hospital emergency room visits in the United States.

Benzodiazepine intoxication is associated with behavioral disinhibition that can result in heightened physical and sexual aggressiveness, especially when combined with alcohol use. The effects of benzodiazepines are additive to those of alcohol, and in combination the two can lead to respiratory depression that can result in death. In general, when the additive central nervous system depressant effects of alcohol are combined with a benzodiazepine, the results can include excessive sedation, cognitive impairment, and psychomotor slowing. The diagnosis of benzodiazepine intoxication is best confirmed through toxicological analysis of blood or urine samples.

Because of the disinhibition effects of the benzodiazepines, some sexual predators use these drugs to dose intended victims, often by surreptitiously introducing the drugs into liquids the victims are drinking. The drugs can reduce the potential victims' capacity to react strongly against sexual assault or may even render them unconscious. In order to prove a charge of a drug-facilitated criminal offense, law-enforcement officials must be able to prove detection of the substance in the victim during commission of the act. Research has shown that the antianxiety agents are detectable in oral fluid, blood, urine, and hair samples of those who ingest the drugs over the course of hours and days. The evidence of benzodiazepine ingestion in hair samples is significant in cases where long delays separate the time of the alleged crimes and the collection of blood and urine samples, which may be of little value after a certain period of time.

State and federal agencies in the United States have carried out a continuing effort to restrict the distribution of benzodiazepines through strict multiple-form reporting of prescriptions for these medications. Some U.S. states have created databases of the names of physicians who prescribe benzodiazepines, as well as the patients who receive the prescriptions, to monitor the distribution of these medications. Requirements for triplicate-form reporting of prescriptions have been found to reduce the use of the benzodiazepines for other than legitimate medical purposes.

Frank J. Prerost

Further Reading

Galanter, Marc, and Herbert D. Kleber, eds. *Textbook of Substance Abuse Treatment*. Washington, D.C.: American Psychiatric Publishing, 2004. Extensive volume provides information concerning the effects of substance abuse in the workplace and describes strategies to overcome the problems.

Meyer, Robert G., and Christopher M. Weaver. *Law and Mental Health: A Case-Based Approach*. New York: Guilford Press, 2006. Focuses on the various legal issues surrounding drug abuse. Includes discussion of drug screening and informed consent.

Sales, Bruce, D., Michael Owen Miller, and Susan R. Hall. *Laws Affecting Clinical Practice*. Washington, D.C.: American Psychological Association, 2005. Describes the issues associated with mental health professionals' bringing evidence to trial in criminal and civil litigation.

Simon, Robert I. *Concise Guide to Psychiatry and Law for Clinicians*. 3d ed. Washington, D.C.: American Psychiatric Publishing, 2001. Brief volume aimed at mental health care professionals provides a good overview of the legal issues surrounding substance abuse.

Stern, Theodore A., et al., eds. *Massachusetts General Hospital Handbook of General Hospital Psychiatry*. 5th ed. St. Louis: C. V. Mosby, 2004. Handbook intended for health care professionals includes an extensive discussion of the screening process for abuse of controlled substances in health care settings that is relevant for investigators who gather forensic evidence in criminal cases.

See also: Amphetamines; Club drugs; Crack cocaine; Drug abuse and dependence; Halcion; Hallucinogens; Illicit substances; Opioids; Psychotropic drugs; Stimulants.

Antibiotics

Definition: Therapeutic agents that kill infectious microorganisms.

Significance: Antibiotics kill certain types of bacteria that cause diseases without severely hurting the patients; they can thus abate the progression of some diseases and extensively reduce the effects of those diseases on human populations. Because of increasing threats of terrorism in the modern world, law-enforcement agencies are interested in the effective use of antibiotics for blunting the potential threat of microorganisms as biological weapons.

Microbial infections cause illnesses that diminish the quality of life and productivity and can eventually cause death. Effective early treatment can reverse the progression of some diseases, decrease the convalescence time, and potentially prevent the spread of infection from one person to another. Treatment can also check the onset of particular undesirable aftereffects caused by some diseases. Antibiotics are the first-line treatments against infectious diseases.

Classification

Most antibiotics are derived from compounds made by various microorganisms to kill competing bacteria. Many antibiotics, however, are completely synthetic in their composition, even though their chemical structures are variations of naturally produced antibiotics.

Antibiotics are classified according to their chemical structures, and drugs with similar chemical structures are classified in a common group. The largest group of antibiotics, the beta-lactams, consists of the penicillins (such as ampicillin, amoxicillin, and carbenicillin), cephalosporins (such as cephalexin, ceflaclor, and ceftizoxime), monobactams (aztreonam), and carbapenems (such as imipenem and meropenem). Other antibiotic groups include the macrolide antibiotics (such as erythromycin, clarithromycin, and azithromycin), tetracyclines (such as doxycycline and minocycline), aminoglycosides (such as streptomycin, kanamycin, tobramycin, and neomycin), sulfanilamides (such as sulfadiazine, sulfamethoxazole, and sulfamethizole), trimethoprim (similar to sulfanilamides but does not contain sulfur atoms), fluoroquinolones (such as ciprofloxacin, levofloxacin, moxifloxacin, and norfloxacin), and glycopeptide antibiotics (vancomycin).

Several antibiotic groups consist of only one drug; these include bacitracin, clindamycin, chloramphenicol, cycloserine, and fosfomycin. Streptogramin A and dalfopristin are given as a combination, and these drugs are the only members of the streptogramin group. The oxazolidinones group contains only one member, linezolid. A handful of antibiotics called antimycobacterials are specifically used to treat tuberculosis: isoniazid, ethambutol, pyrazinamide, and rifampin.

Mode of Action

Several chemically unrelated groups of antibiotics can target similar biochemical processes in bacterial cells. The abilities of distinct antibiotics to kill particular bacterial species vary extensively. Some antibiotics can kill only a few bacterial species (narrow-range antibiotics), whereas others can eradicate many different types of bacteria (broad-spectrum antibiotics).

Several antibiotics inhibit bacterial protein synthesis, which quickly kills bacterial cells. The protein synthesis-inhibiting antibiotics include the macrolides, tetracyclines, aminoglycosides, clindamycin, streptogramins, oxazolidinones, and chloramphenicol. Clindamycin is used to treat infections with anaerobic bacteria, and streptogramins and oxazolidinones are used for infections that resist other antibiotic treatments.

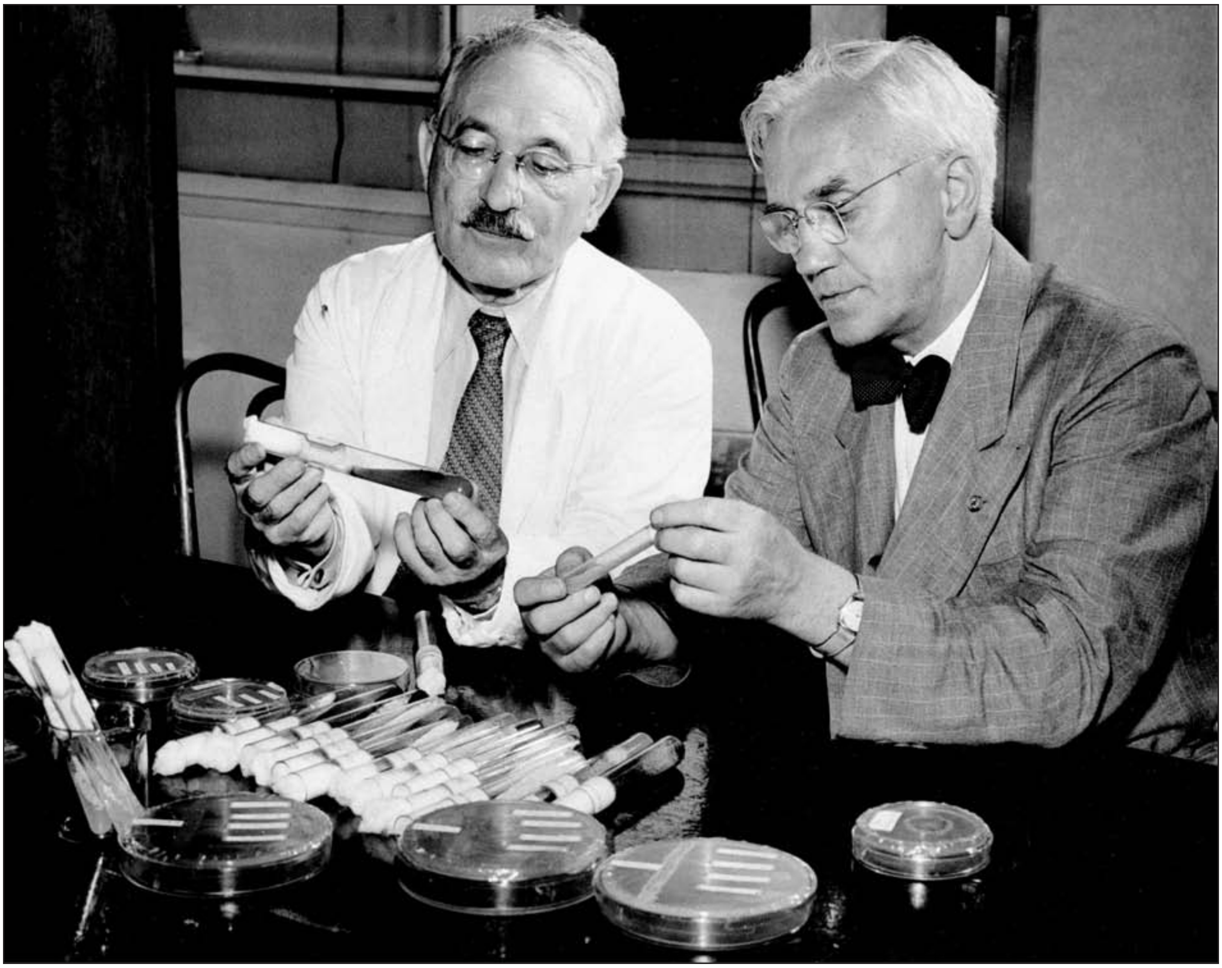
Many antibiotics inhibit the synthesis of the bacterial cell wall, which surrounds the bacterium and protects it. Without their cell wall, bacterial cells succumb to the host's immune system. Antibiotics that inhibit bacterial cell wall synthesis include the beta-lactams, glycopeptides, bacitracin, cycloserine, and fosfomycin.

Some antibiotics interfere with the synthesis of essential molecules. Folic acid is an exceedingly vital cofactor for bacterial metabolism, and without it, bacteria die. The sulfanilamides, trimethoprim, and the drug dapsone (used to fight Hansen's disease, or leprosy) obstruct the synthesis of folic acid. The fluoroquinolones inhibit bacterial DNA (deoxyribonucleic acid) replication.

Of the antituberculosis drugs, rifampin inhibits gene expression, and isoniazid and ethanbutol hamper the synthesis of the waxy cell wall of *Mycobacterium tuberculosis*, the bacterial agent that causes tuberculosis. Pyrazinamide inhibits the synthesis of fatty acids, which are used for the construction of biological membranes.

Clinical Use

Antibiotic treatment can have great benefits even when the exact causative agent of a disease is unknown. Antibiotics thus are usually used before the microorganism responsible for the illness is defined. However, because continuous exposure of bacteria to antibiotics allows the evolution of bacteria that are resistant to antibiotics, the overuse of these drugs is ill-advised, and judicious use of antibiotics is the rule. For example, given that more than 90 percent of sinus and upper-respiratory infections are caused by viruses rather than by bacteria, immediate prescription of antibiotics for such conditions is unwarranted.



Dr. Selman Abraham Waksman (left), the discoverer of streptomycin and neomycin, with Sir Alexander Fleming, the discoverer of penicillin, examining cultures in a Rutgers University laboratory in 1949. Waksman donated his profits from streptomycin to help build a new institute of microbiology at Rutgers. *(AP/Wide World Photos)*

Prescribing heath care professionals use a protocol known as empirical antimicrobial therapy (EAT) to guide their choices of antibiotics. Using EAT, the prescribing professional attempts to identify the bacterium most likely responsible for the illness through collection of a medical history, physical examination, and laboratory analyses of infected tissues. Because certain bacterial species have a tendency to infect certain organs, specific antibiotics are typically recommended for particular infections. Typically, certain drugs are considered to be the first choice for particular infections, and alternative drugs are used if the first-choice drugs fail to achieve the desired results. For example, the bacterial organisms *Streptococcus pneumoniae*, *Moraxella catarrhalis*, and *Haemophilus influenzae* cause the vast majority of middle-ear infections (otitis media), so the first-choice treatment for these infections is amoxicillin or a combination of trimethoprin and sulfamethoxazole (in a one-to-five ratio); the second-choice treatment is amoxicillin in combination with clavulanate or cefurxime axetil.

Antibiotics and Forensics

The presence of antibiotics in bodily fluids or tissue samples obtained after death usually indicates the presence of an infection in the deceased. The techniques for detecting antibiotics or their breakdown products in postmortem tissues exploit the unique chemical structure of each antibiotic. Cephalosporins, for example, are detected in postmortem tissues by means of high-performance liquid chromatography (HPLC), which separates compounds according to their differing rates of movement through a porous support material.

The prescription of antibiotics to prevent an impending infection is called antibiotic prophylaxis. In one example of the use of antibioticprophylaxis, ciprofloxacin was given to approximately ten thousand people who had potentially been exposed to *Bacillus anthracis*, the causative agent of anthrax, as the result of bioterrorism attacks in New York City, Washington, D.C., and Boca Raton, Florida, in the fall of 2001. This step probably saved many lives. The aggressive prophylactic use of antibiotics has the potential to thwart a bioterrorism attack.

Michael A. Buratovich

Further Reading

Gilbert, David N. *Sanford Guide to Antimicrobial Therapy 2007*. 37th ed. Sperryville, Va.: Antimicrobial Therapy, 2007. Simple but elegantly written reference guide provides thorough information on antibiotic prescribing.

Sachs, Jessica Snyder. *Good Germs, Bad Germs: Health and Survival in a Bacterial World*. New York: Hill & Wang, 2007. Presents interesting discussion of the interrelationships between bacteria and our bodies and how antibiotic treatments can affect those relationships.

Scholar, Eric M., and William B. Pratt, eds. *The Antimicrobial Drugs*. New York: Oxford University Press, 2000. Detailed reference book on antibiotics offers wonderfully clear explanations.

Smith, Frederick P., ed. *Handbook of Forensic Drug Analysis*. Burlington, Mass.: Elsevier Academic Press, 2005. Provides precise, detailed discussions of the laboratory techniques used to detect substances in postmortem tissue samples, including antibiotics.

Walsh, Christopher. *Antibiotics: Actions, Origins, Resistance*. Washington, D.C.: ASM Press, 2003. Offers encyclopedic treatment of the activities, structures, modes of resistance, and appropriate uses of antibiotics.

See also: Anthrax; Bacteria; Bacterial biology; Bacterial resistance and response to antibacterial agents; Biodetectors; Biological terrorism; Centers for Disease Control and Prevention; *Escherichia coli*; Parasitology; Pathogen transmission; Tularemia.

Antidotes. *See* Poisons and antidotes

Antipsychotics

Definition: Group of drugs used to treat psychotic disorders such as schizophrenia and mania.

Significance: Antipsychotic drugs have the ability to reduce psychotic symptoms without necessarily producing drowsiness and sedation. Forensic psychiatrists as well as law-enforcement personnel are familiar with antipsychotics because many criminals with mental illnesses use such drugs.

Antipsychotic drugs, also known as neuroleptic drugs or neuroleptics, were first discovered in the late 1940's by Henri Laborit, a French surgeon. Laborit found that when phenothiazines were used in conjunction with surgical anesthesia, the patients became less concerned about their surgery, and he thought that these drugs might be useful for reducing the emotionality of psychiatric patients. Since that time, the use of antipsychotics has become common in psychiatry. Initially, these drugs were called tranquilizers, but as that term seemed to imply sedation, its use was dropped.

All antipsychotic drugs tend to block dopamine receptors in the mesolimbic pathway of the brain; this accounts for their antipsychotic action. The drugs range in potency based on their ability to bind with dopamine receptors. High-potency antipsychotics such as haloperidol require lower dosage (usually a few milligrams) than do low-potency antipsychotics such as chlorpromazine (usually several hundred milligrams). Persons who are prescribed antipsychotics need to be monitored for regular intake, as compliance with drug therapy is an important aspect of treatment for psychotic disorders.

Typical Antipsychotics

Antipsychotics are classified as typical or atypical. Typical, or conventional, antipsychotics (and some of the trade names under which they are sold) include chlorpromazine (Thorazine), thioridazine (Mellaril), mesoridazine (Serentil), loxapine (Loxitane), perphenazine (Trilafon), molindone (Moban), thiothixene (Navane), trifluoperazine (Stelazine), fluphenazine (Prolixin), haloperidol (Haldol), and pimozide (Orap). These kinds of drugs were the first antipsychotics to be developed. The efficacy of typical and atypical antipsychotics is comparable, but typical antipsychotics have the drawback of possibly severe side effects. The main side effects of typical antipsychotics are known as extrapyramidal symptoms—a name arising out of the part of the brain that is stimulated by the drugs. Akathisia, a syndrome involving a subjective desire to be in constant motion and an inability to sit still or stand still, with consequent pacing, is the most common side effect.

Side effects of typical antipsychotics may also take the form of facial tics. Sometimes Parkinson's disease (which is marked by tremors of the hands while they are at rest, muscular rigidity, a masklike face, and a shuffling walk) may be precipitated by antipsychotic drugs. Tardive dyskinesia—the term means "late-appearing abnormal movements"—is among the most serious complications of antipsychotic treatment. It involves repetitive sucking and smacking movements of the lips, thrusting in and out of the tongue, and movements of the arms, toes, or fingers.

Typical antipsychotics can also have several anticholinergic side effects, such as dry mouth, blurred near vision, urinary retention, delayed emptying of the stomach, esophageal reflux, and precipitation of glaucoma. Often these drugs have metabolic and endocrine effects as well, such as weight gain, high blood glucose, temperature irregularities, and menstrual irregularities. Some allergic reactions may also occur, such as jaundice or skin rashes. Rarely, agranulocytosis, or low white blood cell count, can develop in the early stages of treatment.

Atypical Antipsychotics

Atypical antipsychotic medications (and some of the trade names under which they are sold) include clozapine (Clozaril, Fazaclo), risperidone (Risperdal), olanzepine (Zyprexa), quetiapine (Seroquel), ziprasidone (Geodon), and aripiprazole (Abilify). These drugs have an advantage over typical antipsychotics in that they have no extrapyramidal side effects (such as Parkinsonism, akathisia, and tardive dyskinesia). Atypical antipsychotics are at least as effective as conventional or typical agents in inducing positive symptoms, and they also help to improve cognition and enhance mood.

Atypical antipsychotics are not completely free of side effects, however, and the side effects differ from drug to drug. Risperidone, for example, causes an increase in prolactin levels—a hormone that can lead to breast enlargement, production of breast milk, and irregular menses. In high doses, this drug can also cause extrapyramidal side effects. Olanzepine can cause weight gain and may produce modest prolactin elevation. Ziprasidone can cause drowsiness, dry mouth, runny nose, symptoms of high blood sugar, and allergic reactions. Quetiapine can cause drowsiness, dizziness, agitation, pain, and weakness. Clozapine can cause weight gain and sedation.

Manoj Sharma

Further Reading

De Oliveira, Irismar R., and M. F. Juruena. "Treatment of Psychosis: Thirty Years of Progress." *Journal of Clinical Pharmacy and Therapeutics* 31, no. 6 (2006): 523-534. Discusses the evolution of antipsychotics, particularly the general replacement of typical antipsychotics with atypical antipsychotics, largely because the latter lack extrapyramidal side effects.

Parker, John, Jana De Villiers, and Samantha Churchward. "High-Dose Antipsychotic Drug Use in a Forensic Setting." *Journal of Forensic Psychiatry and Psychology* 13, no. 2 (2002): 407-415. Presents the results of a study of the application of antipsychotics in a forensic psychiatric setting.

Pinals, D. A., and P. F. Buckley. "Novel Antipsychotic Agents and Their Implications for Forensic Psychiatry." *Journal of the American Academy of Psychiatry and the Law* 27, no. 1 (1999): 7-22. Review of the literature on the clinical efficacy and mechanisms of action of atypical antipsychotics focuses on their use in forensic psychiatry. Concludes that use of these medications may reduce the risk of civil litigation.

Scherk, Harald, and Peter Falkai. "Effects of Antipsychotics on Brain Structure." *Current Opinion in Psychiatry* 19, no. 2 (2006): 145-150. Discusses the different effects of typical and atypical antipsychotics on brain structure and presents evidence that atypical antipsychotics might ameliorate structural changes caused by the disease process underlying schizophrenia.

Silverstone, Trevor, and Paul Turner. *Drug Treatment in Psychiatry*. 5th ed. New York: Routledge, 1995. Examines both general principles of psychiatric drug treatment and specific clinical applications of antipsychotic drugs.

Sinacola, Richard S., and Timothy Peters-Strickland. *Basic Psychopharmacology for Counselors and Psychotherapists*. Boston: Pearson, 2006. Basic text includes a chapter devoted to the treatment of psychotic disorders and the use of antipsychotics.

Stahl, Stephen M. *Essential Psychopharmacology: The Prescriber's Guide*. Rev ed. New York: Cambridge University Press, 2006. Guidebook for practitioners covers the most important and common drugs used for mood stabilization and treatment of psychosis. Includes information on the advantages and disadvantages of each drug, presented in easy-to-read and user-friendly style.

See also: Drug classification; Halcion; Hallucinogens; Nervous system; Psychopathic personality disorder; Psychotropic drugs; Stimulants.

Argentine disappeared children

Date: Disappearances occurred between 1976 and 1983

The Event: From 1976 to 1983, a military dictatorship was in power in Argentina, and about thirty thousand people whom the government considered to be political dissidents or active opponents of the military were taken from their homes by force, interrogated, tortured, and killed. The "disappeared" included young children captured with their parents and pregnant women who were imprisoned until they gave birth. Many of these children were adopted by families associated with the military. Later, relatives of the disappeared filed inquiries with the courts to try to determine the fates of their children and grandchildren. An organization founded by grandmothers of disappeared children successfully lobbied for changes in Argentine laws to allow grandpaternity testing and to establish a national genetic database to aid in identifying children who had been taken from their families.

Significance: The efforts of the Asociación Civil Abuelas de Plaza de Mayo (known in English as the Grandmothers of the Plaza de Mayo) were essential in the recruitment of the help of international scientists in identifying children who had been separated from their families. The scientists established an Argentine national genetic database and confirmed the validity of tests for grandpaternity. By conducting genetic testing, scientists were able to reunite a number of families.

In 1977, the women of the Asociación Madres de Plaza de Mayo (Mothers of the Plaza de Mayo) began to gather weekly in the main public square of Argentina's capital city, Buenos Aires, to protest the military government's practice of "disappearing" opponents. These women, mothers of missing sons and daughters taken by the government, succeeded in bringing international attention to Argentina's "dirty war."

Also in 1977, twelve grandmothers of children who had disappeared because of government actions formed the Grandmothers of the Plaza de Mayo. Although the military dictatorship was still in power, the Grandmothers began to protest and to gather information about the disappearances of their children and grandchildren. Their focus was on locating the missing children; they launched an international campaign to gather support and met with human rights organizations from around the world. By 1982, the Grandmothers had collected information on some three hundred grandchildren whose parents had disappeared. They knew of the possible whereabouts of fifty grandchildren. After his election to the presidency ended military rule in Argentina in December, 1983, Raúl Alfonsín appointed the Comisión Nacional Sobre la Desaparición de Personas (National Commission on the Disappearance of Persons) to investigate what had happened to the disappeared.

Application of Forensic Science

The Grandmothers sought help from international scientists. Among those who worked on the problem of identifying the missing children were Dr. Fred Allen, an expert on blood groups; Dr. Luigi Luca Cavalli-Sforza, a population geneticist; Dr. Mary-Claire King, a geneticist; and Pierre Darlu, a mathematician. The scientists took an approach that had never been taken before when they applied the idea of grandpaternity testing—that is, they used the same methods used for standard paternity testing to determine the genetic relationships between children and their grandparents.

For the identification of related individuals, genetic markers that are passed from parent to child and that are highly variable in the population are needed. Initially, the scientists used immunological techniques to identify the grandchildren; they examined blood samples from suspected stolen children, their possible grandparents, and other living relatives. No samples were available from the parents of the children because they had been murdered by the military. The genetic markers examined were blood group antigens from red blood cells, such as ABO, Rh, and Kelley, and from white blood cells, such as human leukocyte antigens (HLAs).

King and other scientists also worked to determine what additional genetic markers could be used to identify the children. Mitochondrial DNA (deoxyribonucleic acid) is isolated from blood. The sequence of mitochondrial DNA is an excellent genetic marker for tracking grandpaternity because mitochondrial DNA is maternally inherited—that is, it is passed from a mother to all of her children. Fathers do not pass mitochondrial DNA to their children. Also, one part of the mitochondrial genome that does not contain any genes is the most variable sequence of the human genome.

Members of Argentina's Mothers of the Plaza de Mayo gather in the plaza in April, 1995, to protest the still-unresolved disappearances of thousands of their relatives during Argentina's so-called dirty war of 1976-1983. *(AP/Wide World Photos)*

The mitochondrial genome is a 16,569-base-pair circle that is present in many copies in each mitochondrion, and there are many mitochondria per cell. Because many copies of mitochondrial DNA exist in each cell, it is easier to obtain mitochondrial DNA than it is to obtain nuclear DNA in many cases. In the use of mitochondrial DNA to identify individuals, the highly variable region of mitochondrial DNA is sequenced, and the sequence is compared with the sequences of known persons in a database. Some mitochondrial sequences are unique to particular maternal lineages and can be used to identify grandchildren in these lineages even if the parents cannot be tested.

When the scientists found genetic matches for suspected stolen children, the Grandmothers, the courts, and psychologists worked together to try to ensure that the children were not subjected to further trauma. According to Argentine law, a child could not be considered matched to a family unless circumstantial evidence pointing to the relationship existed in addition to findings from genetic testing indicating a greater than 95 percent probability of a relationship. By 2002, information about more than two hundred grandchildren had been gathered, and more than sixty grandchildren had been identified and returned to their relatives.

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Further Reading

Arditti, Rita. *Searching for Life: The Grandmothers of the Plaza de Mayo and the Disappeared Children of Argentina*. Berkeley: University of California Press, 1999. Describes the work of the grandmothers to identify the disappeared children and return them to their remaining families.

Budowle, Bruce, Marc W. Allard, Mark R. Wilson, and Ranajit Chakraborty. "Forensics and Mitochondrial DNA: Applications, Debates, and Foundations." *Annual Review of Genomics and Human Genetics* 4 (September, 2003): 119-141. Describes the forensic applications of mitochondrial DNA analysis.

Erlich, Henry A., and Cassandra D. Calloway. "Using HLA and Mitochondrial DNA Polymorphisms to Identify Geographic/Ethnic Origins: The Mammoth Lakes Case." *Forensic Magazine*, June/July, 2007, 32, 34-35, 37. Uses a specific murder case to explain the use of mitochondrial DNA in the identification of the remains of unknown persons.

Owens, Kelly N., Michelle Harvey-Blankenship, and Mary-Claire King. "Genomic Sequencing in the Service of Human Rights." *International Journal of Epidemiology* 31 (2002): 53-58. Describes the use of genomic analysis in the identification of victims of human rights abuses, specifically a case in Argentina and one in the Balkans.

Penchaszadeh, V. B. "Abduction of Children of Political Dissidents in Argentina and the Role of Human Genetics in Their Restitution." *Journal of Public Health Policy* 13 (Autumn, 1992): 291-305. Describes the history of the abductions and the actions of the Grandmothers of the Plaza de Mayo as well as the genetic identity testing that was conducted.

_______. "Genetic Identification of Children of the Disappeared in Argentina." *Journal of the American Medical Women's Association* 52 (Winter, 1997): 16-22. Provides an overview of the historical events and the search for the children along with discussion of the genetic research used to identify the missing children.

Scheffler, Immo E. *Mitochondria*. 2d ed. Hoboken, N.J.: John Wiley & Sons, 2008. Presents extensive technical discussion of mitochondrial DNA analysis.

See also: Child abduction and kidnapping; Croatian and Bosnian war victim identification; DNA analysis; DNA database controversies; DNA fingerprinting; DNA profiling; DNA typing; International Association for Identification; Mitochondrial DNA analysis and typing.

Army Medical Research Institute of Infectious Diseases. *See* U.S. Army Medical Research Institute of Infectious Diseases

Arsenic

Definition: Toxic chemical element used industrially in the manufacture of glass, semiconductors, and wood preservatives as well as in insecticides and herbicides.

Significance: Because arsenic is widespread in soil and water and has a number of industrial uses, many opportunities exist for human exposure to this element, which can lead to toxic effects. Both the effects and the mechanisms of exposure to arsenic can be subtle, and the symptoms of intoxication can be confused with those of other conditions.

Life- or health-threatening exposure to the toxic chemical arsenic can result from industrial contact, from deliberate poisoning, or from naturally contaminated food or drinking water. Arsenic poisoning may be acute or chronic, depending on whether a large dose is ingested at one time or smaller doses are taken over a lengthy period.

Acute arsenic poisoning is often associated with attempted murder of the victim. Ingestion of as little as two-tenths of a gram of arsenic trioxide (the arsenic compound most commonly used by poisoners, found in insecticides and weed killers) is followed by intense pain in the stomach and esophagus, followed by vomiting and diarrhea. Chronic poisoning by low levels of arsenic such as may be found in contaminated drinking water produces thickening of the skin (hyperkeratosis) of the hands and feet as well as white lines on the fingernails. Cancer of the bladder or other organs can result with long exposure. Neurological effects are also observed, including weakness in the hands and feet (peripheral neuropathy). These symptoms are not always recognized as arsenic-related unless suitable forensic tests are done.

Arsenic binds to proteins and exerts its toxic effects on the body by interfering with vital enzymes. The presence of arsenic in blood or urine can be confirmed through atomic absorption spectrophotometry, a method developed in the second half of the twentieth century. Previously, the primary method of detecting arsenic was a test developed in 1836 by James Marsh. The Marsh test was first used in Tulle, France, in the 1840 trial of Marie Lafarge, who was accused of murdering her husband.

Occasionally, arsenic poisoning may be suspected as the cause of death long after the person in question has died. In such a case, an expert can analyze a hair sample using neutron activation. In this process, the sample is subjected to a flux of neutrons in a nuclear reactor; the induced radioactivity can reveal arsenic, if it is present. This type of procedure has been used on samples from Napoleon I of France and U.S. president Zachary Taylor, both of whom died in the nineteenth century. Many other long-ago deaths have also been revisited in this way, but a complicating element in such cases is the fact that arsenic was sometimes used in embalming procedures in the past.

Quantitative determination of the arsenic

Clare Boothe Luce in her embassy office one week after arriving in Rome as U.S. ambassador to Italy in April, 1953. Sickened by arsenic-tainted paint chips flaking from her bedroom ceiling, she resigned her post three years later. In 1987, she died from brain cancer at the age of eighty-four. *(AP/Wide World Photos)*

Difficulty of Proving Arsenic Poisoning

The case of Marie Besnard of Loudun, France, provides some perspective on the difficulties that can arise in a trial for murder by arsenic. Besnard was arrested in 1949 on suspicion of having murdered two husbands, her mother, and several other individuals who had died suddenly. Several of the corpses were exhumed and were found to contain high levels of arsenic.

Besnard was brought to trial in 1952 but was not convicted. Her lawyer was able to use the fact that police had mislabeled some of the exhumed remains to impugn all of the forensic evidence, and the trial came to an end with no verdict. Besnard was tried again in 1954, and this time her attorney argued that the arsenic found in the corpses had in fact been carried there from the soil in the graveyard, perhaps by microbial action. Again, the jury could not reach a verdict. In a third trial in 1961, Besnard was acquitted for lack of proof. According to expert testimony, the neutron activation analysis of hair samples taken from the dead had involved too short a period of neutron irradiation, and therefore the results were unreliable. Testimony was also presented that arsenic could be lost from a long-buried body, raising doubt about the significance of the arsenic levels found.

level present in a given person's body is important because a certain amount of arsenic is to be expected from the naturally occurring traces of arsenic that appear in food and water. Elevation of a person's arsenic level above this threshold may indicate accidental or deliberate poisoning. It is estimated that, in the United States, the average person's diet contains 25-30 micrograms of arsenic per day. Excretion of more than 50 micrograms per day is cause for concern. Given that arsenic can exist in many forms of chemical combination, any urine analysis aimed at determining the body's level of arsenic should distinguish between organic arsenic compounds and inorganic ones. The latter are more dangerous.

Arsenic Exposure

In the past, the dangers of arsenic were often treated casually, with the result that many people experienced unnecessary, sometimes dangerous, levels of exposure to the chemical. The use of arsenates as pesticides, now minimal in the United States, once was widespread. Fruit, vegetable, and tobacco crops were often sprayed with such pesticides, and high levels of arsenic were left in the soil and on the crops themselves. When humans suffered ill health as a result, forensic scientists needed to find the source of the trouble. In France, arsenate pesticide residues on grapes found their way into wine that poisoned hundreds of French sailors in 1932. Plants grown on contaminated soil can pick up enough arsenic content to be toxic for human or animal consumption, and residues on tobacco are eventually inhaled by smokers.

Chromated copper arsenate is still used as a wood preservative, but many products that formerly contained arsenic no longer do so. Arsenical pigments were long used in wallpaper and in paint, and this led to many poisonings. Research over many years revealed that wallpaper with pigments such as Paris green or Scheele's green (both arsenicals) could generate arsenic-containing vapors (known as Gosio gas, for Italian physician Bartolomeo Gosio, who published his research on the topic in 1893) if moisture and certain microorganisms were present. This type of vapor, which caused some mysterious deaths in the 1890's, was eventually identified as trimethylarsine during the 1930's. In the 1950's, the U.S. ambassador to Italy, Clare Boothe Luce, became the victim of arsenic poisoning when she absorbed a toxic dose from arsenic-contaminated chips of paint that fell from the ceiling of her bedroom in her embassy quarters. Her resulting health problems forced her to resign her post in 1956 and return to the United States.

Medicines based on arsenic are mostly of historical importance, with some exceptions. Arsenic trioxide has been approved for treatment of leukemia, and arsenicals continue to be used against some tropical parasitic diseases. All these remedies present some danger of arsenic poisoning, as do cosmetic preparations that contain arsenic.

Arsenic is probably an essential trace element in human nutrition in very small amounts. People in the Austrian state of Styria have been known to consume arsenic purposely for its supposed tonic effects. By habituating themselves to ever-increasing doses, they are eventually able to tolerate amounts that would normally be fatal.

Murder by Arsenic

Foul play may be suspected in the death of an otherwise healthy person who develops the symptoms of arsenic poisoning. When such a person dies, forensic testing done postmortem can substantiate toxic levels of arsenic in the liver and other organs, in the stomach contents, and in the blood. If high levels are found, investigators must try to find the source of the poison and its mode of delivery. Accidental or environmental sources must be considered; for example, the victim may have used medicines containing arsenic or taken herbal supplements with arsenic content. If malicious intent is suspected, the dietary habits of the victim may suggest how the poison could have been administered. Any remnants of food or drink known to be ingested by the victim should be tested for arsenic, and anyone who has had access to the victim or the victim's food need should be investigated to see if they have obtained poison or are currently in possession of some.

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Further Reading

Emsley, John. *The Elements of Murder: A History of Poison*. New York: Oxford University Press, 2005. Discusses the use of arsenic and other poisons in murder. Describes a number of cases in detail, many of which involve one spouse poisoning the other.

Gerber, Samuel M., and Richard Saferstein, eds. *More Chemistry and Crime: From Marsh Arsenic Test to DNA Profile*. Washington, D.C.: American Chemical Society, 1997. Collection of chapters covers the history of forensic science as well as developments in the field through the 1990's. Includes chapters that focus on forensic toxicology, on the search for arsenic, and on the depiction of forensic science in detective fiction.

Jones, David. "The Singular Case of Napoleon's Wallpaper." *New Scientist*, October 14, 1982, 101-104. Discusses the case of Napoleon I, who, in exile on the island of Saint Helena, stayed in a house where the wallpaper contained toxic levels of arsenic. Modern scientists have found elevated arsenic levels in samples of Napoleon's hair, which could have been caused by the wallpaper through Gosio gas.

Meharg, Andrew A. *Venomous Earth: How Arsenic Caused the World's Worst Mass Poisoning*. New York: Macmillan, 2005. Focuses on the health consequences of the arsenic contamination of drinking water (from minerals near the water table) in Bangladesh. Also notes other areas of the world where the problem exists and includes examples of the dangers of arsenic-containing pigments, wallpaper, and other products.

Vilensky, Joel A. *Dew of Death: The Story of Lewisite, America's World War I Weapon of Mass Destruction*. Bloomington: Indiana University Press, 2005. Presents the history of the chemical weapon lewisite, an arsenical poison gas developed by the United States for use as a weapon of war. Notes that stockpiles of the compound still exist and may be hazardous.

White, Peter, ed. *Crime Scene to Court: The Essentials of Forensic Science*. 2d ed. Cambridge, England: Royal Society of Chemistry, 2004. General treatment of forensic science includes chapters on analysis of body fluids, forensic toxicology, and courtroom presentation of expert evidence.

See also: Analytical instrumentation; Ancient criminal cases and mysteries; Atomic absorption spectrophotometry; Blood agents; Chemical agents; Marsh test; Napoleon's death; Spectroscopy; Taylor exhumation.

Arson

Definition: Deliberate setting of a fire with the intent to cause damage to a structure or other piece of property.

Significance: Arson is a destructive crime that often results in significant property and monetary losses. Investigations to determine whether fires were set intentionally or caused accidentally are notoriously difficult because of the high level of damage at most fire scenes. The forensic science of fire debris analysis, however, provides significant information that can help arson investigators make such determinations.

Arson has been committed throughout human history. Its definition as a crime originated in old English common law, where the term "arson" referred specifically to a fire set by one person against the dwelling of another. Since then, the definition of arson has developed to encompass fires deliberately set against any structure, inhabited or not, as well as vehicles or any other personal property. The penal consequences for the commission of arson have also progressed over time. In the United States, arson crimes are prosecuted based on the degree of damage inflicted, with the worst offense being first-degree felony arson—that is, the setting of a fire that results in the injury or death of one or more persons, whether purposely or accidentally.

Prevalence and Perpetrators

Although the occurrence of and monetary damages caused by arson fires in the United States decreased steadily in the decade before, the U.S. Fire Administration (USFA) reported that more than thirty thousand structural fires were intentionally set across the nation in 2006. These cases of arson resulted in more than three hundred deaths and caused approximately $755 million in property damage. An estimated twenty thousand vehicle fires were also set in 2006, causing an additional $134 million in damages.

Based on the demographic patterns among those arrested for arson, most perpetrators are Caucasian males, the majority of whom are juveniles or young adults. The Federal Bureau of Investigation (FBI) reports that almost half of the people arrested for arson are under the age of eighteen, and up to two-thirds are younger than twenty-five. General trends show that between 80 and 90 percent of arson offenders are males, although the number of female arsonists has begun to increase. The FBI also reports that only a small percentage (15 to 20 percent) of arson cases, which are notoriously difficult to prosecute, result in an arrests or convictions. This meager success rate can be attributed to the loss of evidence caused not only by the intense heat of fires but also by firefighting efforts. By attempting to put out fires with pressurized water or fire suppression foam, firefighters often wash away any evidence that may point to arson.

Arson Fires in the United States, 1997-2006

Year	*Fires*	*Deaths*	*Direct Losses (millions)*
1997	78,500	445	$1,309
1998	76,000	470	$1,249
1999	72,000	370	$1,281
2000	75,000	505	$1,340
2001	45,500	330	$1,013
		2,451	$33,440
2002	44,500	350	$919
2003	37,500	305	$692
2004	36,500	320	$714
2005	31,500	315	$664
2006	31,000	305	$755

Source: U.S. Fire Administration, Federal Emergency Management Agency. Note that the first line for 2001 excludes the losses sustained in the terrorist attacks of September 11, 2001; the second line for that year includes those losses.

Motives

The people who set fires intentionally do so for many different reasons. Typically, arsonists are motivated by past events. For example, revenge is frequently a primary motive for arson—the arsonist believes that the damage caused by the fire is tantamount to whatever damage has been inflicted on the arsonist by the person targeted. Revenge arson is commonly committed by angry former spouses or significant others; some are committed by outraged students against their schools or by employees against their workplaces. Along similar lines, some arsonists commit their crimes to demonstrate their opposition to practices they deem offensive or immoral. These fires, usually initiated by radical activist groups, may target such organizations as companies that test their products on animals or genetic engineering research laboratories.

Other arsonists act with no prior instigation whatsoever. These people are considered pyromaniacs; they simply enjoy watching anything burn and set fires to satisfy their addiction. Fires set by juvenile offenders are frequently motivated by nothing more than the exciting sensation of pyromania. This infatuation with fire is classified as an impulse control disorder, but its causes and mechanisms of action are not well understood.

Another motive for arson is the wish to conceal the evidence of other crimes. For example, a murderer may set fire to the homicide crime scene in an attempt to obliterate any incriminating evidence, including the victim's body, or even to make the death seem accidental. Both the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) and the Drug Enforcement Administration (DEA) estimate that 30 percent of all arson fires in the United States are set in efforts to hide the effects of other crimes.

Insurance fraud is an increasingly common motive for arson. In old English common law, it was not considered arson for people to burn down their own houses or businesses, as they were allowed to destroy their own personal property as they saw fit. With the inception of property insurance, however, it became prudent for the law to define even the burning of one's own house or business as arson, to discourage the attempted fraudulent collection of insurance money. Arsonists who attempt to commit insurance fraud hope that the fires they set to destroy their homes or businesses will be ruled accidental, given that the determination of arson voids coverage by fire insurance policies.

Fire in Fiction

Don Winslow's *California Fire and Life* (1999) is a skillfully constructed novel about an insurance claims adjuster whose uncovering of an arson fire draws him into ever-deepening intrigue. Taking its title from the name of a fictional insurance company, the story provides a fascinating inside look at arson investigation that draws on Winslow's own long real-life experience in that field.

Another novel by an experienced arson investigator is John L. Orr's *Points of Origin . . . Playing with Fire* (1991). This story about a serial arsonist was written by a city fire captain and arson investigator who was himself convicted of three counts of arson soon after his book was published.

Methods

Arsonists use several different methods to set fires, although some are more common than others. The most common method involves the pouring of an accelerant—an ignitable liquid such as gasoline, kerosene, or lighter fluid—throughout the structure. The accelerant allows for easy ignition and also increases the rate and spread of the fire, which will follow the pour pattern of the accelerant. Many kinds of accelerants are readily available to arsonists; some are particularly dangerous because of their tendency to explode rather than just burn.

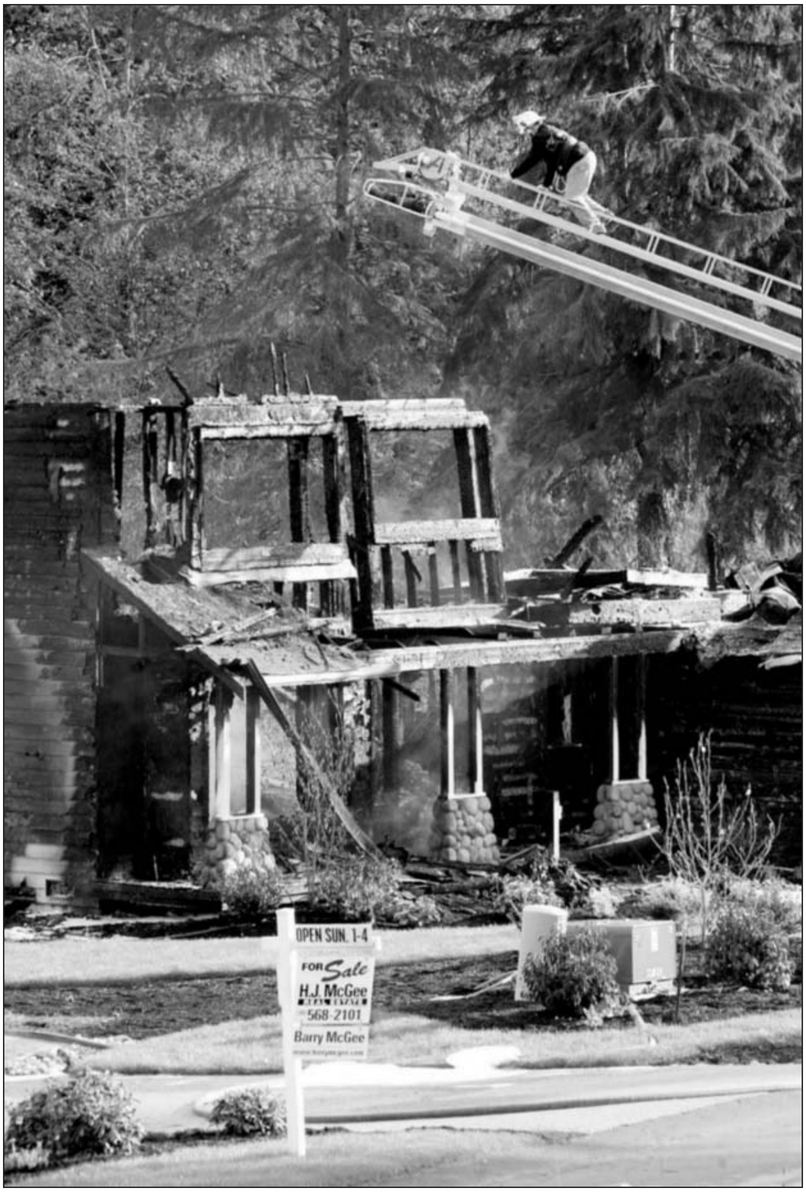
Some arsonists start fires by using incendiary devices, which can range from simple to very complex in their construction. Simple incendiary devices include lighted candles and flares, which can ignite their surroundings. Another frequently seen incendiary device is the Molotov cocktail: an ignitable liquid contained in a glass bottle along with a cloth soaked in the liquid that acts as a fuse. The cloth is ignited and the bottle is thrown at or into the structure, where, on impact, it shatters and the cloud of ignitable liquid vapor ignites a fireball that spreads to the surrounding areas.

Other chemical incendiary devices, such as those that utilize napalm, thermite, or white phosphorus, are rarely seen in civilian arson cases, although they are frequently used in military attacks. More complicated incendiary devices that operate on timers or other signals are seen occasionally in civilian arson cases. Fire investigators are careful to collect any evidence of incendiary devices found at fire scenes; such evidence may include shattered glass, burned cloth, wires, batteries, and other items that may have been used in timing mechanisms.

Investigations

Arson investigators face difficult, and sometimes dangerous, work at scenes where intensive fires have taken place. At such scenes buildings are often reduced to ruins, making them dangerous to enter and also often making it difficult for investigators to discern the features of the structures themselves. The main job of an arson investigation team is to sift through the soot and charred debris at the fire scene and determine the point of origin of the fire. The origin, along with the evidence around it, plays a significant role in identifying whether the fire was accidental or intentional.

The origin of a fire is determined from the direction and intensity of the burn patterns that are observed along the remaining parts of the structure or in the charred debris itself. A fire tends to burn up and out from its point of origin, which results



A deputy fire marshal for Snohomish County, Washington, climbs a fire ladder to photograph the damage done to one of three newly constructed homes that were the targets of arson in 2004. The press office for the Earth Liberation Front, a group that uses radical means to stop what members consider to be the destruction of the natural environment, stated that members of the group were probably responsible for the fires. *(AP/Wide World Photos)* in the commonly observed V-shaped pattern in which the V typically points back to the source of ignition. Trailers, or pour patterns, are also commonly observed at arson scenes. Arsonists often pour accelerants throughout structures in order to maximize the spread of the fire, and areas of intense burning follow the pouring patterns.

After determining a fire's point of origin, the investigators can begin to hypothesize exactly what caused the fire. Evidence suggesting the presence of faulty wiring or a gas leak around the origin point may indicate that the fire was accidental in nature. If the area around the origin appears to have burned more significantly than it should have for the fuel load present, however, the fire may be determined to have been set intentionally. Other signs that point to arson include multiple sources of origin, accelerant pour patterns, and evidence of an incendiary device.

The area around the origin of a fire contains the most significant evidence about the cause of the fire. Arson investigators must collect and package as much debris from the scene as possible to be sent to the forensic laboratory so that more detailed analyses can be performed to corroborate the initial findings at the fire scene. If accelerant use is suspected, the investigators will usually focus on several types of debris around the origin, as well as any debris showing potential pour patterns, in collecting evidence. Control samples are also be taken for reference. For example, if burned carpet samples are collected because they are suspected to contain accelerant residue, samples of carpet that are not burned, if available, are collected also so that forensic analysts can determine whether any potential accelerant identified in the burned carpet is actually inherent to the carpet itself. The debris collected is stored in airtight containers, typically unused metal paint cans, for transport to the lab; such containers prevent any loss of the volatile components that are present in most commonly used accelerants.

Forensic Analysis of Fire Debris Evidence

After the packaged evidence is received at the crime laboratory, it is analyzed for the presence of accelerants. Gas chromatography coupled with mass spectrometry (GC-MS) is the conventional analytical technique used to identify unknown liquids that are potential ignitable liquids, as well as ignitable liquid residues in fire debris. Before GC-MS analysis can be conducted, the ignitable liquid residue must be extracted from the fire debris. A variety of methods can be used to perform this extraction, the most popular of which is passive headspace adsorption/elution with activated charcoal strips.

Accelerants are identified from fire debris through chromatographic comparison of the pattern of the peaks present in the questioned sample to the pattern of peaks present in a known standard. Accelerants are classified according to a standard system developed and maintained by the American Society for Testing and Materials (ASTM). This classification scheme separates ignitable liquids based on chemical composition as well as boiling-point range.

Accelerant identification is subjective, and the experience of the analyst plays an important role. Identifying accelerants can be problematic because several materials commonly found in American homes contain ignitable liquid residues or compounds that are chemically very similar to such residues. Analysts must take these interferences into account when interpreting analytical results. Researchers who are examining methods of fire debris analysis are working on developing more objective methods for the identification of accelerants that are capable of placing a statistical confidence level on such identification.

Lucas J. Marshall

Further Reading

Almirall, José R., and Kenneth G. Furton, eds. *Analysis and Interpretation of Fire Scene Evidence*. Boca Raton, Fla.: CRC Press, 2004. Comprehensive collection addresses many aspects of fire scene investigation and the chemical analysis of fire debris.

DeHaan, John D. *Kirk's Fire Investigation*. 6th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007. Detailed volume covers the physical nature and chemistry of fire. Includes extensive discussion of arson fires.

Faith, Nicholas. *Blaze: The Forensics of Fire*. New York: St. Martin's Press, 2000. Describes how fire investigators work and the methods that forensic scientists use to contribute to solving the crime of arson.

Nic Daéid, Niamh, ed. *Fire Investigation*. Boca Raton, Fla.: CRC Press, 2004. Compilation provides material on the basics of fire investigation as well as informative discussion of laboratory reconstruction and analytical techniques.

Redsicker, David R., and John J. O'Connor. *Practical Fire and Arson Investigation*. 2d ed. Boca Raton, Fla.: CRC Press, 1997. Describes in detail the various steps involved in fire investigation, from scene investigation to courtroom testimony.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007. Textbook discusses all areas of the forensic sciences, including arson investigation.

See also: Accelerants; Bureau of Alcohol, Tobacco, Firearms and Explosives; Burn pattern analysis; Carbon monoxide poisoning; Fire debris; Gas chromatography; Mass spectrometry; National Church Arson Task Force; Smoke inhalation; Spectroscopy; Structural analysis.

Art forgery

Definition: Deliberate manufacture and sale of misattributed works of art with intent to defraud.

Significance: With individual works of art by acknowledged masters selling for millions of dollars, art forgery is a high-stakes business involving finances, academic reputations, and national pride. Despite great advances in scientific methods of analysis, identification of the most meticulously crafted forgeries still depends on the subjective aesthetic judgment of experts. The authenticity of some works remains uncertain despite exhaustive study, and many fakes undoubtedly escape detection altogether. Forensic analysis can also prove an artwork genuine.

The crime of art forgery is nearly as old as art. Archaeologists have unearthed objects with faked inscriptions from the ruins of ancient Babylon and Egypt. A passion for Greek statuary led the Romans to produce numerous works in the style of classical Greek artists. During the Middle Ages, artists embellished religious relics to reinforce the impression that the objects had biblical origins. The Renaissance produced another flurry of reproductions of Greek and Roman statuary. Commercial art forgery, however, really blossomed in the eighteenth century. With the rise of private collectors and public collections of works of art, demand for examples of choice antiquities and works by popular artists greatly exceeded supply, prices skyrocketed, and unknown artists discovered the monetary advantages of passing off copies of the works of the masters as the real thing.

Scope and Limits of Art Forgery

In general, a reproduction or modern work in historic style is not considered to be a forgery unless it would deceive a knowledgeable buyer. A search of any flea market or low-end antique shop will turn up numerous small art objects, purportedly old, that bear obvious signs, through materials and workmanship, of their recent origin in Asian factories. Sometimes the deception is more elaborate, as in the case of one scheme in which an importer commissioned not only bronze "Tiffany" belt buckles but also a forged catalog, dated 1950, advising collectors of the scarcity and value of an item the Tiffany company never made.

Folk art is another gray area. An item newly handmade in a traditional manner assumes aspects of a forgery if it is deliberately altered to simulate age and traditional use. The countries or regions of origin of such items may also be misrepresented, as with "African" carvings from Indonesia or "Amish" quilts from India. The inauthenticity of fake antiques and folk art can usually be detected readily through analysis of materials (such as wood species) and telltale traces of artificial aging.

Some forgeries involve overzealous restoration of or addition of spurious elements to otherwise authentic pieces. A fad for collecting fifteenth and sixteenth century majolica ware

Special Agent John Stevens of the Florida Department of Law Enforcement stands with two forgeries of sculptures purportedly created by artist Frederic Remington. The art dealer arrested for selling the fakes had duped art buyers out of hundreds of thousands of dollars. *(AP/Wide World Photos)*

during the late nineteenth century spawned a whole industry, first of re-creating missing parts for damaged excavated pottery and then of fabricating entire pieces. Two brothers apprenticed to this trade, the Riccardis, used their skill at faking antique ceramics to perpetrate one of the most notorious art frauds in history, the monumental Etruscan warriors displayed for three decades in New York City's Metropolitan Museum of Art. Analysis of the glazing and construction techniques used on the pieces raised suspicions, and thermoluminescence testing confirmed the pieces as modern.

The most spectacular examples of art forgery have been those in which forgers have created completely new pieces that have passed as the works of famous artists. Successfully carrying off such a forgery requires a high degree of technical skill in the medium used by the artist being imitated, knowledge of the materials and techniques appropriate to that artist's period, careful study of comparable pieces by the artist, and the creation of a plausible chain of provenance (history of ownership) that explains how a previously unknown work by an acknowledged master came to be on the market.

Most nations have enacted laws against exporting national art treasures and archaeological artifacts, and many also have internal laws regulating traffic in such items, such as the regulations prohibiting private excavation and sale of pre-Columbian ceramics within the United States. These laws aid art forgers by making the origins of artworks difficult to trace and by creating reluctance on the part of collectors to publicize their holdings or to consult experts.

Wars and civil upheaval create windows of opportunity for both art thieves and art forgers. Multiple copies of authentic artifacts stolen from museums or private collections often appear on the black market during such chaotic periods. Later, when experts attempt to return these items to the original owners, they must distinguish originals from replicas; they may even conclude that all of the recovered works are fakes, raising the possibility that the original exhibited works were forgeries all along.

Detecting Art Forgery

The question of forgery usually arises when works of art are sold or transferred. Collectors and museums are understandably reluctant to amass evidence that tends to show that their existing holdings, especially showpiece items, are fakes. If they engage experts to examine controversial pieces, it is usually their hope that the findings will support the works' authenticity.

To determine whether a work of art is genuine, the dealer or buyer first has it examined by an expert in the artist, the art form, or the period; the expert compares it with known authentic works and looks for telltale signs of the forger's art, such as lines painted on canvas to simulate the cracking that occurs in old paintings. A labored and hesitant technique indicates a copy, but not necessarily a deliberate forgery. A specialist can detect anachronisms in the clothing and furnishings depicted in an artwork.

Judgments concerning conformity of a particular work to a known artist's style are highly subjective. The same expert who praised the style and artistic quality of a piece while believing it to be genuine may as vociferously point to its artistic worthlessness when it is exposed as the work of an impostor. Experts who work for dealers may have a vested interest in overlooking subtle indications that something is not right, and a few are actually in league with forgers. Experts also examine ownership and sales records to determine whether the provenance of a work has been falsified.

Some researchers have begun using computers to compare complex visual images in an attempt to detect art forgery, but this technology is still in its infancy. A team at Dartmouth University has developed a program for analyzing the frequency and density of brushstrokes in digitized images of paintings. Use of this program to compare different portions of a large painting attributed to the late fifteenth and early sixteenth century Italian painter Perugino (Pietro Vannucci) reinforced expert opinion that several artists contributed to the work. One advantage of this kind of analysis is that the analyst does not need to have the actual work of art in hand.

Most scientific detection of art forgeries relies on techniques that determine the age, chemical makeup, and probable source of the materials used as well as on various means of determining the works' internal structure. For wooden sculptures and paintings on wood or canvas, radiocarbon dating of minute fragments places the substrate within a century but cannot distinguish an old copy or a modern fake executed with antique materials. The notorious Dutch forger Han van Meegeren, working in the 1930's, used seventeenth century canvases from which he had scraped originals by obscure artists. Eric Hebborn, in the 1950's and 1960's, used blank pages removed from antique books to forge drawings in the style of the old masters. Both men mixed their own paints and inks from materials available in the seventeenth century; Hebborn also carefully reproduced period pens and brushes to ensure the right quality of line. Suspicion fell on Manhattan art dealer Ely Sakhai when he purchased large numbers of inexpensive late nineteenth century paintings not intended for resale. Sakhai, who was convicted of fraud in U.S. federal court in 2004, purchased genuine Impressionist paintings from auction houses, commissioned forgeries of the works from an artist, probably in China, whose name remains unknown, and sold the fakes to Japanese collectors. The fraud came to light when Sakhai and one of his victims simultaneously tried to sell the "same" painting.

Dendrochronology, or tree-ring dating, can be used to date some wooden objects. The pattern of rings in the wood indicates the years in which the tree was alive; for example, a violin with a spruce sounding board from a tree felled after 1890 obviously cannot be an authentic Stradivarius, as the last Stradivarius violin was made in the early part of the eighteenth century.

Penetrating X rays can be used to reveal images covered by a final coat of paint, including the artist's preliminary sketches, portions of a painting that have been reworked, and entirely different pictures. Using X-ray technology, an expert can detect such telltale signs of forgery as an under-image of obviously later date than the surface image and retouching intended to introduce the characteristic stylistic peculiarities of a known artist into a mediocre painting by an unknown hand.

Thermoluminescence dating is a useful technique for determining when pottery was fired. Crystalline minerals stored at room temperature accumulate electrons in elevated energy states; when subjected to high heat, the minerals release this energy in the form of light, the intensity of which is proportional to the amount of time since the object was last heated.

Tests involving X-ray emission and X-ray fluorescence are two recently developed techniques used to determine the chemical composition of objects without destructive sampling. When subjected to a high-energy beam of radiation, compounds reemit radiation at a lower frequency in bands diagnostic of the elements and molecules present. Because the presence of certain compounds narrows the time frame in which a work could have been created, this method is helpful in identifying restorations and additions.

Analyses of trace elements and stable isotopes are used to identify the sources, and sometimes the ages, of materials used in artworks. Modern smelting methods generally produce much purer metals than were available in earlier times. Competent art forgers know that lead carbonate, rather than titanium oxide or zinc oxide, was the white pigment used by painters before 1920, but unless they have access to the same natural sources of lead carbonate used by Europeans in the seventeenth century, they will not be able to duplicate the profile of trace elements. Trace impurities help distinguish old silver items from modern reproductions. Elements with more than one stable (nonradioactive) isotope can pinpoint the quarry or mine from which raw materials came; thus, for example, analysis of stable isotopes can distinguish whether a white marble sculpture in classical Greek style is Greek, Roman, Renaissance Italian, or modern in origin.

Sometimes scientific analysis vindicates a dealer's or collector's claim that an artwork is genuine. In one case, a Roman marble bust that was believed to be a nineteenth century forgery on stylistic grounds proved to be genuinely ancient. Analysis showed that a nineteenth century dealer in antiquities had "improved" on the work by sculpting away some of the original drapery. In the early twentieth century, the financier J. P. Morgan purchased a collection of silver plates depicting religious scenes that were supposedly excavated in Cyprus and dated to the third to fourth centuries C.E. Experts labeled the plates modern forgeries on stylistic grounds. When they were later reassessed us-

Art Forgery as Defense

One of history's most notorious art forgers used his craft as a successful defense against treason. Han van Meegeren, a mediocre Dutch painter who adopted an archaic style in his own work, began turning out forgeries of works by seventeenth century Dutch painter Jan Vermeer during the 1930's, using antique canvases, period paints, and an aging process that was undetectable at the time. The outbreak of World War II helped Van Meegeren in that it made it more difficult for art buyers to gain access to experts and added plausibility to stories of the discovery of previously unknown art treasures.

Nazi *Reichsmarschall* Hermann Göring was one of Van Meegeren's customers, and after the war, Van Meegeren was accused of collaboration with the Nazis and selling national treasures. He confessed to having painted the picture himself, and, to prove that he was telling the truth, he produced another fake Vermeer in his prison cell.

Any admiration attached to Van Meegeren for having swindled Göring must be tempered by the fact that he also swindled a number of his fellow Dutch, was motivated entirely by greed, and produced clumsy forgeries that, in retrospect, should not have fooled anyone. When listing his other forgeries for the court, Van Meegeren included paintings for which he was almost certainly not responsible, the authenticity of which is still disputed.

ing trace element analysis as well as analysis of production techniques and manufacturer's marks, however, they proved to be seventh century eastern Roman artifacts made in a deliberately archaic style.

Art Forgery as a Criminal Defense

Art forgers themselves are rarely successfully prosecuted for creating fake art. Because the crime lies not in creating something indistinguishable from a valuable original but rather in marketing it as such, forgers can argue that buyers were deceived by the dealers who sold their works. Frank Kelley, a prolific forger of Impressionist paintings, protected himself by signing his forgeries in white lead, which was readily detectable in X rays. Because of the high level of skill required to forge fine art and a lack of public sympathy for wealthy collectors, successful art forgers may attain the status of public heroes.

Creating and marketing bogus art treasures is simple commercial fraud, typically a much less serious charge than theft, trafficking in stolen goods, conducting clandestine archaeological excavations, or smuggling. Consequently, art forgery operations may be exposed when a party accused on one of these crimes confesses that the goods are fake.

Martha Sherwood

Further Reading

Chervenka, Marc. *Antique Trader Guide to Fakes and Reproductions*. 3d ed. Iola, Wis.: Krause, 2003. Contains much useful advice for the private collector on how to detect mass-produced copies of lower-end nineteenth and early twentieth century art objects.

Hebborn, Eric. *Drawn to Trouble: Confessions of a Master Forger*. New York: Random House, 1991. An experienced forger offers an insider's view, describing how the drawings of the old masters are forged and marketed. Compelling reading.

Hoving, Thomas. *False Impressions: The Hunt for Big-Time Art Fakes*. New York: Simon & Schuster, 1996. A former director of New York City's Metropolitan Museum of Art provides a work that is part history and part vivid firsthand account.

Jones, Mark, ed. *Fake? The Art of Deception*. Berkeley: University of California Press, 1990. Published as a companion to an exhibit of notorious forged art pieces, this copiously illustrated volume examines forgeries and their unmasking on a case-by-case basis.

Spencer, Ronald D. *The Expert Versus the Object: Judging Fakes and False Attributions in the Visual Arts*. New York: Oxford University Press, 2004. Describes scientific methods for authentication of artworks and analyzes the psychological factors that facilitate successful art forgery.

See also: Counterfeiting; Forgery; Handwriting analysis; Paint; Paper; Questioned document analysis; Sports memorabilia fraud; X-ray diffraction.

Asian tsunami victim identification

Date: Tsunamis struck on December 26, 2004

The Event: An earthquake measuring 9.3 on the Richter scale triggered tsunamis that devastated the coastlines of several Asian countries. One of the worst mass-casualty disasters in history, the tsunamis killed as many as 250,000 people, including Asians living in coastal communities and many tourists from Western nations.

Significance: The Asian tsunamis of 2004 presented one of the biggest challenges ever faced by forensic teams in identifying the bodies of massive numbers of victims of a natural disaster. The identification effort drew experts from thirty different nations and produced successful collaboration among them.

On December 26, 2004, a massive earthquake struck in the ocean near the west coast of Sumatra, Indonesia, and triggered a series of deadly tsunamis. It has been estimated that up to 250,000 people became tsunami victims along the coasts of many countries bordering the Indian Ocean; victims included the citizens of eleven countries, many of them tourists who were spending time at Asian resorts. An estimated two million people lost their homes, and thousands were reported missing. The magnitude of the tragedy was unprecedented, and it created an unprecedented challenge for the forensic teams that came together to identify the dead.

The Disaster Victim Identification Center

Following the tsunamis, many bereaved families sought assistance in identifying the dead. Despite their pleas for help, the rate at which the bodies were decomposing caused concerns about epidemics and forced local communities and national authorities to sanction mass burials without identification of the bodies. Many Western states, however, exerted every effort to ensure that their citizens who had died were identified before their remains were interred or cremated.

The challenges of identifying victims after the tsunami were daunting. High temperatures accelerated the rate of decomposition of the bodies, and the bloating and discoloration of faces made visual identification almost impossible after two days. Refrigeration was not immediately available to preserve the remains. In addition, no single country among those affected had sufficient forensic capacity to identify thousands of victims. Lack of national and local plans for mass fatalities further limited the quality and timeliness of the response, as did the absence of practical field guidelines or an international agency to provide technical support.

To respond to the problem of victim identification, Thai authorities set up a multinational disaster victim identification (DVI) center in Phuket, Thailand. The center drew the participation of three hundred investigators from thirty countries. Many of these investigators had expertise in DVI, having worked on teams that had identified mass fatalities from wars, natural disasters, and terrorist attacks.

The global effort to identify the victims of the tsunamis involved the participation of private corporations as well as individuals. Kenyon International Emergency Services, for example,

A volunteer takes fingerprints from the body of a victim of the Asian tsunamis of December, 2004, as part of the identification process. Forensic teams from around the world contributed to the effort to identify thousands of victims of the catastrophe. *(AP/Wide World Photos)*

conducted operations and eventually handed over a state-of-the-art identification tool kit worth ten million dollars to the Royal Thai Police's Thai Tsunami Victim Identification (TTVI) unit. Kenyon fielded more than one hundred employees to help create and run a comprehensive forensics database for use by analysts and Interpol experts who worked at the TTVI center in Phuket.

Identification of the tsunami victims was extremely difficult because many bodies recovered from the sea were badly decomposed. The scientists made positive identifications by analyzing dental records, fingerprints, or DNA (deoxyribonucleic acid); relatives of the deceased provided DNA samples and information that helped identify the bodies.

The Information Management Center at the DVI center processed several types of data, including postmortem data collected during victim examinations conducted in temporary morgues and antemortem data on possible victims gathered from the numerous countries involved. These data were entered into the PlassData system under standard operating procedures laid out by the Interpol Disaster Identification Manual. When the scientists were able to match dental, fingerprint, or DNA records with a body, they presented their findings to the Thai Reconciliation Commission, which, if satisfied, authorized the issuance of a Thai death certificate.

Dental Records

The identification of tsunami victims through the use of dental information (forensic odontology) proved to be highly efficient, reliable, and fast. This method of victim identification, however, favored nationals of Western states, who typically had dental records that helped in the identification process. Dental data were generally unavailable for the Thai population, so this method led to the identification of only a small number of Thai victims. In contrast, for non-Thai victims the successful identification rate using dental data was about 80 percent.

Antemortem dental treatment data include X rays and treatment records as well as plaster models. In most cases, reliable identification of bodies using dental data depends on the availability of recent, high-quality data. If the dental data are scarce or old, investigators must utilize all available methods of identification and the assistance of experienced forensic odontologists to achieve reliable results. In the case of the tsunami victims, this was the case especially for children and adolescents, who had had no or very little dental treatment.

The reliability of dental records as a means of identification became evident early in the work with tsunami victims. After the first three months, 88 percent of the successful identifications of victims had been accomplished with the help of dental data. The large majority of those successfully identified were non-Thai victims.

Unidentified Bodies

One year after the tsunamis struck, the TTVI center had identified all but 805 of the 3,750 bodies it had received for analysis. About 45 percent of the identifications had been made through dental records, 35 percent through fingerprint analysis, and the remaining 20 percent through DNA analysis. The remaining unidentified bodies were kept in refrigerated containers as efforts to identify them continued. Many of the unidentified were believed to be illegal immigrants, which could explain why their relatives were reluctant to claim them. One year after the tragedy, 160 non-Thais and 548 Thais remained missing.

Two years after the tsunamis, Thailand opened a cemetery for the last of the unidenti-

Controversy in the Identification Process

Despite the progress made in victim identification following the Asian tsunamis, some complaints surfaced, particularly in regard to the use of funds in carrying out the identifications. In a joint letter sent to the Thai authorities in December, 2006, some Western countries demanded an audit, alleging that funds donated for the purpose of completing the identifications had been misused. The letter was signed by the ambassadors to Thailand from Finland, Germany, the Netherlands, Sweden, the United Kingdom, the United States, and France.

The letter noted that more than four hundred recovered bodies remained unidentified and that more than four hundred persons were still missing two years after the tsunamis. The diplomats stated their belief that among the two thousand bodies released to relatives shortly after the tsunamis struck (before the formal disaster victim identification center was established), some bodies had likely been misidentified. They urged the Thai authorities to complete the allegedly much-delayed analysis of the DNA samples taken from those bodies, to correct misidentifications and help identify the remaining bodies. The letter also raised the issue of suspected misuse of funds donated to support the identification work and requested a professional audit by a reputable private accountancy company to clear up the suspicions.

fied victims, about 400 bodies. The remains, mostly those of Burmese migrants, were buried in identical aluminum coffins. The graves are marked with concrete headstones that include registration numbers that will allow authorities to exhume the correct bodies if identifications are made in the future through the use of DNA samples taken from the bodies before burial.

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Further Reading

Alonso, Antonio, et al. "Challenges of DNA Profiling in Mass Disaster Investigations." *Croatian Medical Journal* 46, no. 4 (2005): 540-548. Examines the different steps of DNA identification analysis and reviews the lessons learned and the scientific progress made in some mass-disaster cases described in the scientific literature.

Kieser, Jules A., et al., "Lessons Learned from Large-Scale Comparative Dental Analysis Following the South Asian Tsunami of 2004." *Journal of Forensic Sciences* 51, no. 1 (2006): 109-112. Examines the quality of the antemortem and postmortem dental data that were submitted for entry into the PlassData system in Thailand following the tsunami of December 26, 2004.

Knoppers, Bartha Maria, Madelaine Saginur, and Howard Cash. "Ethical Issues in Secondary Uses of Human Biological Materials from Mass Disasters." *Journal of Law, Medicine and Ethics* 34 (Summer, 2006): 352-365. Addresses the ethical issues of secondary uses of samples collected for identification purposes following mass disasters. Examines whether research is ethically permissible on these samples and, if so, what kind of research.

Schuller-Götzburg, P., and J. Suchanek. "Forensic Odontologists Successfully Identify Tsunami Victims in Phuket, Thailand." *Forensic Science International* 171, nos. 2/3 (2007): 204-207. Analyzes the success rates in the use of dental records in victim identification after this mass disaster.

Sumathipala, A., S. Siribaddana, and C. Perera. "Management of Dead Bodies as a Component of Psychosocial Interventions After the Tsunami: A View from Sri Lanka." *International Review of Psychiatry* 18, no. 3 (2006): 249-257. Discusses the need for the development of a comprehensive and efficient psychosocial intervention at the community level after a disaster. Focuses on the management of the bodies of the dead as an integral part of such an intervention.

See also: Beslan hostage crisis victim identification; Croatian and Bosnian war victim identification; DNA fingerprinting; Fingerprints; First responders; Forensic odontology; Mass graves; National Transportation Safety Board; September 11, 2001, victim identification; Tattoo identification.

Asphyxiation

Definition: Act of causing death or unconsciousness by impairing normal breathing.

Significance: Immediately before death, the body enters a low-oxygen state as respiration slows. Forensically speaking, a death by asphyxiation is one in which the low-oxygen state happened in an unnatural manner, such as by suffocation or smothering.

Death by asphyxiation can occur in a number of ways: through airway obstruction, through displacement of oxygen, or through neck or chest compression. Forensic pathologists determine the types of asphyxiation in particular deaths by looking for certain signs.

In some cases, asphyxiation occurs when oxygen cannot get into the lungs because something is obstructing the airway. This could be a foreign object, such as food, that fills the throat or something from the body itself, such as the tongue or vomit. When oxygen cannot reach the lungs because the airway is swollen, whether as the result of an allergic reaction or heat, this is also classified as airway-obstruction asphyxiation. Hanging or garroting, in which the airway is physically pinched off by a rope or something else wrapped around the neck, is another type of airway-obstruction asphyxiation. This may occur during the practice of autoerotic asphyxiation, in which individuals enhance sexual pleasure by depriving the body of oxygen; this practice sometimes results in accidental death that may be mistaken for suicide.

Asphyxiation by displacement of oxygen is more commonly known as suffocation. It occurs when the oxygen in the air a person is breathing is replaced by something else, such as smoke, toxic fumes, or chemicals. Drowning also qualifies as this type of asphyxiation, as water replaces air in the lungs. In this type of death, pathologists generally observe no external signs of asphyxiation.

Compressing the chest or neck so that no air is able to enter the lungs is another type of asphyxiation. Neck compression, or strangling, also causes asphyxiation because the arteries leading to the brain are not able to provide oxygen to the brain.

A forensic pathologist looks for particular signs to determine whether asphyxiation was the cause of death and, if so, what type of asphyxiation occurred. One of these signs is cyanosis, or a bluish tinge to the skin caused by a decreased amount of oxygen in the blood at the time of death. Facial congestion or edema may occur in a strangling asphyxiation. Because blood is not able to return through the veins to the rest of the body, the face may be swollen. Petechial hemorrhages, which are small broken blood vessels, usually in the eyes, eyelids, or lining of the mouth and throat, may occur during a strangling or hanging type of death, when blood is not allowed to return to the body and the blood pressure causes the veins to rupture.

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Further Reading

Dix, Jay, Michael Graham, and Randy Hanzlick. *Asphyxia and Drowning: An Atlas*. Boca Raton, Fla.: CRC Press, 2000.

Sheleg, Sergey, and Edwin Ehrlich. *Autoerotic Asphyxiation: Forensic, Medical, and Social Aspects*. Tucson, Ariz.: Wheatmark, 2006.

See also: Autoerotic and erotic asphyxiation; Choking; Drowning; Hanging; Inhalant abuse; Petechial hemorrhage; Smoke inhalation; Suffocation.

Assassination

Definition: Intentional killing of a human being for political, moral, or ideological reasons.

Significance: The consequences of assassinations can often be greater than the consequences related to other murders because of the kinds of positions held by many of the targets of assassination; in cases of political assassination, for instance, wars or civil unrest may result. It is therefore critical that forensic investigations into such deaths determine the objective facts of these events.

Even a brief look at the history of assassination suggests the important role forensic science could have played in providing objective information as to cause of death in various assassinations. In ancient times, many assassinations were committed at very short range, as were many other murders. Victims were stabbed, strangled, or clubbed to death, and often the assassins, like other murderers, were quickly identified and apprehended. Philip II of Macedonia (382-336 B.C.E.) and Julius Caesar (100-44 B.C.E.) are only two of a long list of political leaders assassinated in ancient times.

Given the likely apprehension of assassins who used such short-range killing techniques as stabbing or strangling, poisoning became a widely used alternative. Although it required that the assassin gain immediate access to the target, poisoning constituted a much less obvious attack, and proving that someone had been poisoned was difficult after the fact. In the cases of such assassinations, better forensic science would have been helpful in the apprehension of the perpetrators. In modern times, the facts revealed through forensic science in the poisoning deaths of Bulgarian dissident Georgi Markov (poisoned with ricin) in 1978 and Russian dissident Alexander Litvinenko (poisoned with polonium 210) in 2006 pointed to the killers, implicating, in both cases, the secret police forces in Russia (under communist rule in 1978 and under the more "democratic" regime of Vladimir Putin in 2006). The motivation for both killings was presumably a desire to silence the victims' criticisms of the regimes under which they lived.

American Assassinations

The importance and the limitations of forensic science in the investigation of assassinations are clear in the modern era and in the United States, where law-enforcement resources make exhaustive investigations possible. In the cases of the assassinations of U.S. presidents James A. Garfield and William McKinley, in 1881 and 1901, respectively, the role of forensic science was small, as both were shot at close range by individuals who were captured immediately. The fact that the assassins of both presidents were obviously deranged obscured the political aspects of these events, but the questions raised by these assassinations later motivated attempts to use forensic psychology to construct profiles of persons who become assassins.

In the case of President Abraham Lincoln, dozens of spectators saw John Wilkes Booth, a well-known actor, leap from the president's box at Ford's Theatre after Booth fired the fatal shot. Better forensic science than was available in 1865 could have been helpful in resolving another aspect of the case, however. Booth escaped from the theater and from Washington, D.C., despite having injured his leg when he jumped from the president's box. Law-enforcement officials pursued Booth and eventually cornered him—or at least a person they believed to be him—in a barn in Virginia. Before they could take Booth into custody, the barn burned down, presumably with Booth inside. Although a corpse with an injured leg was recovered from the ashes, the body was too badly burned to be readily identified, and ever since that time, some commentators have raised the possibility that Booth may have escaped. If the techniques used by modern forensic scientists had been available then, the question of the burned man's identity would have been resolved.

Modern forensic science has sometimes been used in novel ways with regard to deaths of the past, including possible assassinations. For example, U.S. president Zachary Taylor was hated by certain political opponents, and his death in 1850, reputedly from food poisoning, was a boon to them. Although some suspicions were raised at the time, the primitive nature of forensic science precluded an effective analysis. In 1991, given the advances that had been made in forensic science, some researchers thought it might be possible to determine whether Taylor was in fact poisoned. His body was exhumed and examined by a team of experts who concluded that he had died of natural causes, most likely food poisoning.

Uses and Limitations of Forensic Science

Three major assassinations in recent American history provide ample examples of the uses of a wide variety of forensic scientific techniques in attempts to find objective evidence about these crimes. In the 1968 assassinations of the Reverend Martin Luther King, Jr., and Senator Robert F. Kennedy, the purported assassins (James Earl Ray and Sirhan Sirhan, respectively) were apprehended, convicted of the crimes, and sentenced to imprisonment for life. A preponderance of the forensic evidence in each case clearly supports the conclusion that the accused man was involved in the assassination—probably by actually pulling the trigger. However, the forensic evidence available so far cannot reveal whether anyone else might have been involved in either case. Both Ray and Sirhan denied their guilt and sought new trials. Ray died in 1998 without achieving his goal of a new trial, and Sirhan has had no success in gaining a retrial.

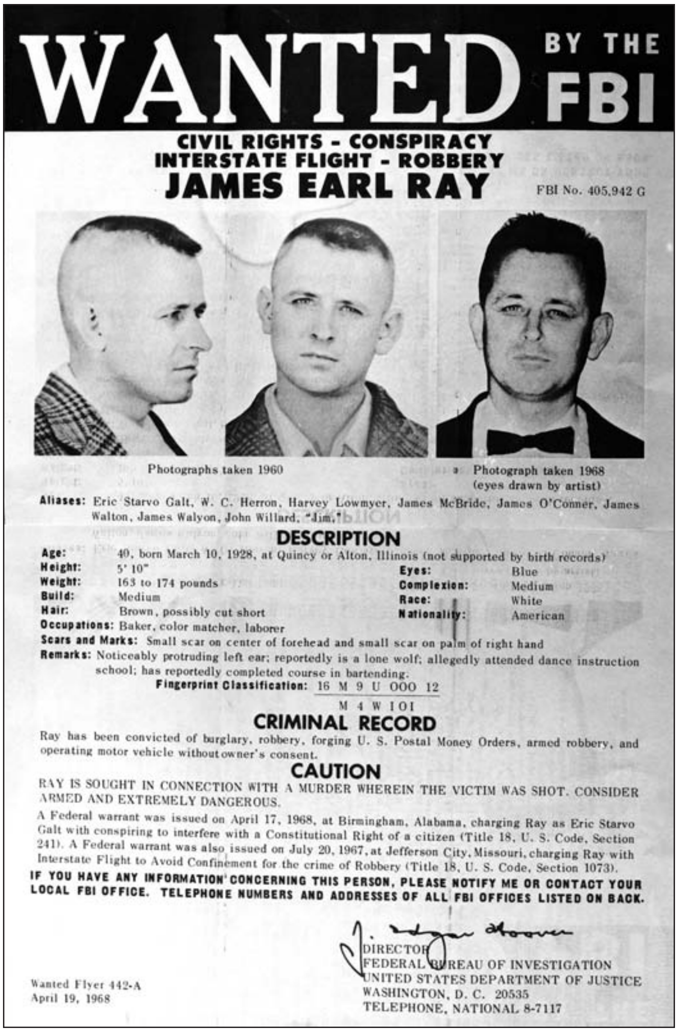
In the case of James Earl Ray, the heart of the issue turned on Ray's contention that he was set up as a fall guy by other conspirators who have never been found. Ray was the principal witness to the existence of any conspirators. Sirhan's case is more complicated, as he clearly fired a gun in the direction of Senator Kennedy and was seized at the scene. Some conspiracy theorists, however, question whether any of the shots Sirhan fired at Kennedy actually struck him. They argue that there was a second gunman who fired two shots—one of which was the fatal shot to the head.

The conspiracy theorists gained a major piece of supporting forensic evidence for their theory when a tape recording of the shooting was found. Three acoustical experts have concluded that the tape reveals that at least ten shots were fired at the scene. Given that Sirhan was apprehended with a single gun with only eight shells in it and that he had no time to reload, this points to the existence of a second gunman. The recording further reveals that some of the shots came too close together to have been fired by Sirhan's weapon. Whatever one makes of this evidence, the basic problem is that forensic science often cannot eliminate the possibility that persons other than the person who pulls the trigger may have been involved in an assassination.

Nowhere is this clearer than in the case of the assassination of President John F. Kennedy in 1963. The first major report on the assassination by the government investigative panel known as the Warren Commission claimed to provide a thorough review of the available forensic evidence, but subsequent research has shown a great deal of sloppiness in the commission's work—inadequacies that have fueled a plethora of conspiracy theories. The proponents of these theories advance different forensic evidence or arrive at strikingly different conclusions based on the same evidence. The greatest problem with the use of forensic science in the case of the Kennedy assassination has been the failure of various government agencies to maintain control of the evidence on which the forensic science relies. For example, if—as some contend—Kennedy's body was altered to make it appear that he was shot from the back when he was in fact shot from the front, then any subsequent autopsy would obviously be faulty.

Despite the advances that have been made in forensic science, forensic evidence often cannot answer every question related to a case of political assassination, including the question of whether anyone other than the direct assassin is involved.

Richard L. Wilson



Wanted poster for James Earl Ray, the suspected assassin of Martin Luther King, Jr. Ray was apprehended in London, England, slightly more than two months after King was shot in June, 1968. *(AP/Wide World Photos)*

Further Reading

Ayton, Mel. *The Forgotten Terrorist: Sirhan Sirhan and the Assassination of Robert F. Kennedy*. Washington, D.C.: Potomac Books, 2007. Comprehensive review of the Robert F. Kennedy assassination supports the view that Sirhan, a Palestinian, was the assassin, motivated by his hatred of Kennedy's support of Israel.

Bugliosi, Vincent. *Reclaiming History: The Assassination of President John F. Kennedy*. New York: W. W. Norton, 2007. A major supporter of the Warren Commission's conclusion that Oswald was the lone assassin offers an exhaustive reexamination of the evidence from his point of view.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Forensic Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005. Provides an excellent overview of forensic science for the general reader.

Kurtz, Michael L. *The JFK Assassination Debates: Lone Gunman Versus Conspiracy*. Lawrence: University Press of Kansas, 2006. Weighs the forensic evidence supporting the views of both sides of the main debate concerning the Kennedy assassination. One of the best sources available on the topic.

Lifton, David S. *Best Evidence: Disguise and Deception in the Assassination of John F. Kennedy*. New York: Signet, 1992. Argues that much of the forensic evidence used to prove Oswald was the lone assassin is faulty because Kennedy's body was altered before the official autopsy to prove that Kennedy was shot only from behind, whereas he was really shot from the front.

Posner, Gerald. *Case Closed: Lee Harvey Oswald and the Assassination of JFK*. New York: Random House, 1993. Carefully reviews the forensic evidence and concludes that Oswald—and Oswald alone—killed Kennedy.

_______. *Killing the Dream: James Earl Ray and the Assassination of Martin Luther King, Jr*. San Diego, Calif.: Harcourt Brace, 1999. Exhaustive account marshals all the forensic evidence to support the argument that James Earl Ray killed Martin Luther King while holding out the possibility that Ray may not have acted alone.

Sturdivan, Larry M. *The JFK Myths: A Scientific Investigation of the Kennedy Assassination*. St. Paul, Minn.: Paragon House, 2005. Comprehensive account of the forensic evidence disposes of several myths about the assassination without conclusively resolving all potential conspiracies.

See also: Ancient criminal cases and mysteries; Ballistics; Eyewitness testimony; Federal Bureau of Investigation Laboratory; Fingerprints; Forensic psychology; Gunshot residue; Kennedy assassination; Markov murder; Silkwood/Kerr-McGee case; Taylor exhumation.

ATF. *See* Bureau of Alcohol, Tobacco, Firearms and Explosives

Athlete drug testing

Definition: Analyses conducted on athletes to determine if they have taken banned substances.

Significance: Athletes competing at high levels seek to gain advantages over their opponents. Some do so by using substances that they believe can improve athletic performance or the body's physical work capacity. Many of these substances are drugs and many are banned by various organizations that regulate sports, such as the National Collegiate Athletic Association and the International Olympic Committee. Despite such bans, some athletes still use these substances, making drug testing necessary to keep competition fair. Athletes who fail drug tests may be ruled ineligible for competition or may have their previously awarded medals or titles revoked.

The use of particular substances to improve athletic performance dates back to the ancient Greeks. It was not until 1928 that the International Amateur Athletic Federation became the first sports organization to ban athletes' use of certain substances. The federation, however, had no way to detect whether athletes were breaking the rules, and the use of performance-enhancing substances continued to increase. Drug testing of athletes for banned substances was first used in 1966 by the international federations governing the sports of soccer and cycling. They were soon followed by the International Olympic Committee (IOC), which began drug testing in 1968 with the Grenoble Winter Olympic Games and the Mexico City Summer Olympic Games. The first athlete in Olympics history to be disqualified based on the results of drug testing was a Swedish modern pentathlon participant who tested positive for excessive alcohol in Mexico City.

By the 1970's, the widespread use of anabolic steroids among athletes forced the introduction of drug testing by most international sports organizations. The National Collegiate Athletic Association (NCAA) implemented a drug-testing program in the fall of 1986 for all athletes participating in NCAA bowl games and national championships. By 1990, the NCAA had adopted year-round testing of athletes on teams within the association.

Drug-Testing Techniques

Common methods used to detect illicit drug use include the testing of blood, urine, hair, and saliva samples. The method chosen for a particular purpose must take into consideration the accuracy level provided by the test, the ease of

U.S. major league sports executives and player representatives appear before the Senate Commerce, Science, and Transportation Committee in September, 2005, to discuss drug-testing policy. From left: Antonio Davis, president of the National Basketball Association (NBA) Players Association; David Stern, NBA commissioner; Gene Upshaw, executive director of the National Football League (NFL) Players Association; Paul Tagliabue, NFL commissioner; Donald Fehr, executive director of the Major League Baseball Players Association; Ted Saskin, executive director of the National Hockey League (NHL) Players Association; and Gary Bettman, NHL commissioner. *(AP/Wide World Photos)* obtaining the sample, and the period of time for which the test can detect drugs in the sample. Urine testing is most commonly used for athletes because it is accurate, no cutting or piercing of the skin is involved, and it can detect drug use for the previous seven days or longer.

To complete a urine test, an athlete must provide a fresh sample of urine collected in a clean vessel under supervision. Although this may be awkward for some, it is important that the tester be certain that the vessel contains that particular athlete's actual urine. After the vessel is appropriately labeled, it is sent to a laboratory for analysis.

The techniques used to examine urine for the presence of drugs include gas chromatography, mass spectrometry, and immunoassay. In gas chromatography, the urine sample is vaporized in the presence of a gaseous solvent as it travels through a machine called a gas chromatograph. Because the various substances in the urine dissolve in the solvent at different rates, they come out of the solvent at different times, leaving a pattern on a liquid or solid material. The pattern is analyzed by a detector, and a chromatogram is produced. Because different drugs produce different chromatograms, the analyst can compare the urine sample output with known drug outputs to identify the presence of specific drugs in the urine.

A mass spectrometer is a machine with a long magnetic tube with a detector on the end. An electron beam blasts the urine sample and sends it down the tube to the detector. Every substance has a unique mass spectrometer output, so by comparing the outputs of known drugs with the urine output, the analyst can identify any specific drugs present in the urine.

Immunoassay tests are used to detect the presence of hormonelike drugs in urine. A specific antibody (a protein that binds to particular substances) is tagged with a fluorescent dye or a radioactive marker and then mixed with the urine sample. The antibody binds to the drug (hormone), and the analyst measures the amount of fluorescent light or radioactivity in the sample to determine the amount of the drug or hormone present. Because this test also measures naturally occurring hormones in the urine, the analyst must know the athlete's natural hormone level to determine whether the athlete has taken a hormonelike drug.

Challenges to Drug Testing

In 1987, one year after the NCAA adopted its drug-testing program, a member of Stanford University's women's diving team filed a lawsuit in which she claimed that the program violated her right to privacy. As the case made its way through the courts, the drug testing continued, and in 1994 the California Supreme Court ruled that the NCAA was "well within its legal rights" to conduct drug testing. This ruling cleared the way for other athletic organizations to establish drug-testing programs.

The ongoing challenge of athletic drug testing is the constant development of new drugs that existing methods and technologies are unable to detect. Athletes are continually looking for new advantages, and manufacturers are developing new drugs to improve athletic performance. After a new performance-enhancing substance becomes available, it often takes months or years for it to become popular enough to warrant the attention of sports officials. Then months or even years may elapse before scientists can develop new tests to determine whether athletes have used these drugs. During this lag of up to several years before a given drug is detectable, even more drugs are developed and the process begins again. This cycle creates a perpetual challenge to those who seek to keep sports competitions free from the use of banned performance-enhancing substances.

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Further Reading

Bahrke, Michael S., and Charles E. Yesalis, eds. *Performance-Enhancing Substances in Sport and Exercise*. Champaign, Ill.: Human Kinetics, 2002. Text includes information on the history of athletes' use and abuse of performance-enhancing drugs. Chapters 27 and 28 address the topic of drug testing in sports.

Cotten, Doyice J., and John T. Wolohan. *Law for Recreation and Sport Managers*. 3d ed. Dubuque, Iowa: Kendall/Hunt, 2003. Comprehensive text on sports law includes information on drug testing of athletes in chapter 7.

Gardiner, Simon, Mark James, John O'Leary, and Roger Welch. *Sports Law*. 3d ed. Portland, Oreg.: Cavendish, 2006. Discusses the legal issues related to governing sports. Chapter 7 is devoted to the topic of illegal doping and includes discussion of drug testing.

Ray, Richard. *Management Strategies in Athletic Training*. 3d ed. Champaign, Ill.: Human Kinetics, 2005. Chapter 10 provides an overview of existing programs concerned with athlete drug testing.

Yesalis, Charles E., and Virginia S. Cowart. *The Steroids Game*. Champaign, Ill.: Human Kinetics, 1998. Provides interesting historical information about how drug testing has been used in sports and how athletes have tried to beat the tests.

See also: Anabolic Steroid Control Act of 2004; Analytical instrumentation; Drug abuse and dependence; Drug classification; Drug confirmation tests; Gas chromatography; Mandatory drug testing; Mass spectrometry; Performance-enhancing drugs; Sports memorabilia fraud.

Atomic absorption spectrophotometry

Definition: Technique used to determine the concentrations of metal elements in a sample based on the absorption of light energy by atoms.

Significance: By using atomic absorption spectrophotometry, forensic scientists can determine the concentrations of the elements that are present in evidence samples collected at crime scenes. Using this information, they may be able to match evidence samples with materials linked to suspects or found at other crime scenes.

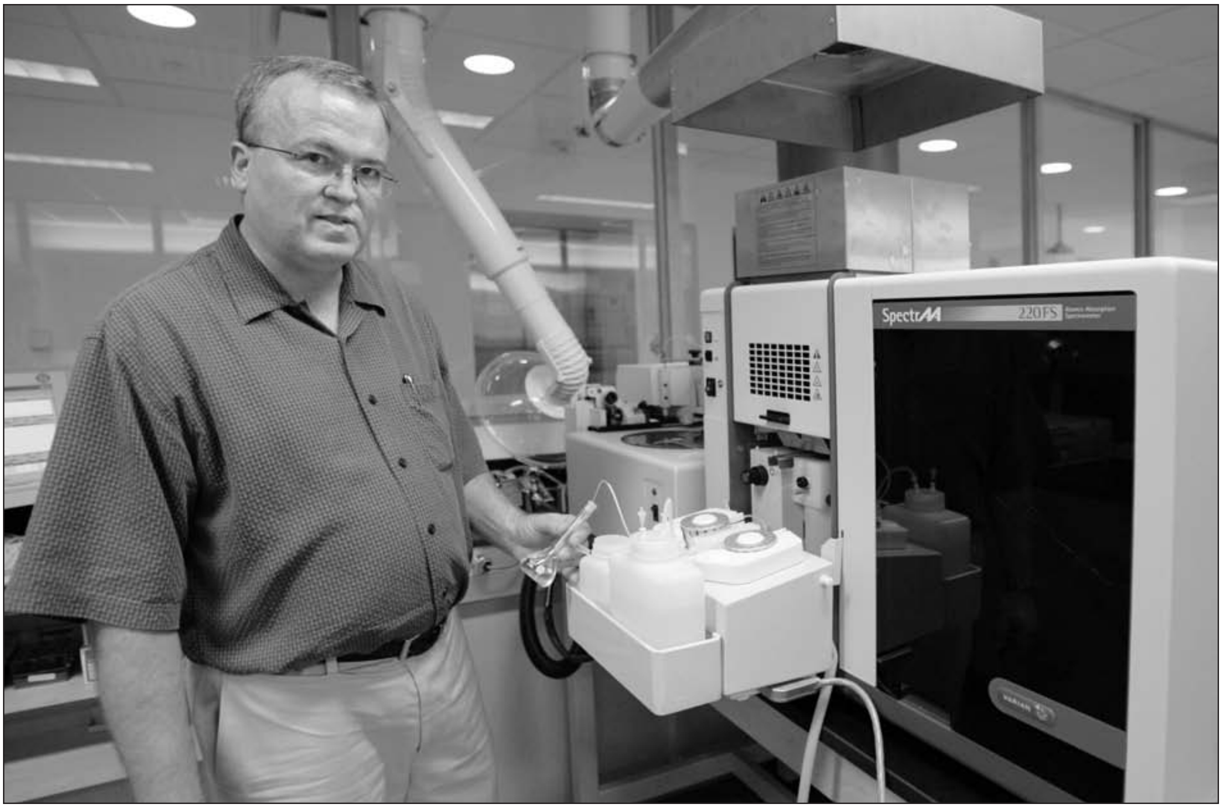
The phenomenon of atomic absorption was discovered as the result of the observation of the dark absorption lines in the spectrum of the sun, which are caused by the absorption of light by elements existing as gaseous atoms being promoted from "ground" state to "excited" state in the sun's atmosphere. These dark lines were first observed by William Hyde Wollaston in 1802, then rediscovered by Joseph von Fraunhofer in 1814; they are now known as Fraunhofer lines. In 1953, Alan Walsh developed the first chemical analysis using atomic absorption.

Atom-Light Relationship

Atoms absorb light energy based on electrons surrounding the atomic nuclei. Every atom of a specific element has a specific number of electrons in orbital positions. The most stable orbital configuration for an atom, called the "ground" state, possesses the lowest energy. The light energy resonates, or travels in space, like waves with specific wavelength. If light energy strikes an atom, the light is absorbed by the atom, and the electron in the outer orbital position is promoted to an unstable higher energy configuration, called the "excited" state. The excitation from ground to excited state is called atomic absorption; this absorption can be measured by the instrument known as the atomic absorption spectrophotometer. Because of the instability of the excited state, the electron decays and returns to the ground state; in doing so, it emits energy equivalent to the energy absorbed during the excitation process. The energy emitted during the decay process is not measured by the instrument.

Instrumentation and Sample Analysis

The atomic absorption spectrophotometer has five basic features: a light source that emits a spectrum specific to the element of interest, an absorption cell in which gaseous atoms are produced during excitation, a monochromator that disperses light, a detector that measures absorption, and a readout system (printer or computer) that shows the results of the analysis. The spectrum emitted by the light source (for example, a hollow cathode lamp) is focused through the absorption cell leading to the monochromator. The lamp contains a specific metal element that emits a specific wavelength of light for the same element to be determined in the sample. For example, to determine the concentration of iron in the sample, the lamp used



Chemistry professor Jeffrey Weidenhamer poses next to an atomic absorption spectrophotometer in the laboratory at Ashland University in Ashland, Ohio, where, in 2006, researchers using this technology found high levels of toxic lead in toy jewelry imported from China. *(AP/Wide World Photos)*

must contain iron. The light source must be modulated, or chopped, so that it is possible to distinguish between the emission from the lamp and the emission from the absorption cell. The monochromator disperses the modulated signal emitted from the lamp (not from the absorption cell) and isolates the specific wavelength of light that passes to the detector, which processes the light absorbed by the atoms. The absorption, which is proportional to the concentration of the element in a sample, is then displayed in the readout system.

A sample is introduced and atomized in the absorption cell in liquid or solid form (depending on atomizers) to accomplish the excitation process. If a liquid solution is required, elements are extracted by liquid reagents from solid materials. The liquid sample in the absorption cell is atomized, with thermal means (flame or graphite furnace) or chemical means (hydride or mercury vapor generator) used to excite the atoms. Flame produced by an air-acetylene mixture (2,100-2,400 degrees Celsius) is used for most metal elements (such as calcium or zinc) that do not form refractory compounds, which cannot be ionized or atomized at this temperature range. A hotter nitrous oxide-acetylene flame (2,600-2,800 degrees Celsius) is used for elements (such as silicon or aluminum) forming refractory compounds (silicon dioxide or aluminum dioxide). A graphite furnace atomizer provides a wider range of temperatures (2,100-2,900 degrees Celsius) and handles liquid or solid samples.

A hydride or mercury vapor generator converts certain elements into gas. Elements that chemically react with sodium tetrahydridoborate (such as arsenic and selenium) are reduced to form hydride vapor. Mercury is reduced to mercury vapor. The vapors in the absorption cell are excited to absorb energy from the light source.

Not all elements are detected by atomic absorption. Elements with wavelengths of resonance lines below 190 nanometers, nonmetals (such as hydrogen, carbon, nitrogen, and oxygen), and noble gases are volatile, easily absorbed by air, immediately lost at temperatures greater than 2,100 degrees Celsius, and disappear before excitation. Elements that form very strong refractory compounds have extremely high melting points (greater than 2,900 degrees Celsius). Because these compounds cannot be atomized by flame or furnace, no atoms can be excited.

Use in Forensics

In a criminal investigation, atomic absorption spectrophotometry can be used to discover the presence and the concentration of the elements in sample evidence. When explosives or poisons are used to kill, for example, they leave evidence that can be examined through chemical analysis. Some explosives contain platinum; others contain nickel, silver, cadmium, or mercury. The elements that are found in the residues of signature explosive products can be used to find the sources, manufacturers, and buyers of such explosives.

Atomic absorption spectrophotometry can also be used to detect concentrations of elements from poisons found in human victims. Poisoning is confirmed to have occurred (whether accidentally or intentionally) if concentrations of toxic elements—such as arsenic or mercury—exceed safe levels in the body. The atomic absorption spectrophometer enables analysts to determine whether poisoning has occurred by examining the levels of toxic elements appearing in a victim's blood, urine, and hair.

Domingo Jariel

Further Reading

Caroli, Sergio. *The Determination of Chemical Elements in Food: Applications for Atomic and Mass Spectrometry*. Hoboken, N.J.: Wiley-Interscience, 2007. Covers the quantification of beneficial and toxic elements in food products.

Emsley, John. *Elements of Murder: A History of Poison*. New York: Oxford University Press, 2005. Describes the properties of five toxic elements (arsenic, antimony, lead, mercury, and thallium) and how they were used in some of the most famous murder cases in history.

Tsalev, Dimiter L. *Atomic Absorption Spectrometry in Occupational and Environmental Health Practice*. Boca Raton, Fla.: CRC Press, 1995. Covers fifty-five elements and provides almost eight hundred atomic absorption procedures for analysis of blood and other biological specimens.

Vandecasteele, C., and C. B. Block. *Modern Methods for Trace Element Determination*. New York: John Wiley & Sons, 1993. Describes the theory and usage of atomic absorption and other spectroscopy for element determination.

Welz, Bernhard, Helmut Becker-Ross, Stefan Florek, and Uwe Heitmann. *High-Resolution Continuum Source AAS: The Better Way to Do Atomic Absorption Spectrometry*. New York: John Wiley & Sons, 2005. Discusses both instrumentation and measurements of elements.

See also: Analytical instrumentation; Arsenic; Crime laboratories; Forensic toxicology; Quantitative and qualitative analysis of chemicals; Spectroscopy.

Attention-deficit/hyperactivity disorder medications

Definition: Pharmacologically produced agents used in the treatment of the syndrome of disruptive behavior known as attention-deficit/hyperactivity disorder.

Significance: Medication management of attention-deficit/hyperactivity disorder targets the areas of the disorder that contribute to the patient's impairment: inattention, hyperactivity, and impulsivity.

These conditions can, at times, lead persons with the disorder to involvement with legal authorities. Researchers who have studied attention-deficit/hyperactivity disorder in prison populations have estimated its prevalence from as low as 20 percent to as high as 70 percent.

Most medications used in the treatment of attention-deficit/hyperactivity disorder (ADHD) are rudimentarily separated into stimulant and nonstimulant categories; further distinctions are made between those that are approved for treatment of the disorder by the U.S. Food and Drug Administration (FDA) and those that are nonapproved or used "off-label" by prescribing physicians. FDA-approved medications in the stimulant category comprise amphetamine preparations (brand names include Adderall and Dexedrine) and methylphenidate preparations (brand names include Ritalin, Metadate, Concerta, and Focalin). Although many nonstimulant medications are used to treat ADHD, only one, atomoxetine (brand name Strattera), has been approved by the FDA for use in children, adolescents, and adults.

Stimulants

Although it may seem counterintuitive to treat a hyperactive patient with a stimulant, a simple explanation regarding the theory of ADHD is as follows: In the ADHD patient, the frontal lobe of the brain, which is responsible for executive functions (such as planning, organizing, and focusing attention) and other tasks (including controlling impulses, motivation, and movement), is deficient in the neurotransmitters that are restored to a more normative state with the use of stimulant medications. The main catecholamine neurotransmitters that are affected by the use of stimulants are dopamine and norepinephrine. These transmitters are involved in focusing attention, motivation, learning, and other cognitive functions that are adversely affected in patients with ADHD.

In general, the use of methylphenidate and amphetamine medications with patients who have ADHD leads to an approximation of a normal neurochemical state, both by blocking the reuptake of dopamine into and promoting the release of dopamine out of the nerve cells in the brain wherein dopamine is produced, stored, and released. The net effect is an increase in the amount of dopamine available to communicate between nerve cells. This area of communication between the cells is termed the synapse. Amphetamine preparations have the added effect of promoting release and blocking reuptake of norepinephrine.

When treatment is optimized, between 77 and 90 percent of patients with ADHD will have a favorable response to stimulant medications. This may be reflected in improvements in academic accuracy and grades, parent-child relations, and social functioning. However, although the stimulant medications have well-documented usefulness in the treatment of ADHD and are generally well tolerated, they may also be associated with side effects. These side effects include, but are not limited to, insomnia, weight loss, headaches, irritability, loss of appetite, stomach upset, and increases in blood pressure and heart rate. Other less common but potentially serious side effects include the development of undesired movements called tics, slowing of growth, the possibility of seizures, and the risk of developing psychotic symptoms such as hallucinations and paranoia. Often, side effects can be minimized or eliminated through the reduction of the medication dosage or through a change to a different type of stimulant that may be better tolerated.

Atomoxetine

Atomoxetine is a selective norepinephrine reuptake inhibitor that is approved by the FDA for treatment of ADHD in children and adults. It is thought that atomoxetine blocks the norepinephrine transporter in nerve cells in the brain, thereby increasing the amount of norepinephrine in the synapse between nerve cells. It is further hypothesized that in the brain's frontal lobe, norepinephrine transporters may, to some extent, also be responsible for the reuptake of dopamine, not just norepinephrine. Research indicates that atomoxetine may be as effective in the treatment of ADHD as the stimulant methylphenidate, but atomoxetine may take a longer period of time to reach its full benefit.

Atomoxetine's side effects may include stomach upset, constipation, decreased appetite, headache, fatigue, irritability, and an inability to empty the bladder completely when urinating. More serious side effects include rare cases of liver toxicity and the concern, given that the chemical structure of atomoxetine is similar to that of certain antidepressants, that it could promote suicidal thinking and behavior in children and adolescents such as that seen clinically in 3-4 percent of patients in the population taking traditional antidepressants.

Other Treatments

Typically, alternative medications have been used as second- or third-line options to treat ADHD. Although these approaches are not approved by the FDA, they still have usefulness for those patients who cannot tolerate or do not benefit from more traditional treatments. Further, these medications may be used in conjunction with other treatments to augment or boost a patient's response.

Tricyclic antidepressants, such as imipramine (brand names include Tofranil and Antideprin) and nortriptyline (brand names include Aventyl and Pamelor), have been used in the treatment of ADHD with some success. It is theorized that the beneficial effects of these antidepressants on ADHD symptoms are related to the blockade of norepinephrine reuptake into nerve cells. Use of these medications, however, has fallen out of favor with most treatment providers because of the limiting side effects associated with the drugs, the most concerning of which is the risk of sudden cardiac death if the medications are taken in overdose or if the blood levels of the medications get too high. Concerns also exist regarding an increase in suicidal thoughts and behaviors in child and adolescent patient populations. Nevertheless, in experienced hands and with proper monitoring, these medications can be prescribed safely and effectively for treatment of ADHD.

An alternative and structurally chemically different antidepressant with usefulness in treating ADHD is bupropion (brand names include Wellbutrin and Zyban). It is thought that bupropion helps patients with ADHD through its effects on norepinephrine and dopamine. This medication does not have the cardiac concerns that are present with tricyclic antidepressants, but, in high doses, it may make patients more prone to seizures. The suicide risk warnings with children and adolescents are the same as those applied to tricyclic antidepressants.

Alpha-2 Adrenergic Agonists

The medications known as alpha-2 adrenergic agonists include clonidine (brand names Catapres and Disarit) and guanfacine (brand names Tenex and Intuniv). These drugs are used to treat high blood pressure and, through their effects on the central nervous system mediated by norepinephrine-containing nerve cells, are helpful in diminishing impulsivity, hyperactivity, and even aggression in patients with ADHD. They may also help with sleep disturbance and motor (movement) tics that are seen in some patients. The main side effects are dry mouth, headache, sedation, constipation, slowing of heart rate, and lowering of blood pressure.

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Further Reading

Sadock, Benjamin James, and Virginia Alcott Sadock. *Kaplan and Sadock's Synopsis of Psychiatry: Behavioral Sciences/Clinical Psychiatry*. 10th ed. Philadelphia: Lippincott, Williams & Wilkins, 2007. General text aimed at mental health practitioners provides an overview of the entire field of psychiatry.

Schatzberg, Alan F., Jonathan O. Cole, and Charles DeBattista. *Manual of Clinical Psychopharmacology*. 6th ed. New York: American Psychiatric Publishing, 2007. Practical manual addresses the psychotropic management of psychiatric conditions.

Stahl, Stephen M. *Essential Psychopharmacology: Neuroscientific Basis and Practical Applications*. 3d ed. New York: Cambridge University Press, 2008. Good resource for readers seeking an understanding of the fundamentals of psychotropic interventions.

_______. *Essential Psychopharmacology: The Prescriber's Guide*. Rev. ed. New York: Cambridge University Press, 2006. Guidebook for practitioners provides information regarding the advantages and disadvantages of the various psychotropic medications.

See also: Bacterial resistance and response to antibacterial agents; Forensic psychiatry; Psychotropic drugs; Stimulants.

Autoerotic and erotic asphyxiation

Definition: Potentially deadly practice of increasing sexual pleasure by restricting oxygen to the brain through hanging or suffocation during sex acts.

Significance: Deaths resulting from autoerotic and erotic asphyxiation are often mistaken for suicide (especially among teenagers) or homicide because many health care workers, emergency personnel, and police personnel are unfamiliar with the signs of these sexual practices. More widespread education about the dangers of these practices could save lives.

Erotic asphyxiation (EA) is the practice of depriving the brain of oxygen during sexual stimulation with a sex partner for purposes of increasing sexual pleasure and heightening orgasm. Autoerotic asphyxiation (AEA) is the same practice carried out by one person, without a sex partner; that is, autoerotic asphyxiators masturbate while voluntarily strangling themselves. Neck compression (strangulation), exclusion of oxygen (suffocation), airway obstruction (blocking the airway with a foreign object), and chest compression (restricting the movement of the chest) are all methods of depriving oxygen used during erotic asphyxiation.

During a normal breath, carbon dioxide is exhaled and oxygen is inhaled, keeping the brain's oxygen at an adequate level. In AEA and EA, oxygen deprivation is achieved in a variety of ways, including the use of a plastic bag over the head and self-strangulation using a ligature. When a person's supply of oxygen to the brain is too low and carbon dioxide is too high, some resulting effects may be a sense of euphoria, dizziness, lowered inhibitions, and even hallucinations.

Statistics

Research indicates that some 70 percent of those who practice autoerotic or erotic asphyxiation are under the age of thirty. In the United States, AEA and EA are most common among single, white, middle-class, male teenagers and young adults (thirteen to twenty years of age). Teenagers are also the practitioners who most often die as the result of these practices. The most common reasons teenagers take part in AEA and EA are sexual experimentation, thrill seeking, and fantasies of masochistic bondage. No research has linked gender confusion, homosexuality, or transvestism with the practice of AEA or EA. Some psychologists believe that a history of child sexual abuse may influence later participation in these sexual practices.

Teenage girls and women also participate in AEA and EA, but to a much lesser extent than do young men. The techniques of AEA that women use tend to be less obvious than those used by men. Often a female practitioner will use a single neck ligature and only limited sexual props, such as a vibrator or a dildo. The small amount of evidence available when a woman dies as the result of AEA may be a cause of underreporting of AEA practices among women.

One study of autoerotic asphyxiation found that adult practitioners, in contrast with teenagers who participate in these acts, were often lonely and depressed. Other experts disputed this finding, however, noting that anecdotal reports indicate that adults who have died as a result of AEA have often been happily married men who were not deprived of sex or companionship.

Suicide is one of the leading causes of death among teenagers in the United States, and some researchers believe that many of the teen deaths labeled as suicide are actually accidental deaths from AEA or EA. According to estimates of the Federal Bureau of Investigation (FBI), some five hundred to one thousand deaths result from the practice of AEA and EA each year in the United States, but they are often misreported as suicide or homicide. Some experts theorize that in many cases embarrassed or shocked relatives of the deceased clean up AEA and EA death scenes before the police arrive.

Additionally, emergency personnel and police are not always educated about the signs of AEA and so may easily misinterpret deaths resulting from this practice as suicide.

AEA Syndrome

Although release mechanisms are often built into devices intended for use in autoerotic asphyxiation, the practice remains extremely dangerous. Death or permanent brain damage can result if a practitioner loses consciousness before removing the device used to deprive oxygen or if a release mechanism malfunctions.

The paraphernalia and practices of sexual bondage are common to both AEA and EA. Sometimes practitioners insert foreign bodies in the rectum for anal stimulation, and many place mirrors strategically to view themselves during the act of sexual asphyxiation. Some other signs of AEA and EA that may appear at death scenes, and of which investigators should be aware, include the presence of lubricants, sex toys, and pornographic pictures or literature and the binding of the body and genitals with chains, leather strips, or ropes. Items that may be found at such scenes include belts, cords, ropes, scarves, and neckties. Practitioners of AEA and EA also sometimes cover their heads with plastic bags to deprive their brains of oxygen.

Evidence of asphyxia by strangulation, protective padding around the neck, and evidence of trying to prevent marks on the body are all common elements of a death scene involving AEA. In addition, the presence of devices with self-release mechanisms, sexual aids and props, and pornography is associated with an AEA death. Body position—with feet touching the floor, sitting in a chair or lying in bed, partially or totally nude, with arms and legs bound in chains or ropes—and evidence that masturbation occurred are also indicators of an AEA death. Another feature of the AEA death scene is what it lacks—no suicide letter or other evidence that the death resulted from a suicide attempt is found.

Some warning signs that a person may be participating in autoerotic asphyxiation include unexplained marks on the neck, bloodshot eyes, complaints of frequent headaches, and possession of knotted short ropes and neckties. Teenage boys who engage in AEA may install locks on their bedroom doors, keep women's clothing hidden in their rooms, and show a strong interest in sexual bondage and sadomasochism. Parents, teachers, and counselors of young people should be aware of all these signs. Each sign by itself is not necessarily indicative of AEA, but in combination these indicators should not be ignored. When parents and others involved with teenagers suspect the practice of autoerotic or erotic asphyxiation, they should investigate and communicate with these young people to inform them about the risks of such activities. Accidental deaths can be prevented when young people involved in these practices receive prompt counseling by professionals who are familiar with AEA and EA.

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Further Reading

Boglioli, Lauren R., and Mark L. Taff. "The Medicolegal Investigation of Autoerotic Asphyxial Deaths." In *The Handbook of Forensic Sexology: Biological and Criminological Perspectives*, edited by James J. Krivacska and John Money. Amherst, N.Y.: Prometheus Books, 1994. Provides an overview of autoerotic asphyxiation, statistics, and description of the biological events that occur during AEA. Also discusses individual victims and death scenes.

Brody, Jane E. "'Autoerotic Death' of Youths Causes Widening Concern." *The New York Times*, March 27, 1984. Discusses growing concerns among members of the public about adolescents' experimentation with autoerotic asphyxiation. Offers information on the warning signs of AEA in young people.

Jenkins, A. "When Self-Pleasure Becomes Self-Destruction: Autoerotic Asphyxiation Paraphilia." *International Electronic Journal of Health Education* 3, no. 3 (2000): 208-216. Presents statistics and describes the characteristics of AEA participants.

Sheleg, Sergey, and Edwin Ehrlich. *Autoerotic Asphyxiation: Forensic, Medical, and Social Aspects*. Tucson, Ariz.: Wheatmark, 2006. Reviews the research regarding AEA and discusses the practice from the perspectives of both professionals and society.

Tournel, Gilles, et al. "Complete Autoerotic Asphyxiation: Suicide or Accident?" *American Journal of Forensic Medicine and Pathology* 22 (June, 2001): 180-183. Focuses on the topic of deaths associated with AEA.

See also: Asphyxiation; Choking; Hanging; Psychological autopsy; Strangulation; Suffocation; Suicide.

Automated fingerprint identification systems. *See* Integrated Automated Fingerprint Identification System

Autopsies

Definition: External and internal medical examinations of dead bodies to determine cause of death, identify decedents or their body parts, or study changes caused by disease.

Significance: An autopsy is a very important part of many forensic investigations, given that the body is usually the center of any death case. In a death investigation, the body is just as much a crime scene as the geographic area in which it was found. During the autopsy, evidence is collected from the body "scene." This evidence, along with the determination of the cause and manner of death, contributes greatly to the resolution of the investigation. It can also positively identify an otherwise visually unidentifiable person, making it possible for authorities to release the remains to the appropriate family.

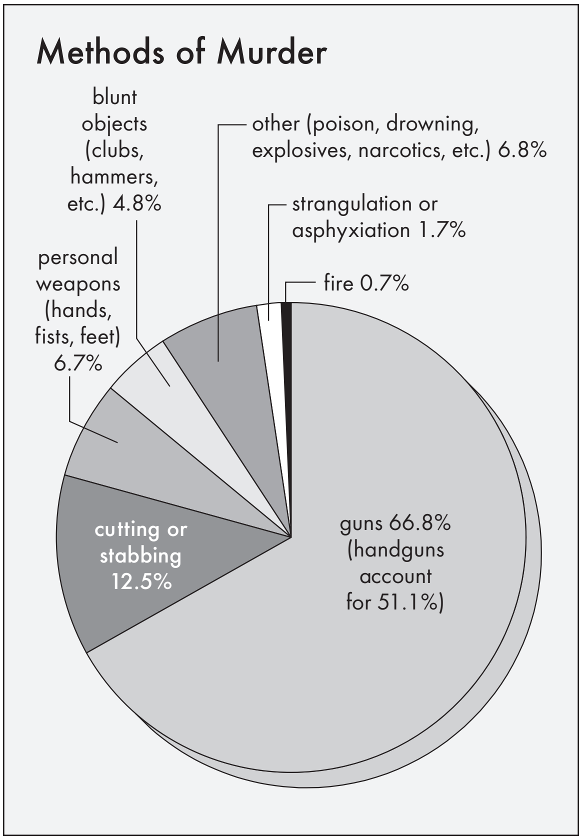
Autopsies may be divided into two primary types: the clinical autopsies done at hospitals and the forensic autopsies executed by medical examiners or coroners. The aim of the clinical, or academic, autopsy is to determine, clarify, or confirm diagnoses that remained unknown or did not become sufficiently clear during the stay of a patient in a hospital or other health care facility. The forensic, or medicolegal, autopsy focuses primarily on violent death (death by accident, suicide, or homicide), suspicious and sudden death, death without medical assistance, or death that could result in a lawsuit, such as a death related to surgical or anesthetic procedures. The purposes of the forensic autopsy are to find the cause and manner of death and to identify the decedent.

Cause, Manner, and Mechanism of Death

The term "cause of death" refers to the situation or illness that resulted in the loss of life. Examples of causes of death include heart disease, stroke, knife wound to the wrist, gunshot wound to the chest, and hanging. In assigning the cause of death, some medical examiners use the "but for" test, as in "But for the gunshot wound, the victim would still be alive." The cause of death is what brought about the person's death.

Manner of death is determined according to a classification system that coroners and medical examiners use to certify a death. Only five manners of death are possible: natural, accidental, homicide, suicide, and undetermined. Any doctor can pronounce death, but only a coroner or a medical examiner can certify a death as a manner other than natural. A natural death is one that results from the normal course of life. Death from heart disease would be a type of natural death. An accidental death is one that results from a mishap, such as a death resulting from a fall off a ladder.

Homicide, in this context, is a death that results from the actions of another person. This is a medical declaration only; it does not imply anything about the guilt or motives of the other person. A manner of death of homicide on a death certificate is not a legal assertion. The determination of the other party's culpability is made by the legal system, independent of the autopsy. Deaths that result from vehicle accidents that involve other vehicles are often clas-



Source: Federal Bureau of Investigation, *Crime in the United States*. Figures are based on 14,274 murders in the United States in 2002.

sified as homicides. Accidental shootings also are often classified as homicides, although they do not warrant a verdict of murder. Aside from such exceptions, however, many cases with a manner of death of homicide are indeed the result of malicious actions that would constitute the legal determination of murder.

Suicide is the manner of death used to describe a death that resulted from the victim's own determined actions. Hangings and self-cuttings are both classified as suicide manners of death. A finding of undetermined manner of death simply means that enough evidence was not available for the pathologist to distinguish between two or more of the other manners of death. As an example, without proper investigative information, a medical examiner may have problems ruling between accidental death and suicide if the deceased took a few too many pills or mixed medications. The attending coroner or medical examiner makes every effort to gain as much information as possible to avoid the need to use the undetermined manner of death classification.

Laypersons often confuse the concept of mechanism of death with cause of death. Mechanism of death is much more specific than cause of death, however; it is the actual specific biological reason the person died. In a case where the cause of death is a gunshot wound to the chest, the mechanism of death might be exsanguination, meaning that the victim bled out; death was the result of the loss of blood caused by the gunshot wound. Chronic alcoholism and cirrhosis are causes of death, whereas hepatic encephalopathy (the impairment of the brain cells caused by the release of liver toxins into the body) would be the actual mechanism of death in such cases. Cardiac arrest is often a stated mechanism of death, but many coroners and medical examiners disapprove of this determination, as heart failure (meaning the heart stopped) is a result of every death and may not be the true mechanism of death.

Identification of the Deceased

In addition to establishing cause and manner of death, the forensic autopsy positively identifies the deceased. Visual identification is not considered sufficiently accurate to be counted as positive identification. The body goes through many physical changes during decomposition that can make recognizing an individual difficult. Also, the person who is asked to identify the deceased visually is often in a highly emotional state, which can lead to mistakes and misidentification.

The clothing on the body, likewise, is not a positive identifier. For example, members of the U.S. military have their last names on every uniform they are required to wear, and they also must wear dog tags that bear their names, but even these precautions do not guarantee that a dead soldier will be correctly identified by these items. Sometimes people do not wear their own clothes, and, in some documented cases, good friends in the military have exchanged dog tags in particularly dire situations as a means of encouraging each other or lifting morale. Reliance on clothing and dog tags has occasionally resulted in the misidentification of deceased military personnel.

To make a positive identification of a deceased person, investigators use one of three main recognized methods. The first is fingerprint examination. If the decedent was part of the military, ever served time in prison, worked for the government, or participated in a local "Protect Our Children" or similar drive, he or she likely had fingerprints taken. These antemortem (prior to death) records can be compared with fingerprints taken from the body at autopsy to identify the decedent with certainty.

Another positive identification technique is forensic odontology, in which the decedent's teeth are compared with antemortem dental records. To carry out the comparison, a forensic odontologist takes X rays and castings of the decedent's teeth and then compares tooth positions, shapes of fillings, root lengths, and other factors with those found in the dental records of the person suspected to be the deceased.

The third method used for positive identification of a body involves the examination of DNA (deoxyribonucleic acid). DNA comparison methods are of two types. One uses nuclear DNA, which is in the blood and tissue; this DNA is somewhat fragile and can be damaged by decomposition. Identification using this DNA involves strict comparison of the DNA found in the blood and tissue of the deceased to antemortem material. If the nuclear DNA cannot be used, it is possible to use mitochondrial DNA, which is much sturdier and can withstand decomposition changes. Mitochondrial DNA is a bit trickier in its comparison because this type of DNA is

A team of Yugoslav and Finnish forensic specialists perform an autopsy in a Kosovo morgue on one of forty-five ethnic Albanians killed by Serbian security forces in early 1999. *(AP/Wide World Photos)* passed on only from the mother to the child, so a family member from the mother's side of the family is needed for comparison.

Other methods of positive victim identification are also available. A radiologist can compare X rays of the body to X rays from any previous injuries in the medical records of the person believed to be the deceased. If evidence of previously documented injuries can be found on the postmortem (after death) X rays, the pathologist can identify the victim. If antemortem facial X rays exist, a radiologist can compare how the sinuses line up, as well as their sizes and shapes. Evidence of some type of extreme medical procedure, such as the attachment of a metal plate to a bone to aid in the healing of a serious injury, can also be an identifier. These methods, however, are used relatively rarely because they rely on the presence of previous X rays in the suspected victim's medical records and on the uniqueness of those X rays.

Initial External Examination

Significant examination of the body occurs during an autopsy prior to any cutting. This initial procedure may vary a bit from practitioner to practitioner, but the same basic principles are always followed. The first and most important step in any autopsy is photography. Pictures of the body are taken before the body is removed from the body bag, to document exactly how the remains appeared when they came into the care of the coroner or medical examiner. Typically, a few shots of the body bag are taken, with any identifying tags visible, and then the bag is opened and the first shots of the body are taken, still in the body bag. In cases of mass disasters and severe commingling of bodies, these initial shots are very important to show what exactly was received and then later put together as related remains.

In another external stage of the autopsy, full-body X rays are taken of the remains so that when the body is ready for postmortem examination, the pathologist can get an idea of what is inside prior to cutting. Broken bones and other injuries are documented, as these may help to guide the pathologist in determining the cause of death. X rays are essential in shooting cases because they allow the pathologist to document and count the bullets that remain in the body before cutting and provide information on where the bullets will be when the cutting begins, thereby saving a search that could otherwise take hours.

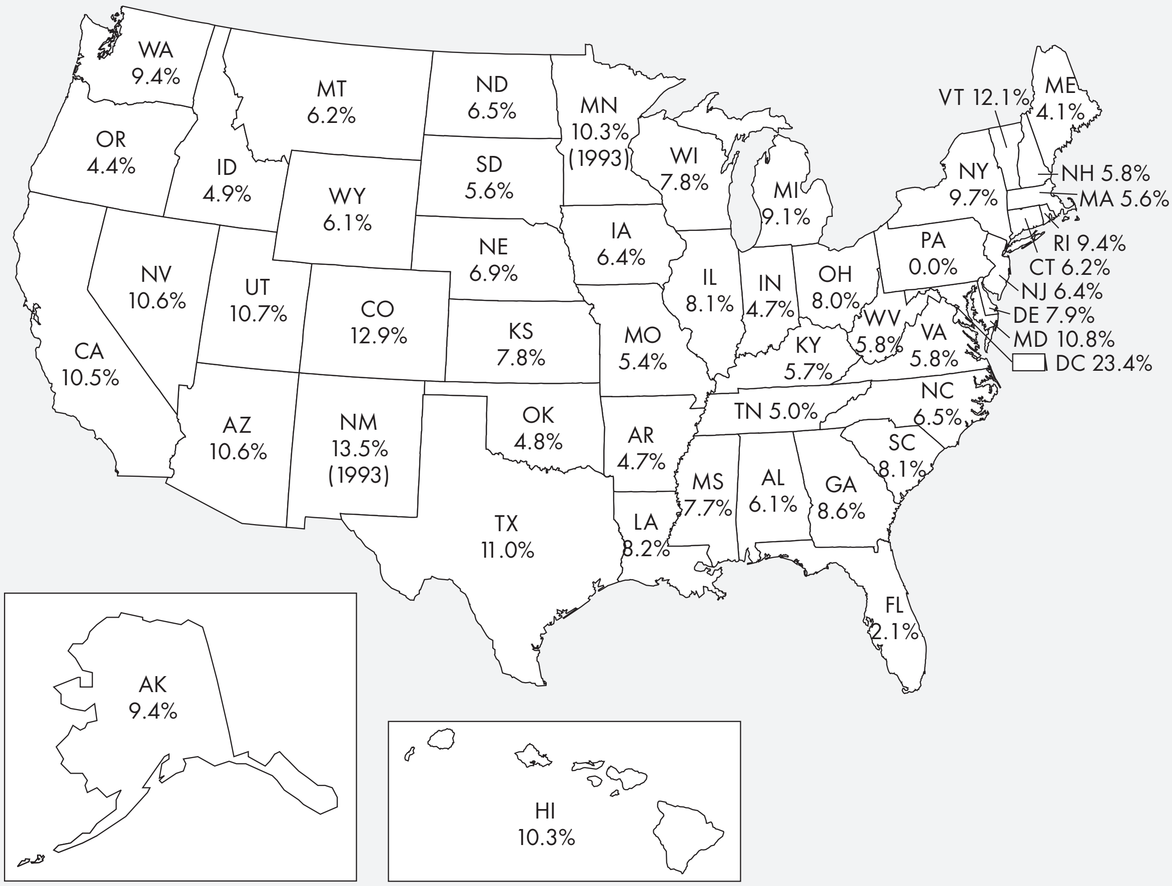
The coroner or medical examiner also typically allows any law-enforcement personnel attending the autopsy to take the fingerprints of the deceased at this time. Some medical examiner offices have their own investigators who work as liaisons between the medical examiners and law-enforcement agents. These in-house investigators may be the ones who routinely take decedents' fingerprints.

Forensic odontology may be done before the pathologist cuts or after, depending on the procedures set up for that office. The forensic odontologist makes a thorough postmortem dental examination and compares the findings to antemortem dental records. Dental X rays are taken, casts are made, and, if necessary, sometimes the jaw is removed from the body for examination. (The jaw is removed only in specialized cases, however, and only when it has already been determined with certainty that there will be no open-casket funeral.)

After all of the steps described above have taken place, the pathologist does an external examination as well. The body is taken out of the body bag, and pictures are once again taken. The doctor then carefully removes the clothing and jewelry from the body while noting any cuts, tears, or other indicators of injury or struggle shown by these items. These personal effects are then set aside and photographed separately for documentation. The doctor may refer back to the clothes if they have any cuts in them to marry up the cuts with injuries on the body or perhaps to find marks on the body that are not readily visible. If there are other marks on the body, the doctor may also refer to the clothing to see if the marks may have been made by it.

All salvageable personal effects that are not going to be kept as evidence are set aside for return to the family of the deceased. The doctor tries not to add further damage to any salvageable effects; for example, if possible, the clothes are unbuttoned or unzipped as opposed to cut away from the body. If the clothes are not salvageable, whether because they are saturated

Autopsy Rates in the U.S. States, 2003



Source: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, 2007. Figures indicate percentages of deaths for which autopsies were reported in 2003, except in Minnesota and New Mexico, whose figures are from 1993.

in blood or somehow destroyed, they are usually cut off. If a garment is covered with body fluid, it is dried prior to packaging to prevent spoilage from bacteria activity.

The doctor then examines the body itself, documenting any and all injuries as well as any unusual markings (birthmarks or tattoos), noting their placement on the body, their shapes, and their measurements. References to placement on the body are always made from the decedent's perspective. That is, an injury on the right side of the body's chest is described as such, although the injury appears on the left as the doctor views the body from above.

Sometimes, depending on the type of case, the pathologist will also take fingernail scrapings or clippings from the body for evidence; materials of interest to investigators may include soil samples and blood or skin that may have been left on the body by a suspect. The naked body is then washed, and the wounds are cleaned. The corpse is photographed once again, with separate shots taken of all identified injuries.

Internal Examination

After all the external evidence is recorded and set aside for possible further examination, the process of dissection begins. As a rule, a forensic pathologist begins an autopsy at the upper portion of the body and works downward. Some pathologists may open the head at a later step, but initial examination always starts there. First, the scalp is searched for hidden wounds or artifacts, and hair samples are taken if needed. The mouth is examined for tooth damage, tongue lacerations, chemicals or toxic substances, and cuts on the lip and inner mouth, and the nose and ears are examined for any blood accumulations.

The inner eyelids are examined for petechiae, which are tiny pinpoint blood specks that may suggest asphyxiation. Whether at the beginning or at the end of the autopsy, when the pathologist opens the head to gain access to the brain, an incision is made that reaches from behind one ear to behind the other. The scalp is then inverted until it rests over the face and the outer skull is accessible. A bone saw is used to open the skull so that the brain can be removed, weighed, and sampled and the cranium can be inspected for injuries. In some cases the cranium is also sawed at various angles to expose the sinuses, jawbone, or other parts of the skull that require scrutiny.

The standard American autopsy begins with a cut known as a Y incision (the cut looks like the letter Y when it is completed). A cut is made from each shoulder, and the two cuts meet at the lower part of the sternum (breastbone), although some pathologists intersect these cuts as low as the stomach. A straight cut is then made from the intersection down to the pubic bone. The skin and muscle are then cut back, revealing the rib cage beneath. The ribs are examined for any breaks or healing injuries before each rib is cut so that the breastplate—beneath which many of the body's organs are housed—can be removed.

Each organ (the heart, lungs, liver, kidneys, spleen, stomach, and testicles) is removed, weighed, and examined for injury. Each organ is then sliced, and samples are preserved for toxicology screens (tests for any drug use or poison) and histology analysis (study of the organ on a microscopic level). Samples are also preserved in case they are needed for reexamination at some point in the future. Blood, bile, and urine are also taken, examined, and preserved, along with fluids from the lungs and pleural cavity. The contents of the stomach are also inspected.

The autopsy ends in the pelvic cavity. The external and internal anus and genitalia are inspected, the bladder is removed and studied, and, in cases of suspected sexual assault, vaginal and anal swabs are made.

Upon completion of the examination, all organs (including the brain) are placed in a bag that is put into the chest cavity. The piece of the skull that has been removed is put back into place, and the scalp is pulled back down to hold it in place. The scalp and chest incisions are sewn shut, so that when the body is dressed for viewing, no cuts are visible and open-casket viewing is possible.

After all else is completed,

The Autopsy Through History

The term "autopsy" comes from *autopsia*, a Greek word meaning "to see with one's own eyes." Around 3000 B.C.E., the Egyptians practiced mummification—removing organs through tiny slits in the body so that the body itself remained whole—and the Greek Herophilus broke religious taboos by dissecting bodies to learn how the inner organs worked. By around 150 B.C.E., autopsy results had legal parameters in the Roman Empire. In 1761, the Italian anatomist Giovanni Battista Morgagni published *De Sedibus et Causis Morborum per Anatomen Indagatis* (*The Seats and Causes of Diseases Investigated by Anatomy*, 1769), the first exhaustive written work on pathology.

The nineteenth century Austrian anatomy professor Karl Rokitansky is regarded as the founder of the modern autopsy. Rokitansky personally performed or supervised more than one hundred thousand autopsies and was also one of the world's first pathologists. Under his leadership, all autopsies were carried out equally so that every part of the body in question could be studied exactly the same way.

Kelly Rothenberg

including any toxicology, DNA, and histology analyses, the pathologist writes a full report that describes the autopsy procedures and findings in detail. Included in the report is a brief history of the case; a death scene description; a list of all persons present at the scene; an X-ray description of the body; descriptions of the clothing found on the body, of the naked body prior to dissection, of the condition of the organs at autopsy, and of the wounds; the toxicological findings; and the cause and manner of death.

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Further Reading

DiMaio, Vincent J., and Dominick DiMaio. *Forensic Pathology*. 2d ed. Boca Raton, Fla.: CRC Press, 2001. One of the best reference sources available in the field of forensic pathology. Covers autopsies in detail as well as certain techniques for specific kinds of deaths.

Mann, Robert, William Bass, and Lee Meadows. "Time Since Death and Decomposition of the Human Body: Variables and Observations in Case and Experimental Field Studies." *Journal of Forensic Sciences* 35, no. 1 (1990): 103-111. Excellent comprehensive study focuses primarily on the decomposition of a body but gives a good idea of what to expect at autopsy from certain types of cases. Discusses the difficulty of determining time of death.

Sheaff, Michael T., and Deborah J. Hopster. *Post Mortem Technique Handbook*. London: Springer, 2001. Provides a very good in-depth look at postmortem examinations. Thorough discussion covers every step of an autopsy extensively.

Shkrum, Michael J., and David A. Ramsay. *Forensic Pathology of Trauma: Common Problems for the Pathologist*. Totowa, N.J.: Humana Press, 2007. Excellent technical reference work discusses how trauma affects a body and the problems that forensic pathologists face in conducting trauma autopsies.

Spitz, Werner U., ed. *Spitz and Fisher's Medicolegal Investigation of Death: Guidelines for the Application of Pathology to Crime Investigation*. 4th ed. Springfield, Ill.: Charles C Thomas, 2006. Indispensable volume for those conducting forensic investigations and forensic pathology. Includes comprehensive sections on specific cases along with their pathological findings.

Timmermans, Stefan. *Postmortem: How Medical Examiners Explain Suspicious Deaths*. Chicago: University of Chicago Press, 2006. Outstanding work on forensic pathology explains the autopsy process and gives case study examples.

Zugibe, Frederick, and David L. Carroll. *Dissecting Death: Secrets of a Medical Examiner*. New York: Broadway Books, 2005. A forensic pathologist discusses some of his cases and how he performed the autopsies. Interesting book aimed at readers who like the popular *CSI* television shows.

See also: Antemortem injuries; Coroners; DNA analysis; Fingerprints; Forensic odontology; Forensic pathology; Forensic toxicology; Gunshot wounds; Oral autopsy; Petechial hemorrhage; Psychological autopsy; Puncture wounds; Suicide; Thanatology; Toxicological analysis.

B

Bacteria

Definition: Single-celled organisms lacking a nucleus, found in and on humans and widespread in the environment.

Significance: Bacteria are ubiquitous on Earth, and some species can cause disease in humans. An understanding of the classification of bacteria as well as the ways in which bacterial populations grow and reproduce is useful to the identification, diagnosis, and treatment of bacterial diseases.

The tiny unicellular organisms known as bacteria define the biosphere on Earth—that is, if bacteria do not inhabit a particular environment, no living things reside there. Bacteria are extremely adaptable and have managed to exploit a wide variety of habitats successfully. One niche exploited by bacteria is the human body. Humans support a population of more than two hundred species of bacteria in numbers greater than the cells that make up an individual human host. These members of the normal flora are found on the skin and in the digestive, urinary, reproductive, and upper respiratory tracts of humans.

Although some species of bacteria can cause disease in humans, other animals, and plants, the majority of bacterial species are not pathogenic (disease-causing). Bacteria are key players in the ecology of the Earth, functioning in important roles in global chemical cycles. Perhaps most important, bacteria are the only organisms on Earth that possess the ability to fix nitrogen—that is, to convert the nitrogen gas in the atmosphere to a form that is usable by other organisms.

Disease-causing bacteria have attracted the most interest and study since the confirmation of the germ theory of disease by Louis Pasteur and Robert Koch in the 1870's. It is interesting to note that Koch's proof that germs cause disease involved the bacterium *Bacillus anthracis*, which causes anthrax, an organism that has been used as a biological weapon.

The first sixty years of the study of medical bacteriology focused on identification and diagnosis, with little attention to the basic biology of bacteria. The discovery and development of antibiotics led to an overly optimistic view that infectious disease had been conquered. The emergence of antibiotic-resistant strains of bacteria as well as outbreaks of previously unknown pathogens stimulated a renewed interest in bacteriology.

Classification and Taxonomy

Bacteria are classified as prokaryotic cells—that is, the genetic material of a bacterium is not enclosed in a nucleus. This lack of a nucleus distinguishes bacterial cells from the cells that make up plants and animals, which are classified as eukaryotic. Additional differences between bacterial cells and eukaryotic cells include the types of molecules found in the cell walls, organization and expression of genes, and sensitivity to certain antibiotics.

Bacteria themselves have been classified in several ways. In 1923, the first edition of *Bergey's Manual of Determinative Bacteriology* offered descriptions of all the species of bacteria then identified, an outline of the taxonomic relationships among bacteria, and keys for diagnosis of diseases caused by bacteria. The ninth edition of *Bergey's Manual*, published in 1994, focuses primarily on identification of bacteria and uses taxonomic divisions that do not necessarily reflect evolutionary relationships.

During the 1980's, *Bergey's Manual of Systematic Bacteriology* was published in an attempt to organize bacterial species into the type of hierarchical classification schemes that have been applied to eukaryotic organisms. This manual later underwent revision to include new species and to cover the progress that had been made in molecular classification methods.

The International Committee on Systematics of Prokaryotes (ICSP) is the organization that oversees the nomenclature of prokaryotes and issues opinions concerning related taxonomic matters. When a researcher discovers a previously undescribed bacterium, the ICSP must approve the researcher's proposed name for the newly described species as well as the taxonomic classification of the species.

Clinically, classification of bacteria is performed primarily to diagnose particular diseases. Identification of bacteria in a clinical specimen can be accomplished through direct microscopic examination, isolation and culture of the responsible bacteria, and biochemical and immunological tests. Researchers have developed and marketed a number of automated microbial diagnosis systems that allow rapid diagnosis without the need to isolate the organisms of interest.

Cell and Population Growth

In discussing the growth of living organisms, one can focus on the growth of an individual or the growth of a population. Because bacteria are single-celled organisms, growth of an individual bacterium does not include development of organs or other body parts, but rather just enlargement of the cell itself.

Discussion of the growth of bacterial species is usually concerned with the growth of a population of cells. Because almost all bacteria reproduce through the division of one cell into two, the growth of a population of bacterial cells is geometric—that is, the population doubles in size with each round of cell division. The length of time required for a population of bacterial cells to double varies depending on the species and strain of bacteria as well as on the environmental conditions, including temperature, pH, nutrient availability, and waste accumulation.

Some bacteria, such as *Escherichia coli*, have a maximum doubling rate of less than thirty minutes. At this rate, a single cell could generate a population of one million cells in less than ten hours. In fact, if the environmental conditions remained optimal, with ready nutrients and regular waste removal, a culture of maximally reproducing *E. coli* bacteria would equal the mass of the planet Earth within one week. Other bacteria, such as *Mycobacterium tuberculosis*, divide much more slowly, taking twelve to eighteen hours under optimal conditions for one

Dr. Robert Koch with his wife in 1908, three years after he won the Nobel Prize in Physiology or Medicine for his work on tuberculosis. During the 1870's, Koch and French biologist Louis Pasteur proved the germ theory of disease that laid the foundation for modern bacteriology. *(Library of Congress)* round of binary fission. The optimal growth rates estimated for many bacteria are merely speculative because the majority of species have not yet been cultured on defined or artificial media.

Even slowly dividing bacteria can reproduce in far less time than nearly every other type of organism. Because of their rapid reproductive rates and omnipresence in the living world, bacteria can rapidly overwhelm any unpreserved biological sample. Unrefrigerated food, blood and tissue samples, and other biological specimens can quickly become host to a diverse, rapidly growing population of bacteria.

Reproduction

Most bacteria reproduce by binary fission. One cell grows by manufacturing more cellular components. The genome is replicated, and the single cell divides into two essentially identical cells. This type of reproduction is termed asexual because it does not involve the recombination of genetic material from two parents. Because the cells that result from binary fission are virtually identical genetically, the individual cells in a group or colony of bacteria all descended from a single ancestral cell could well be clones of the original cell.

The cellular machinery involved in replicating the genetic material does not perform this replication with perfect fidelity. At each round of replication, there is a finite probability of errors occurring. These errors lead to changes in the genetic material known as mutations. These mutations may result in cells with characteristics that are different from those of the other cells in the population. These altered characteristics may lead to cells that are better adapted to a particular environment—perhaps the ability to metabolize a new nutrient or survive in the presence of an antibiotic. Because bacterial cells reproduce by simple cell division, altered characteristics are transmitted to all offspring of the altered cell (barring further mutation).

Although bacteria do not reproduce sexually by recombination of genetic material from two parents, many bacteria are capable of obtaining genetic material from other cells through various methods. Some bacteria can take up DNA (deoxyribonucleic acid) from the environment (probably released from decomposing cells), can receive DNA through viral infections, and can transfer DNA directly from one living cell to another. These genetic recombination processes allow genes (such as those that confer antibiotic resistance) to be spread throughout a bacterial population rapidly.

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Further Reading

Betsy, Tom, and James Keogh. *Microbiology Demystified*. New York: McGraw-Hill, 2005. This alternative to hefty textbooks is intended as a review for allied health students having difficulty understanding concepts in microbiology. Clearly written.

Madigan, Michael T., John M. Martinko, Paul V. Dunlap, and David P. Clark. *Brock Biology of Microorganisms*. 12th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2008. The industry standard for introductory microbiology textbooks. Contains extensive information on bacterial classification and diversity.

Nester, Eugene W., Denise G. Anderson, Jr., C. Evans Roberts, and Martha T. Nester. *Microbiology: A Human Perspective*. 5th ed. New York: McGraw-Hill, 2007. Introductory textbook intended for nonscience majors and allied health students includes frequent discussion of real-world applications of concepts.

Pommerville, Jeffrey C. *Alcamo's Fundamentals of Microbiology*. 8th ed. Sudbury, Mass.: Jones & Bartlett, 2007. Accessible textbook is designed for introductory college students, particularly those in the health sciences. Includes numerous sidebars and case studies.

Willey, Joanne, Linda Sherwood, and Chris Woolverton. *Prescott, Harley, and Klein's Microbiology*. 7th ed. New York: McGraw-Hill, 2007. Comprehensive textbook has sections on bacterial growth (including techniques) and diversity (several chapters describe various categories of bacteria). The organization is clear and logical; introductory discussions of topics are accessible to readers with little scientific background.

See also: Anthrax; Anthrax letter attacks; Antibiotics; Bacterial biology; Bacterial resistance and response to antibacterial agents; Biological terrorism; Biological warfare diagnosis; Biotoxins; Bubonic plague; Centers for Disease Control and Prevention; Decomposition of bodies; *Escherichia coli*; Food and Drug Administration, U.S.; Parasitology; Pathogen genomic sequencing; Pathogen transmission; Tularemia.

Bacterial biology

Definition: Study of prokaryotic organisms that lack membrane-bound organelles and nuclei—simple, single-celled microscopic organisms that grow by cell division to produce identical daughter cells.

Significance: Forensic scientists are sometimes called upon to identify the bacterial strains that caused such problems as hospital-acquired infections, food-borne infections, or microbial diseases; they may also need to identify the biological agents used in acts of bioterrorism. Bacteria have different DNA polymorphisms (variations in DNA sequence between individual bacteria or bacterial strains) that serve as markers for typing different bacteria.

Several types of polymorphisms are used for DNA (deoxyribonucleic acid) profiling. One type is single nucleotide polymorphisms (SNPs), in which only a single nucleotide in a sequence varies. A second type is variable number of tandem repeats (VNTRs). A sequence of DNA is tandemly (end-to-end) repeated, with the number of repeats differing between individual bacteria. An example is a sequence of thirty nucleotides that is repeated between twenty to one hundred times in different bacterial cells. To identify VNTRs in bacteria, polymerase chain reaction (PCR) primers are designed for both sides of the VNTR locus. With PCR, the sequence between the two primers is amplified, giving a large amount of this specific DNA, which is then separated by gel electrophoresis to determine the size (number of repeats) of the region amplified. The different numbers of tandem repeats are thought to arise from mistakes in DNA replication that generate INDEL (insertion or deletion of DNA) mutations.

An additional polymorphism is short tandem repeats (STRs), which are short sequence elements that repeat themselves within the DNA molecule. The repeating sequence is usually three to seven bases in length, and the entire length of an STR is fewer than five hundred bases in length.

Other types of markers used to identify bacteria are the sequences of 16S rRNA (ribosomal ribonucleic acid) and the spacer between the 16 and 23S rRNAs. Ribosomal RNA is part of the ribosome that translates messenger RNA into proteins. By comparing rRNA sequences, scientists can identify types of bacteria. PCR is used to amplify the specific DNA coding for the 16S rRNA. For example, 16S rRNA can be used to identify the bacterial pathogen causing disease in different persons.

Forensic Applications

The ability to identify bacteria is important in many kinds of cases. For example, when patients develop infections while in the hospital, this can pose a particular problem because of the extensive use of antibiotics and the development of antibiotic-resistant bacterial strains such as methicillin-resistant *Staphylococcus aureus*, which is seen in hospital-acquired infections. The different strains of *Staphylococcus* can be identified through DNA typing. The identification of an antibiotic-resistant strain of a bacterium leads to a more effective type of antibiotic treatment for the patient. Also, in some cases infections may be caused by inadequate hygienic precautions taken during surgery or in postoperative care. DNA analysis is important to identify the source of such infection-causing bacterial strains.

In cases of food-borne infections, it is important to be able to trace the microbes that caused them to the sources—whether companies, farms, or persons—to determine the origin of the microbes. Scientists use DNA analysis to track food-borne infections caused by *Salmonella* or the *Esherichia coli* strain O157:H7 to identify the types of bacteria causing the problems.

Molecular techniques are used to follow outbreaks of microbial diseases. The U.S. Centers for Disease Control and Prevention (CDC) maintains a database of microbial DNA fingerprints (PulseNet). Scientists have examined some thirty-one VNTR loci to compare strains of *Mycobacterium tuberculosis*, the bacterium that causes tuberculosis.

It is also important to be able to identify bacteria in cases of biological terrorism. For example, in 2001, letters containing *Bacillus anthracis*, the bacterium that causes anthrax, were sent through the mail in the eastern United States, and five people died of inhalation anthrax. Because *B. anthracis* spores are commonly found in soil, it was essential that prosecutors prove that spores found in a suspect's home or laboratory were the same strain that was found on the material mailed to the victims. In 2002, the American Academy of Microbiology met to formulate standards for evidence collection and analysis of molecular tests for microbial forensics.

Bacteria can also be used to estimate time of death. After death, the action of bacteria destroys the soft tissues of the body. The bacteria generally found are those normally present in the respiratory and intestinal tracts, such as bacilli, coliform, and clostridiuim. The temperature of the environment surrounding the body determines the rate of bacterial growth.

Susan J. Karcher

Further Reading

Breeze, Roger G., Bruce Budowle, and Steven E. Schutzer, eds. *Microbial Forensics*. Burlington, Mass.: Elsevier Academic Press, 2005. Details the importance of forensic microbiology and discusses its uses.

Butler, John M. *Forensic DNA Typing: Biology, Technology, and Genetics of STR Markers*. 2d ed. Burlington, Mass.: Elsevier Academic Press, 2005. Accessible textbook provides a detailed overview of DNA methodologies used by forensic scientists.

Cho, Mildred K., and Pamela Sankar. "Forensic Genetics and Ethical, Legal, and Social Implications Beyond the Clinic." *Nature Genetics* 36 (2004): S8-S12. Discusses the ethical considerations related to DNA profiling and genetic analysis.

Jobling, Mark A., and Peter Gill. "Encoded Evidence: DNA in Forensic Analysis." *Nature Reviews Genetics* 5 (October, 2004): 739-751. Provides an informative summary of DNA forensics.

Kobilinsky, Lawrence F., Thomas F. Liotti, and Jamel Oeser-Sweat. *DNA: Forensic and Legal Applications*. Hoboken, N.J.: Wiley-Interscience, 2005. Presents a general overview of the uses of DNA analysis and profiling.

Madigan, Michael T., John M. Martinko, Paul V. Dunlap, and David P. Clark. *Brock Biology of Microorganisms*. 12th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2008. Widely respected basic microbiology textbook includes information about biological weapons and methods of microbial identification.

See also: Antibiotics; Bacteria; Bacterial resistance and response to antibacterial agents; Biological terrorism; Biological warfare diagnosis; Biological weapon identification; Biotoxins; Centers for Disease Control and Prevention; *Escherichia coli*; Food poisoning; Pathogen genomic sequencing; Pathogen transmission.

Bacterial resistance and response to antibacterial agents

Definition: Ability of some bacteria to resist or entirely withstand the effects of antimicrobial agents.

Significance: Although most bacteria are benign, a small percentage are pathogenic, or disease-causing. Bacteria rank among the most important of all disease-causing organisms in humans, and bacterial infections are countered by a wide variety of antibiotic and antibacterial agents. Repeated use of such agents results in bacterial resistance, necessitating the development of stronger antibacterial agents.

> Increasing fears that antibiotic-resistant strains of bacteria may be used as bioweapons add urgency to efforts to develop new antibacterial agents.

Less than 10 percent of all bacteria threaten human health. These disease-causing species are notorious for such diseases as cholera, typhus, and syphilis. The most common and some of the most deadly forms of bacterial diseases are respiratory infections, such as tuberculosis, which kill millions of people every year. Countries around the world have used antibiotic drugs to treat bacterial infections for more than fifty years. The initial introduction of antibiotics was markedly successful, but continued and widespread use has resulted in a phenomenon in which microbial adaptation is making targeted bacteria increasingly difficult to control. This bacterial resistance to antibiotics is of special concern, as ever more powerful antibiotics must be developed.

Antibiotics and Antibacterials

In its broadest definition, an antibacterial is an agent that interferes with the growth and reproduction of bacteria. Although antibiotics and antibacterials both attack bacteria, these terms have evolved over the years to mean two different things. The term “antibacterials” is most commonly applied to agents that are used to disinfect surfaces and eliminate potentially harmful bacteria. The term “antibiotics” is commonly reserved for medicines given to humans or animals to treat infections or diseases.

Bacteria become resistant to antibacterial agents in one of three ways: natural resistance, vertical evolution, and horizontal evolution. Therefore, bacteria exhibit either inherited or acquired resistance to antibacterial agents. Natural resistance occurs when bacteria are inherently resistant to an antibacterial. For example, a gram-negative bacterium has an outer membrane that establishes an impermeability barrier against the antibiotic it manufactures, so it does not self-destruct.

Acquired resistance occurs when bacteria develop resistance to an antibacterial agent to which the population has been exposed. This may occur through mutation and selection (vertical evolution) or exchange of genes between strains and species (horizontal evolution) of the bacteria exposed to the antibacterial agent.

Vertical evolution represents an example of Darwinian evolution driven by principles of natural selection. Genetic mutations in the bacteria population create new genes or combinations of genes that are resistant to the antibacterial agent. While the nonmutant, sensitive bacteria are killed, bacteria containing the mutated genes survive, and their progeny populate the increasingly resistant colony.

Another form of acquired resistance, horizontal evolution, is the transfer of resistant genes from one bacterium to another in the population. For example, *Escherichia coli* or *Shigella* may acquire a gene from a streptomycete that is resistant to the antibiotic streptomycin. Following this transfer, the population contains a mutant *E. coli* bacterium now resistant to streptomycin. Then, through the process of selection, it donates these genes to further generations, creating a resistant strain.

Transfer of genes in bacteria occurs in one of three ways: conjugation, transduction, or transformation. In conjugation, the gene-containing DNA (deoxyribonucleic acid) crosses a connecting structure, called a pilus, from a donor bacterium to recipient bacteria. In transduction, a virus may transfer genes between bacteria. In transformation, DNA is acquired directly from the environment, having been released from another bacterium. Following transfer, the combination of the newly acquired gene or genes results in a process called genetic recombination that may lead to the emergence of a new genotype. The combination of transfers and genetic recombination promotes rapid spread of antibacterial resistance through a species population and also between strains and other bacterial species.

The combined effects of fast growth rates, high concentrations of cells, genetic processes of mutation and selection, and genetic recombination account for the extraordinary rates of adaptation and evolution observed in bacteria populations. For these reasons, bacterial resistance to antibacterials is a common occurrence and one that promises to be of increasing concern in the future.

Facts About Antibiotic Resistance

The Centers for Disease Control and Prevention provides the following information about the growing problem of antibiotic resistance.

- Antibiotic resistance has been called one of the world's most pressing public health problems.
- The number of bacteria resistant to antibiotics has increased in the last decade. Nearly all significant bacterial infections in the world are becoming resistant to the most commonly prescribed antibiotic treatments.
- Every time a person takes antibiotics, sensitive bacteria are killed, but resistant germs may be left to grow and multiply. Repeated and improper uses of antibiotics are primary causes of the increase in drug-resistant bacteria.
- Misuse of antibiotics jeopardizes the usefulness of essential drugs. Decreasing inappropriate antibiotic use is the best way to control resistance.
- Children are of particular concern because they have the highest rates of antibiotic use. They also have the highest rate of infections caused by antibiotic-resistant pathogens.
- Parent pressure makes a difference. For pediatric care, a recent study showed that doctors prescribe antibiotics 65% of the time if they perceive parents expect them, and 12% of the time if they feel parents do not expect them.
- Antibiotic resistance can cause significant danger and suffering for people who have common infections that once were easily treatable with antibiotics. When antibiotics fail to work, the consequences are longer-lasting illnesses; more doctor visits or extended hospital stays; and the need for more expensive and toxic medications. Some resistant infections can cause death.

Bacterial Resistance and Forensic Science

The importance of bacteriology in forensic science is recognized in diverse areas, including DNA profiling, toxicology studies, fingerprinting, and the tracing of violence stemming from or potentially relating to murders. Bacteria have been used as weapons and can be the causes of violence, but they may also serve as tools in the investigation of crimes.

The most serious threat posed by bacteria is their possible use in biological warfare, especially in acts of bioterrorism. For example, *Bacillus anthracis*, which causes anthrax, has become a preferred bacterial strain used by terrorists. Strains of deadly bacteria selected especially for their antibody resistance can pose health threats of enormous proportions at both local and global levels.

Some research has suggested that bacterial infections can lead to criminal behavior. For example, *Streptococcus* infections have been linked to hyperactivity, and hyperactivity has been linked to criminal behavior. Some defense lawyers have used such research findings in attempts to explain their clients' actions, connecting criminal behavior with infection-caused states of delirium.

In some cases, the bacteria present at the site of a crime can give important clues about the crime itself. For instance, bacteria can reveal how long a person has been dead or the temperature the body was subjected to after death. Heart and spleen blood cultures may be taken at autopsy to identify any possible infections or diseases the deceased may have had.

Dwight G. Smith

Further Reading

Bartelt, Margaret A. *Diagnostic Bacteriology. A Study Guide*. Philadelphia: F. A. Davis, 2000. Provides a comprehensive, user-friendly introduction to bacteriology for general readers.

Breeze, Roger G., Bruce Budowle, and Steven E. Schutzer, eds. *Microbial Forensics*. Burlington, Mass.: Elsevier Academic Press, 2005. Details the importance of forensic microbiology and discusses its uses.

Cummings, Craig A., and David A. Relman. "Microbial Forensics: When Pathogens Are 'Cross-Examined.'" *Science* 296 (2002): 1976-1979. Discusses the science involved in inferring the origin and transmission route of a microbial strain that has caused an infectious disease outbreak.

Larkin, Marilynn. "Microbial Forensics Aims to Link Pathogen, Crime, and Perpetrator." *The Lancet Infectious Diseases* 3, no. 4 (April, 2003): 180-181. Brief discussion of microbial forensics covers basic information on the field.

Tsokos, Michael, ed. *Forensic Pathology Reviews*. Vol. 4. Totowa, N.J.: Humana Press, 2006. Collection of articles by forensic pathologists includes valuable information on advances in forensic work concerned with bacteria.

See also: Anthrax; Antibiotics; Bacteria; Bacterial biology; Biological warfare diagnosis; Biotoxins; Bubonic plague; Pathogen genomic sequencing.

Ballistic fingerprints

Definition: Marks that are etched on a rifle or handgun bullet as it is pushed through the gun's barrel.

Significance: The analysis of ballistic fingerprints is used in criminal investigations to gain information about the models of guns as well as the individual guns that fired bullets recovered from crime scenes. By comparing the marks that guns leave on bullets, experts can often identify the weapons used in crimes.

The examination of ballistic fingerprints is part of the field of internal ballistics, which is the study of events that begin when the firing pin of a rifle or handgun strikes the cartridge and end when the bullet exits the barrel. Ballistic fingerprinting is not a new science. In June, 1900, Dr. Albert Llewellyn Hall published an article titled "The Missile and the Weapon" in the *Buffalo Medical Journal*, in which he presented the first analysis of bullet marks imparted by rifling in a gun barrel.

The interior of the barrel of a rifle or handgun has raised and lowered spirals, called rifling, that impart spin to the bullets as they are fired, making them more aerodynamically stable. As a bullet is pushed down a gun's barrel by the gas that is generated by burning gunpowder, it is etched with fine lines, or striations, from the rifling. Under microscopic examination, these striations look something like the parallel lines of a universal product code. In addition, "skid marks" may be left on a bullet in the short period after it leaves the firing chamber and before it is fully engaged by the rifling.

The striations common to all guns of a particular model are known as class characteristics. Individual characteristics are the striations unique to a particular gun; these result from tiny imperfections in the rifling process and in the rifling tools used as well as from the wear

A forensic firearms examiner at the Ohio Bureau of Criminal Identification and Investigation uses a model of an enlarged bullet to explain how bullet comparisons are made using unique barrel marks. *(AP/Wide World Photos)* and tear caused by the particular usage of that gun. Individual characteristics change over time. Criminals sometimes deliberately change a gun's individual characteristics; common techniques include shortening the barrel and rubbing the interior of the barrel with a steel brush.

Different types of ammunition fired through the same gun will produce very different striations. Even the small natural variations from one cartridge to another in the same box of commercial ammunition can produce some differences in patterns.

The analysis of ballistic fingerprints produces its most accurate results when the cartridge case (which holds the bullet, gunpowder, and primer before firing) as well as the bullet has been recovered; the firing pin, extractor, magazine, and other parts of the gun often leave distinctive marks on the case. Ballistic fingerprinting cannot be used on shotgun pellets because shotgun bores are smooth rather than rifled. However, shotgun cases can still be examined for firing pin marks and the like.

Several databases of digitized ballistic fingerprints of bullets recovered from crime scenes are available to criminal investigators. Forensic experts who conduct ballistic fingerprinting can use these databases to narrow their selection of bullets for microscopic examination. Binocular microscopic comparison of two bullets can take many hours.

A few jurisdictions require that ballistic fingerprint samples from new, lawfully sold handguns be put into a digitized database, but the efficacy of such efforts is the source of ongoing debate.

David B. Kopel

Further Reading

Burnett, Sterling, and David B. Kopel. *Ballistic Imaging: Not Ready for Prime Time*. Dallas: National Center for Policy Analysis, 2003.

Heard, Brian J. *Handbook of Firearms and Ballistics: Examining and Interpreting Forensic Evidence*. New York: John Wiley & Sons, 1997.

Warlow, Tom. *Firearms, the Law, and Forensic Ballistics*. 2d ed. Boca Raton, Fla.: CRC Press, 2005.

See also: Ballistics; Bullet-lead analysis; Class versus individual evidence; Firearms analysis; Gunshot residue; Integrated Ballistics Identification System; Microscopes.

Ballistics

Definition: Study of the motion, behaviors, effects, and impact signatures of projectiles.

Significance: When projectiles—whether bullets, bombs, or missiles—are involved in crimes, ballistics experts play a vital role in the investigations. Forensic scientists trained in ballistics can identify the specific types of firearms used in crimes based on bullets, shell casings, and other evidence found at crime scenes. By comparing this information with weapons belonging to possible suspects, they can confirm individual weapons as those used in the crimes.

A ballistic body is any object used to exert force to make another object move or change in form, state, or direction. A bullet, for example, is a ballistic body when it is propelled by the sudden increase of pressure that takes place within a handgun or other firearm when the trigger is pulled and a discharge of explosive powder propels the bullet forward in a direction dictated by the barrel of the weapon. When the bullet exits the weapon, it is subject to the laws of ballistics. As the projectile reaches its target, its velocity and trajectory cause distinctive entry and exit wounds.

The science of firearms ballistics is divided into four components: internal ballistics, transition ballistics, external ballistics, and terminal ballistics. Internal ballistics is the study of the forces that cause the acceleration of ballistic bodies; in the case of a bullet fired from a gun, internal ballistics is concerned with the detonation of the bullet, its discharge from the chamber, and its pathway through the barrel. Transition, or intermediate, ballistics is the study of the immediate effects on ballistic bodies as they leave the barrels of weapons; this area of ballistics focuses on forces such as air pressure, gravity, and air density, which act collectively on projectiles as their initial acceleratory force is reduced.

External ballistics is the study of projectiles' flight through the air. This includes the examination of changes in velocity and trajectory of ballistic bodies during the time they are in flight from weapons to targets. The last component of basic ballistics, terminal ballistics, is concerned with the impacts of projectiles on the objects with which they come in contact. This includes the effects of impacts on projectiles themselves and the ways in which bullets penetrate various surfaces (including human flesh).

Criminal Cases

Because the barrels of firearms are rifled (that is, they have raised and lowered spiral surfaces) to impart spin to bullets, distinctive marks (striations) are left on bullets as they swirl down the shafts of barrels after firing. The first recorded use of such marks as evidence in a criminal case took place in 1835. It was found that bullets fired from a weapon taken from the home of the primary suspect had a distinctive ridge that was identical to the ridge seen on a bullet recovered from the scene of the crime. When confronted with this evidence during questioning, the suspect confessed to the crime. Nearly seventy years later, in 1902, attorney Oliver Wendell Holmes, Jr., introduced ballistics evidence in a court of law. In a murder case, Holmes had a local gunsmith test fire a weapon belonging to the suspect into a wad of cotton stuffing. Under magnification, the marks on the test-fired bullet were seen to match those on the bullet retrieved from the crime scene, and this evidence was presented to the jury.

Shortly thereafter, two ballistics experts of that time, Calvin Goddard and Charles Waite, began compiling a database of information on all known gun manufacturers and on specific types of handguns as well as the marks made on bullets fired from them. Waite later invented the comparison microscope, which forensic scientists use to make side-by-side comparisons of the marks on two bullets at a time.

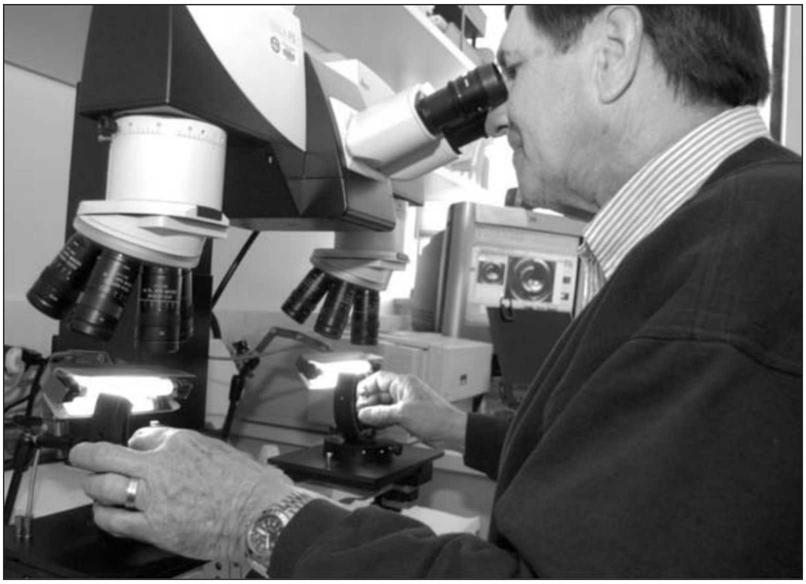
In the twenty-first century, forensic ballistics examinations are undertaken in virtually every criminal case involving firearms in the United States. The two basic types of weapons involved in forensic ballistics cases are handheld weapons (handguns or pistols) and shoulder weapons (rifles). The two types of firearms produce unique marks on bullets and shell casings when fired. Even after a weapon has fired hundreds of rounds, a bullet from that weapon will still match the first bullet from its barrel. For experts in forensic ballistics, bullet marks are like fingerprints; each firearm leaves marks that are unique to that weapon.

Forensic Techniques

Experts in forensic ballistics perform many different kinds of analyses, including making bullet comparisons, matching projectiles to weapons, and estimating the lengths of projectile flights, which enables them to determine the types of weapons used and the locations of the operators of weapons when they were fired. During investigations of crime scenes involving shootings, ballistics experts analyze the impacts of bullets on victims, whether wounded or dead, to determine the types and sizes of projectiles fired and the types of weapons used, the distances from the shooters to the victims, and the angles at which the shots were fired.

If bullets, cartridges, or cartridge cases are not found at the scene of a fatal shooting, a forensic pathologist will usually analyze the victim's wounds to determine information about the type of weapon used. Entry wounds are generally smaller than exit wounds and have dark rings around the injured surfaces, and by examining these, experts can often determine the width and thus the likely caliber of the bullets that made the wounds. This technique is referred to as wound ballistics.

When bullets are recovered from crime scenes, ballistics experts compare the striations on the bullets to those on other bullets from known sources. If the firearm suspected to have been used in a given crime is available, a test bullet is shot from that weapon and then the marks on that bullet are compared with the marks on the bullets found at the crime scene. The bullets found at crime scenes are also often



A forensic scientist and arms examiner at the Ohio Bureau of Criminal Identification and Investigation uses a comparison microscope to conduct a side-by-side comparison of two fired bullets. *(AP/Wide World Photos)*

compared with thousands of images of bullets stored in law-enforcement databases. Matches to bullets in such databases can give investigators important information about the histories of the weapons that fired the bullets.

The identification of specific weapons is another important aspect of the forensic investigation of crimes involving firearms. Many criminals remove the serial numbers from the guns they use—by filing the numbers off or using acid washes—because they believe this will make the weapons untraceable. Forensic scientists, however, are able to reclaim obliterated serial numbers using sophisticated techniques. To recover a gun's missing serial number, the examiner files down the metal that carried the serial number to retrieve a strip of highly polished and hardened metal located beneath where the original serial number was stamped. By adding a solution of copper salts and hydrochloric acid to the area, the scientist can dissolve the weaker metal below where the numbers were stamped to reveal an imprint of the original serial number. This imprint is then photographed before the metal dissolves completely, and the photograph serves as documentation of the weapon's serial number.

Related to the work of ballistics experts is the detection and evaluation of gunshot residue, which figures importantly in forensic investigations. The amount and scatter of gunshot residue provides information about the proximity of a victim to a weapon as it was fired. In addition, gunshot residue on the hands, skin, hair, and clothing of persons who were present at the time of a crime can reveal how close those individuals were to the weapon. Firearms give off a back-spray of gunpowder when discharged, and this hot and sticky substance adheres to most items of clothing and skin with which it comes in contact. It may remain embedded in objects during subsequent and sometimes repeated washings or cleanings. Forensic scientists sometimes use electron scanning techniques to detect minute particles of gunshot residue on watches and other jewelry worn by people suspected of having used guns in crimes.

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Further Reading

Carlucci, Donald E., and Sidney S. Jacobson. *Ballistics: Theory and Design of Guns and Ammunition*. Boca Raton, Fla.: CRC Press, 2008. Comprehensive work covers all aspects of the topic, including the theory and fundamental physics of ballistics, design techniques for firearms and ammunition, and the tools used to investigate firearms-related crimes.

Heard, Brian J. *Handbook of Firearms and Ballistics: Examining and Interpreting Forensic Evidence*. New York: John Wiley & Sons, 1997. Thorough volume focuses on the science of forensic firearms analysis.

Rinker, Robert A. *Understanding Firearm Ballistics: Basic to Advanced Ballistics, Simplified, Illustrated, and Explained*. 6th ed.

Clarksville, Ind.: Mulberry House, 2005. Provides an easy-to-understand general introduction to theory of weapons ballistics.
Zukas, Jonas A., and William P. Walters, eds. *Explosive Effects and Applications*. New York: Springer, 1998. Collection of essays by experts focuses on the component of ballistics concerned with the explosive impacts of bullets.

See also: Ballistic fingerprints; Bullet-lead analysis; Bureau of Alcohol, Tobacco, Firearms and Explosives; Firearms analysis; Gunshot residue; Improvised explosive devices; Integrated Ballistics Identification System; Sacco and Vanzetti case.

Barbiturates

Definition: Family of chemically related drugs belonging to the sedative-hypnotic class.

Significance: The habit-forming drugs known as barbiturates have a variety of therapeutic applications and have been used as drugs of abuse. Barbiturates depress the central nervous system and can cause significant psychomotor performance impairment as well as fatal toxicity. The potential for toxic interactions with other drugs, including alcohol, is significant. Forensic toxicologists are often called upon to measure barbiturate concentrations in biological samples.

The barbiturates are a family of drugs with related chemical structures derived from barbituric acid. In the past, barbiturates were used extensively as sedative-hypnotics—that is, drugs that reduce anxiety and induce sleep. Barbiturates are also used as anticonvulsants and in anesthesia. Because of barbiturates' significant potential for toxicity, their use has been largely replaced by the safer benzodiazepines, but selected barbiturates are still used in specific applications.

Effects

Barbiturates depress central nervous system (CNS) function in general rather than specific CNS functions. The severity of CNS depression increases with dose, potentially causing significant impairment of psychomotor skills (such as those required for safe driving) and, ultimately, fatal respiratory depression. Dose-dependent effects also extend to the peripheral nervous system, where they manifest primarily as reductions in blood pressure and heart rate. However, at appropriate sedative-hypnotic doses, these latter effects are not hazardous.

At subanesthetic doses, barbiturate effects may include euphoria, reduced anxiety and inhibitions, slurred speech, loss of coordination, and dizziness. CNS depression intensifies with increasing dose; sedation becomes more pronounced, and significant stupor, drowsiness, and loss of coordination may ensue. Anesthetic doses produce coma as well as depressed respiration and blood pressure. Uncontrolled overdose can result in fatal respiratory depression. These effects are intensified in combination with other CNS depressants (such as alcohol or benzodiazepines), and significant impairment or death may occur at lower barbiturate doses (or blood concentrations) when such drugs are coadministered.

Chronic barbiturate use results in the development of tolerance—that is, progressively larger doses are required to achieve a given effect. Repeated administration of and tolerance to the effects of one barbiturate confers tolerance to the effects of the others as well as to other depressant compounds with similar mechanisms of action (for example, alcohol and benzodiazepines). Chronic use can lead to physical dependence and corresponding withdrawal symptoms upon cessation of use. Symptoms of barbiturate withdrawal range from minor symptoms—nausea, vomiting, agitation, and confusion—to more severe symptoms including seizures, hallucinations, delirium tremens, very high fevers (hyperpyrexia), and death.

Other Chemical and Pharmacological Properties

Barbiturates are weakly acidic and are often prepared as the sodium salts. Their weakly acidic nature becomes important in the design of analytical methods requiring extraction of the drug from a complex forensic sample (for example, blood or tissue). Alteration of the chemical structure results in variation in drug potency (the magnitude of effect at a given dose) and time course of action.

Even in cases where the drug effects last a short time, barbiturates have a relatively long time course within the body. One indicator of this is the half-life of the drug, or the time required for the reduction of drug concentration to 50 percent of its original value. Half-life values for the various barbiturates range from approximately 3 hours to 80 hours. Any drug with a long half-life poses the risk of accumulation in the blood if dosing regimens are not carefully monitored, creating the potential for toxicity. Half-life is also related to the duration of drug action: Typically, a drug with a shorter half-life has a shorter duration of action. This is relevant to forensic investigation, as the half-life is indicative of the time window over which a drug may be detected in the blood; generally, a drug is essentially completely eliminated from the blood within five elimination half-lives.

One of the most famous victims of barbiturate poisoning was film star Marilyn Monroe, seen here on the set of *The Misfits* (1961), the last film in which she appeared, flanked by Montgomery Clift (left) and Clark Gable. Two years after this picture was taken, Monroe was found dead from an overdose of drugs that included the barbiturate Nembutal. Los Angeles County coroner Dr. Thomas Noguchi attributed her death to "acute barbiturate poisoning." *(AP/Wide World Photos)*

Duration of action and half-life are important considerations in the choice of a barbiturate for a particular therapeutic action. For example, thiopental is an ultrafast-acting barbiturate, typically used in induction of anesthesia. Due to its high lipid solubility, it is rapidly and extensively distributed into the central nervous system, wherein it exerts its anesthetic effect through depression of various functions. The elimination half-life for thiopental is 8 to 10 hours, although its ability to diffuse into and out of the CNS results in anesthetic action lasting only minutes following a single intravenous dose. Conversely, phenobarbital, a barbiturate used as an anticonvulsant and as a sedative-hypnotic, is significantly longer acting, with a half-life of 80 to 120 hours.

The route of administration of the drug is also dependent on the desired therapeutic action. Barbiturates used as sedative-hypnotics or anticonvulsants may be administered orally and have a slower onset of action than those given by parenteral (for example, intravenous) administration, where the onset of drug action is very rapid. Accordingly, parenteral administration is typically used in the treatment of status epilepticus (a condition in which the brain is in a state of persistent seizure) and for general anesthesia. The route of administration is ultimately related to the maximum blood drug concentration achieved, and therefore the magnitude of drug effect, at a given dose. Consequently, knowledge of the route of administration is valuable to toxicological interpretation. It should be noted, however, that some drugs intended for oral administration—in tablet form—are illicitly administered by parenteral routes, potentially leading to greater toxic effects.

The metabolism of most barbiturates occurs primarily in the liver, where the drugs undergo various biotransformation reactions (such as oxidation) that reduce or eliminate pharmacological activity. In a few cases (for example, aprobarbital, phenobarbital), renal elimination of unchanged drug into the urine also occurs to a significant extent. Consequently, barbiturate metabolism may be affected by processes that affect hepatic metabolism (for example, liver disease or drug interactions). Inhibited barbiturate metabolism may result in the development of significant toxicity.

Forensic Analysis and Interpretation of Evidence

Law-enforcement personnel may encounter barbiturates in the form of suspicious materials (for example, tablets) requiring identification or quantitative analysis. Forensic scientists may analyze biological samples (such as blood, tissues, urine, or stomach contents) to establish exposure to barbiturates. Correlation of toxic symptoms with measured barbiturate concentration is done in both clinical and forensic settings and in attempts to establish a toxicological cause of death.

Methods used for forensic barbiturate analysis include immunoassay, spectrophotometry, gas or liquid chromatography, and mass spectrometry. Usually, the analysis of biological samples for barbiturates requires preparatory steps to extract the drug from the complex matrix and minimize or eliminate other compounds (such as lipids or proteins) that may be present in those samples that may interfere with analysis, leading to spurious results. The exact nature of the sample preparation steps taken is determined by the nature of the sample being analyzed. Solid samples typically require dissolution or digestion as a first step.

Extraction of drugs from complex samples may be accomplished through the manipulation of chemical conditions (such as pH adjustment) and subsequent partition into a suitable organic solvent system or into a solid phase with subsequent recovery. Following extraction, analysis is typically done using gas chromatography or liquid chromatography to separate extracted constituents for accurate quantitative analysis.

The interpretation of measurements requires consideration of the nature of the sample analyzed as well as the measured drug concentration. Drug concentrations in blood may allow estimation of toxic effect, with consideration given to the potential for tolerance to drug action. Conversely, detection of a barbiturate in hair under properly controlled conditions is indicative of drug exposure only, but it may be useful in establishing an approximate time line of drug exposure.

The forensic detection of a particular barbiturate must be considered in the context of the case under investigation. The tolerance of the individual must be considered in the interpretation of measured barbiturate concentrations as well. For example, in toxicological analysis of blood samples from a known epileptic, the detection of phenobarbital may be consistent with a therapeutic regimen, and some degree of tolerance may often be assumed. In routine forensic practice, tolerance is difficult or impossible to quantify, so interpretation is difficult. Correlation of a measured blood concentration with toxicity or fatality requires comparison of the result to other similar cases that have been previously reported, giving due consideration to the history of use of barbiturates and other drugs by the subject, the detection of other relevant drugs in the sample (such as CNS depressants), and any observed symptoms (such as shallow breathing, impaired coordination, or slurred speech).

James Watterson

Further Reading

Baselt, Randall C. *Disposition of Drugs and Chemicals in Man*. 7th ed. Foster City, Calif.: Biomedical Publications, 2004. Describes the properties and associated tissue concentrations of a wide range of toxic compounds and discusses the techniques used to analyze these chemicals.

_______. *Drug Effects on Psychomotor Performance*. Foster City, Calif.: Biomedical Publications, 2001. Comprehensive reference work presents information on the impairing effects of a wide range of therapeutic and illicit drugs, including barbiturates.

Brunton, Laurence L., John S. Lazo, and Keith L. Parker, eds. *Goodman and Gilman's the Pharmacological Basis of Therapeutics*. 11th ed. New York: McGraw-Hill, 2006. Authoritative advanced textbook explains basic pharmacological principles and the specific pharmacological features of therapeutic agents. Includes some discussion of barbiturates.

Karch, Steven B., ed. *Drug Abuse Handbook*. 2d ed. Boca Raton, Fla.: CRC Press, 2007. Describes the pharmacological, physiological, and pathological aspects of drug abuse in general, and individual chapters address specific compounds, such as alcohol, as well as specific issues related to drug abuse, such as workplace drug testing.

Levine, Barry, ed. *Principles of Forensic Toxicology*. 2d ed., rev. Washington, D.C.: American Association for Clinical Chemistry, 2006. Introductory textbook describes the analytical, chemical, and pharmacological aspects of a variety of drugs of forensic relevance.

See also: Analytical instrumentation; Antianxiety agents; Controlled Substances Act of 1970; Drug abuse and dependence; Forensic toxicology; Gas chromatography; High-performance liquid chromatography; Homogeneous enzyme immunoassay; Illicit substances; Mass spectrometry; Nervous system; Pseudoscience in forensic practice; Truth serum; Ultraviolet spectrophotometry.

BATFE. *See* Bureau of Alcohol, Tobacco, Firearms and Explosives

Beethoven's death

Date: March 26, 1827

The Event: Ludwig van Beethoven suffered from many chronic ailments during his life, and the precise cause of his death has long been a topic of debate. Dr. William Walsh, director of the Beethoven Research Project, announced at a press conference on October 17, 2000, that samples of Beethoven's hair revealed extremely heavy lead deposits, indicating that lead poisoning may have caused the great composer's many illnesses and death.

Significance: The forensic investigation into the death of Beethoven proves both the achievements of forensic technology in historical investigation and the limitations of such technology. Analyses of hair and bone fragments have shed light on Beethoven's many illnesses, but researchers still question whether lead poisoning or lead poisoning alone caused Beethoven's problems.

Born in Bonn, Germany, in mid-December, 1770, Ludwig van Beethoven died on March 26, 1827, in Vienna, Austria, where he had lived since 1792. Ferdinand V. Hiller, a German admirer who visited the composer's deathbed, received a lock of Beethoven's hair that was later enclosed in a locket inscribed with names and date. This keepsake remained in the Hiller family until the 1930's, when the family, which was Jewish, was forced to flee Adolf Hitler's Nazi regime. The lock of hair then became the property of a Danish physician who aided Jewish refugees; the physician's family had possession of the hair until 1994, when it was offered for auction.

The hair was purchased by a consortium of members of the American Beethoven Society. Arizona urological surgeon Dr. Alfredo Guevara, the principal purchaser, retained 27 percent of the hair (160 individual hairs), and the remaining 422 strands were donated to the Ira F. Brilliant Center for Beethoven Studies at San Jose State University in Northern California. Guevara wanted to know if forensic technology could show the cause of Beethoven's poor health and death. In addition to becoming totally deaf, Beethoven suffered from eye disorders, liver disease, and a broad range of gastrointestinal and respiratory symptoms. When an autopsy was performed on his body on March 27, 1827, visual inspection showed abnormalities of the liver, gallbladder, spleen, pancreas, and kidneys.

Forensic Analysis

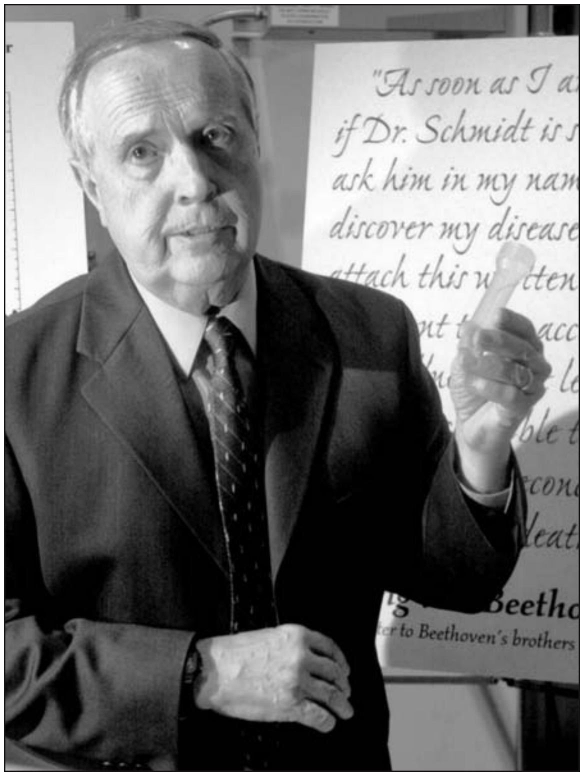
Dr. Werner Baumgartner of Psychemedics Corporation's laboratories in Los Angeles examined twenty hairs to determine whether Beethoven received relief from opiates during his final illness. A radioimmunoassay found no evidence of opiates. William Walsh speculated that Beethoven, who continued to compose music until very near the time of his death, rejected substances that would dull his mind.

McCrone Research Center in Chicago performed side-by-side analyses of two hairs from Beethoven and three samples from living subjects, using a scanning electron microscope, energy-dispersive spectroscopy, and scanning ion microscope-mass spectrometry. Using nondestructive synchrotron X-ray beams, the U.S. Department of Energy's Argonne National Laboratory tested six Beethoven hair strands in a side-by-side comparison with hair from a control group and a glass film of known lead composition. Both facilities found heavy lead concentrations. Beethoven's hair revealed an average lead content of 60 parts per million; living Americans, in comparison, average 0.6 parts per million. Researchers concluded that Beethoven suffered from lead poisoning, or plumbism.

In Beethoven's time, lead was used in pewter cups and dinnerware as well as in paint, cosmetics, medical preparations, and food coloring. Wine bottles were sealed (plumbed) with lead to keep the contents from turning sour. In an online interview on December 6, 2005, on *Online NewsHour*, Walsh offered an explanation for Beethoven's exceptionally poor health, speculating that the composer may have been among the 5 percent of people who are extremely sensitive to heavy metals and cannot excrete lead.

Scientists who examined Beethoven's hair found no traces of mercury, which led them to conclude that Beethoven had not been treated for syphilis, given that mercury was the most common treatment for the disease in Beethoven's time.

Because some of the hairs in the Beethoven sample included partial bulbs, DNA (deoxyribonucleic acid) examination was possible. In 2005, researchers at the Argonne National Laboratory's Advanced Photon Source facilities conducted additional testing using elemental X-ray fluorescence analysis on hair and fragments of Beethoven's skull made available after the original research was completed. DNA testing positively identified the bone and hair as Beethoven's. Researchers used microimaging to calculate the distribution of lead in the bone and hair fragments and again found substantial lead deposits. Mitochondrial DNA testing was also performed at the University of Münster in Germany.



William Walsh, director of the Beethoven Research Project, holds a vial containing a sample of Ludwig van Beethoven's hair at the press conference held to announce scientists' findings that lead poisoning may have caused the composer's many illnesses and death. *(AP/Wide World Photos)*

Controversy

A number of researchers have noted that not all questions concerning Beethoven's death can be answered through hair and bone analysis. They question whether lead poisoning or any single problem explains Beethoven's ill health, which was markedly worse than that of most of his contemporaries, or could be conclusively named as the sole, primary, or immediate cause of the composer's death. Concerns about the relatively simple explanation of lead poisoning begin with Beethoven's family history. In his early years, Beethoven was exposed to the tuberculosis that killed his mother and one brother. His father and his paternal grandmother were incapacitated by alcohol abuse, suggesting inherited alcohol intolerance. Some have speculated that Beethoven may have overused alcohol; observers at the time were divided, but consumption of alcoholic beverages was high in his lifetime, a period when urban water supplies, including Vienna's Danube River, were badly contaminated with human and animal waste. (No connection had yet been made between contaminated water and disease.)

Peter J. Davies has raised the possibility that Beethoven suffered from adult-onset diabetes mellitus, which was then uncontrollable. Deborah Hayden has noted that if Beethoven had been treated for syphilis in early manhood, the treatment would leave no evidence at his death decades later. In 1796, Beethoven contracted typhus, and this illness may have undermined his general health; his hearing loss began soon afterward.

The medical treatment that Beethoven received may have been immediately responsible for his death. He consulted at least a dozen physicians, usually insisting on receiving unknown medications and altering dosages. Four times in a period of three months, Dr. Johann Seibert, chief surgeon of the Vienna General Hospital, tapped Beethoven's abdomen to drain fluid. Neither anesthesia, other than opiates, nor the need for sterile conditions was known at that time, and physicians did not wash their hands between patients, as the possibilities of contagion and fatal infection were not recognized. Surgery was conducted hastily for the patient's sake, but, as Davies has noted, rapid fluid drainage may cause shock or acute renal failure. Effective diuretics were unknown during Beethoven's lifetime.

Betty Richardson

Further Reading

Davies, Peter J. *Beethoven in Person: His Deafness, Illnesses, and Death*. Westport, Conn.: Greenwood Press, 2001. Includes a time line of the composer's symptoms, information on the credentials of his physicians, critiques of the various suggested possible causes for his many symptoms, and a glossary of medical terms.

Emsley, John. *Elements of Murder: A History of Poison*. New York: Oxford University Press, 2005. Volume devoted to the use of poisons in murder includes a brief account of the Beethoven findings. Also discusses the historical use of lead in common substances and the effects of lead exposure on the human body.

Hayden, Deborah. *Pox: Genius, Madness, and*

A Finding of Lead Poisoning

In a press release dated December 6, 2005, the U.S. Department of Energy's Argonne National Laboratory announced the findings of research conducted on fragments of bone from Ludwig van Beethoven's skull:

The bone fragments, confirmed by DNA testing to have come from Beethoven's body, were scanned by X-rays from the Advanced Photon Source at Argonne, which provides the most brilliant X-rays in the Western Hemisphere. A control bone fragment sample from the same historic period was also examined. Both bone fragments were from the parietal section—the top—of the skull.

"The testing indicated large amounts of lead in the Beethoven bone sample, compared to the control," said Bill Walsh, chief scientist at the Pfeiffer Treatment Center in Warrenville, Ill., and director of the Beethoven Research Project. . . .

"The finding of elevated lead in Beethoven's skull, along with DNA results indicating authenticity of the bone/hair relics, provides solid evidence that Beethoven suffered from a toxic overload of lead," Walsh said. "In addition, the presence of lead in the skull suggests that his exposure to lead was not a recent event, but may have been present for many years."

the Mysteries of Syphilis*. New York: Basic Books, 2003. Argues that Beethoven may have had both lead poisoning and syphilis.

Mai, François Martin. *Diagnosing Genius: The Life and Death of Beethoven*. Montreal: McGill-Queen's University Press, 2007. Includes information about Beethoven's physicians and treatment and a timetable of his symptoms. Suggests the possibility that the conductor suffered from liver cirrhosis or infectious hepatitis and bacterial peritonitis, among other disorders.

Martin, Russell. *Beethoven's Hair: An Extraordinary Historical Odyssey and a Scientific Mystery Solved*. New York: Broadway Books, 2000. Describes the history of the famous lock of hair, from Beethoven's deathbed through the research results announced in 2000.

See also: DNA analysis; Exhumation; Hair analysis; Lead; Mitochondrial DNA analysis and typing; Napoleon's death; Opioids; Scanning electron microscopy; Taylor exhumation.

Benzidine

Definition: Chemical formerly used in the standard presumptive test for blood at crime scenes.

Significance: A positive reaction to benzidine or tetramethylbenzidine of a stain found at a crime scene suggests that the stain is probably blood; such information can facilitate an initial reconstruction of a crime and prompt follow-up.

For most of the twentieth century, benzidine was the standard chemical used in presumptive testing for blood at crime scenes. In the presence of heme iron and hydrogen peroxide, benzidine, which is clear in the reduced state, is converted to the oxidized state, which is deep blue. Because heme iron is present in hemoglobin, the protein that carries oxygen in the blood, a positive test can indicate the presence of blood. This test does not distinguish between human blood and animal blood, however; further testing is necessary to make that distinction and, if the blood is human, to determine whose blood it is. In addition, constituents of some plants, such as potatoes and horseradish, as well as oxidizing agents found in some cleansers, can catalyze the reaction. Accordingly, a benzidine test is only presumptive of blood; a positive result must be confirmed by laboratory test.

Developed in 1904, the benzidine test became the most popular presumptive test for blood because of its high sensitivity, specificity, and reliability. Benzidine, however, which was also used for the synthesis of dyes in the textile industry, proved to be highly carcinogenic, and its use and manufacture in the United States was banned by the Environmental Protection Agency in 1974. At that time, 3,3′,5,5′ tetramethylbenzidine (TMB) was developed as a presumptive test for blood. It is not as sensitive as benzidine, but it is much safer to use, although it is a probable carcinogen.

Typically, a forensic investigator performs the TMB test by moistening a cotton swab with deionized water and rubbing the swab on the suspect stain, adding a drop of TMB solution to the swab, waiting thirty seconds, and then adding a drop of 3 percent hydrogen peroxide to the swab. A positive reaction will turn the swab a blue-green color within fifteen seconds. Often a swab taken from near the stain is used as a control. If the swab turns blue-green before the hydrogen peroxide is added, the test is invalid. Validation of the reagents using a known blood standard is usually conducted.

The TMB reagent in a colloidal mixture can also be used to spray an area in order to raise faint bloodstains, such as might be left by handprints or shoe prints. Like luminol, this substance can allow investigators to see evidence of attempts to clean up blood from crime scenes. The standard TMB test does not destroy the sample, which can be subsequently tested for blood type and DNA, but the spray reagent, like luminol, fixes a stain so that it cannot be tested further; investigators must thus take care to limit the use of the reagent.

James L. Robinson

Further Reading

Lee, Henry C., Timothy Palmbach, and Marilyn T. Miller. *Henry Lee's Crime Scene Handbook*. San Diego, Calif.: Academic Press, 2001.

Nickell, Joe, and John F. Fischer. *Crime Science: Methods of Forensic Detection*. Lexington: University Press of Kentucky, 1999.

See also: DNA recognition instruments; DNA typing; Luminol; Orthotolidine; Phenolphthalein; Presumptive tests for blood; Reagents; Serology.

Beslan hostage crisis victim identification

Date: Hostage siege occurred between September 1 and 3, 2004

The Event: On September 1, 2004, a group of about thirty men and women, who were reportedly Muslim Chechen separatists, took over School Number One in the town of Beslan in the Russian Federation republic of North Ossetia-Alania, and held nine hundred students and fifty-nine teachers hostage. A three-day siege ended when Russian special forces and civilian volunteers attacked the school. This resulted in a violent confrontation in which the hostages were caught in the middle of gunfire and explosions; when it was over, nearly four hundred people were dead. The incident contributed to a growth in the power of the Russian government, which instituted new security measures, at the same time it heightened public mistrust of Russian authorities, who were suspected of covering up official incompetence in the handling of the incident and of censoring press coverage about it.

Significance: Forensic scientists played an important role in the aftermath of the tragedy in efforts to identify the dead as well as in the investigation of the motivations and the actions of the terrorists.

Since the dissolution of the Soviet Union in 1991, the region of Chechnya, located between the Black Sea and the Caspian Sea on part of the northern border of Georgia, has fought for independence from the Russian Federation. The Chechens are Muslim, and the separatist struggle has given rise to radicalism that is based both in nationalism and in Islamic extremism. The terrorists who took over School Number One in Beslan identified themselves as Chechen separatists, and most were indeed later found to be Chechens.

The hostage takers seized the school on the traditional first day of the Russian school year. After a brief exchange of gunfire with the police, the terrorists forced their hostages to crowd into the school's gymnasium. The terrorists then shot a number of men who appeared to be most capable of resistance and forced other hostages to throw out the bodies and clean up the blood.

The perpetrators may have hidden weapons and explosives in the school before their attack, but this point is denied by official reports and remains open to question. As security forces surrounded the school, the terrorists mined the gym and set up wires that, if tripped, would cause the explosives to go off. They also announced that if anyone attempted to intervene forcefully, they would kill fifty hostages for every one of their own number killed and twenty hostages for every one of their group injured.

The Tragedy

On the afternoon of the second day of the siege, the hostage takers allowed Ruslan Aushev, the president of the Russian republic of Ingushetia, to enter the school. Several of the hostage takers were later revealed to be Ingushetians, an ethnic group closely related to the Chechens. Aushev was allowed to bring twenty-six hostages out of the school with him. The terrorists also gave Aushev a list of demands, apparently authored by Chechen rebel leader Shamil Basayev, who reportedly had ordered the seizure of the school but was not present. One of the demands was that Russia recognize the independence of Chechnya.

The events that took place on September 3 are still not entirely clear. Some members of the

In the aftermath of the Beslan school hostage siege, authorities were faced with the task of identifying the dead, many of whom had been badly burned. *(AP/Wide World Photos)*

Russian military were allowed to approach the school to take away bodies, and as they did so, bombs went off in the gymnasium and the hostage takers began firing, killing two of the servicemen. About thirty hostages were able to escape in the chaos. Then Russian special forces, along with civilian volunteers, began to attack the school, and a pitched battle ensued. Explosions and gunfire continued for the rest of the night, and when the fighting was over, 334 hostages, 31 hostage takers, and more than 20 other people were dead.

The Application of Forensic Science

The primary use of forensic science in relation to the Beslan incident was in the identification of the dead, both victims and hostage takers. After the tragedy, family members initially attempted to identify children and other victims from their clothing or by looking for distinguishing physical features. Many of those who died had been badly burned, however, so investigators had to use more sophisticated approaches. More than one hundred of the corpses were so badly damaged that DNA (deoxyribonucleic acid) analysis was necessary to establish positive identification. This involved comparison of the DNA of the victims with the DNA of existing family members; investigators took blood samples from the bodies of the dead and from relatives of those lost in the event and sent the samples to Moscow for matching. In many cases, the bodies were so badly damaged that the extraction of DNA for testing was very difficult. Researchers used the technique of polymerase chain reaction (PCR) to amplify pieces of DNA to provide sufficient material for testing.

Forensic investigators also helped to examine the motivations and behavior of the terrorists. Along with identification of the thirty-one attackers who died in the incident, the investigation revealed that drug use appeared to be an element in the Beslan tragedy. Moscow researchers reported that toxicological analyses of the hostage takers' bodies showed that the blood of several of them showed high levels of the narcotics heroin and morphine, and several showed signs of other drugs in their systems. Moreover, the hostage takers who had been drug users had apparently not taken in these substances in several days, and so they were likely in states of drug withdrawal. Some observers have suggested that the experience of withdrawal may have accounted for the remarkable brutality and callousness with which the hostage takers treated children and other innocent victims at the school.

Carl L. Bankston III

Further Reading

Giduck, John. *Terror at Beslan: A Russian Tragedy with Lessons for America's Schools*. Golden, Colo.: Archangel Group, 2005. Describes the background, events, and aftermath of the Beslan incident and provides a good description of the investigation. Asserts that similar events could happen in the United States and draws on the Beslan example to suggest how American schools should prepare for this possibility.

Kornienko I. V., V. V. Kolkutin, and A. V. Volkov. "Molecular-Genetic Identification of the Hostages Killed in the Terror Act on September 1-3, 2004, in Beslan." *Forensic Medical Examination* 5 (2006): 31-35. Examines the technical forensic issues involved in the identification of the Beslan victims and notes the importance of the precise staging of the investigation.

Lansford, Lynn Milburn. *Beslan: Shattered Innocence*. Charleston, S.C.: Booksurge, 2006. Addresses the needs of the Beslan survivors for support and assistance following the tragedy. Lansford has worked with children's relief programs and was involved in helping the Beslan survivors.

Phillips, Timothy. *Beslan: The Tragedy of School No. 1*. London: Granta Books, 2007. Account of the ordeal at Beslan includes testimony by the people of the town and a critique of the Russian government's response.

See also: Asian tsunami victim identification; Autopsies; Croatian and Bosnian war victim identification; DNA extraction from hair, bodily fluids, and tissues; DNA fingerprinting; Forensic toxicology; Hostage negotiations; Mass graves; Osteology and skeletal radiology; Police psychology; September 11, 2001, victim identification.

Biodetectors

Definition: Devices comprising highly specific sensing components—such as biolayers of DNA, proteins, or enzymes—immobilized on surfaces that serve as transducers that measure electrical signals produced by interactions between the biomolecules of interest and the biolayers.

Significance: Combining the ability to process data with the selectivity of biological systems, biodetectors are powerful analytical tools employed in forensic science. They can be used to counter the growing threat of biocrimes or acts of bioterrorism because of their ability to detect even minute levels of colorless and odorless harmful agents (such as pathogenic viruses, fungi, bacteria, and other noxious substances) days before concentrations of the agents are high enough to cause medical symptoms.

Following a biocrime, responses based on data obtained from biodetection may include forensic investigation, medical diagnoses, and crisis management. In 2001, the importance of timely forensic investigation of surface contamination was demonstrated following identification of the anthrax bacterium found in letters sent to the Hart Senate Office Building in Washington, D.C.; early detection allowed for prophylactic treatment with antibiotics, thus saving the lives of those exposed to the pathogen. For highly contagious diseases such as smallpox, it may be crucial to institute immediate measures such as vaccination or quarantine to halt the spread of the disease.

The significance of early detection of harmful biological agents cannot be overemphasized. At first, medical symptoms may seem mild, and outbreaks may be mistaken for ordinary influenza; this can delay necessary remedial actions that could lessen, or even prevent, morbidity and mortality. The greatest benefit of biodetectors may be to protect against highly lethal pathogens such as Ebola and Marburg viruses, for which no vaccines, treatments, or cures have been developed.

In the mid-1960's, Leland C. Clark, considered the "father of biosensors," developed the first enzyme electrodes, which eventually led to creation of more advanced versions for applications in biotechnology and forensic science, especially as the latter pertains to countering acts of bioterrorism. Biosensors of this type, employed to detect DNA and related biomolecules, are also known as biodetectors; they are key players in the investigation of events leading up to and following exposure to such pathogenic agents as ricin (a highly toxic protein derived from the castor bean) and *Bacillus anthracis*, the bacterium that causes anthrax. Biodetectors may also be employed for continuous monitoring of the environment, surveillance of medical symptoms, and ancillary intelligence activities that may be put in place to mitigate or prevent the aftereffects associated with biocrimes and acts of bioterrorism.

Ideally, biodetectors should be networked—that is, decentralized—during an attack involving biological weapons so that they can be used to define the perimeter of the assault. Portability is another desirable characteristic for biodetectors; such devices could be moved quickly to the locations of biocrimes to perform evaluation and monitoring. Although the task of building a system of networked biodetectors is fraught with complexity, the future of emerging biosensor technology lies in scientists' ability to develop networks of sophisticated alarm-bearing biodetectors that can differentiate between harmful and benign entities and can be used anywhere, with wireless and remote capabilities.

Cynthia Racer

Further Reading

Behnisch, Peter A. "Biodetectors in Environmental Chemistry. Are We at a Turning Point?" *Environment International* 27 (December, 2001): 441-442.

Cooper, Jon, and Tony Cass, eds. *Biosensors: A Practical Approach*. 2d ed. New York: Oxford University Press, 2004.

Malhotra, Bansi D., et al. "Recent Trends in Biosensors." *Current Applied Physics* 5 (February, 2005): 92-97.

See also: Air and water purity; Biological terrorism; Biological warfare diagnosis; Biological weapon identification; Biosensors; Breathalyzer; Cadaver dogs; Canine substance detection; Chemical Biological Incident Response Force, U.S.; DNA recognition instruments.

Biohazard bags

Definition: Containers used by laboratories for the safe disposal of blood and other potentially infectious wastes.

Significance: Forensic, clinical, and research laboratories, as well as publicly and privately owned health care establishments such as hospitals, medical clinics, long-term care facilities, dental clinics, and blood banks, are required to use safety containers known as biohazard bags when disposing of blood or other potentially infectious materials. Forensic laboratories often analyze such materials when they are obtained as evidence in various crimes.

The use of biohazard bags, as an element of hazard communication, is one of the key provisions in the Standard on Occupational Exposure to Bloodborne Pathogens issued by the U.S. Occupational Safety and Health Administration (OSHA) on December 6, 1991. Biohazard bags are used to communicate the presence of blood or other potentially infectious materials (OPIM). Such bags serve to warn workers who may be exposed to potentially hazardous and infectious materials; facilities that use biohazard bags must train their workers to use universal precautions in handling the bags and their contents.

According to OSHA, OPIM include human body fluids (semen, vaginal secretions, saliva, any body fluid visibly contaminated with blood, and all body fluids that are difficult or impossible to differentiate) and any unfixed tissue or organ from a human being (dead or alive). OSHA also considers as OPIM any materials containing human immunodeficiency virus (HIV) or hepatitis B virus (HBV), such as blood, liquids, solutions, and cell, tissue, and organ cultures used in clinical, research, and forensic laboratories. Forensic laboratories often conduct evidence analyses on blood and OPIM.

The Bloodborne Pathogens Standard also uses the term "regulated waste," which refers to blood, OPIM, and materials or wastes contaminated with either one. Regulated waste requires special handling, including placement in containers with biohazard warnings (that is, biohazard bags) and safe disposal in keeping with federal, state, and local regulations.

Biohazard bags are color coded red (sometimes red-orange) and generally display the universal biohazard symbol to warn individuals that the materials contained are potentially infectious. As part of the special handling of regulated waste, before disposal biohazard bags are often sterilized in an autoclave, a device that uses high pressure and high-temperature steam to eradicate bacteria, viruses, and other microbes. OSHA thus requires that biohazard bags be made of substances—such as thick blended polymers—that are resistant to leakage and can withstand high pressure and high temperature. Biohazard bags also have indicators that change color after exposure to steam and thus indicate that the materials contained inside have been subjected to sterilization or decontamination.

Miriam E. Schwartz and Charlene F. Barroga

Biohazard bags are clearly marked with the blaze-orange biohazard symbol. The symbol itself has no intrinsic meaning; it was chosen because it is distinct and easily recognized. *(© iStockphoto.com/Mark Evans)*

Further Reading

Acello, Barbara. *The OSHA Handbook: Guidelines for Compliance in Health Care Facilities and Interpretive Guidelines for the Bloodborne Pathogens Standard*. Clifton Park, N.Y.: Thomson/Delmar Learning, 2002.

Barker, Kathy. *At the Bench: A Laboratory Navigator*. Cold Spring Harbor, N.Y.: Cold Spring Harbor Laboratory Press, 2004.

O'Neal, Jon T. *The Bloodborne Pathogens Standard: A Pragmatic Approach*. New York: Van Nostrand Reinhold, 1996.

World Health Organization. *Laboratory Biosafety Manual*. Geneva: Author, 2005.

See also: Blood residue and bloodstains; Blood spatter analysis; Crime laboratories; Crime scene cleaning; Decontamination methods; Forensic pathology; Saliva; Semen and sperm; U.S. Army Medical Research Institute of Infectious Diseases.

Biological terrorism

Definition: Spread of dangerous biological agents within civilian populations or agricultural areas with the intent of causing disorder and intense fear.

Significance: A bioterrorist attack is perhaps one of the events most feared by emergency responders and government officials in the field of counterterrorism, in large part because, although the probability of a wide-scale attack is rather low, in the event of such an attack, the potential for catastrophic results is high.

Ever since the influenza pandemic of 1918-1919 (a natural event), which killed some forty million people around the world, a heightened awareness has existed of the potential for the spread of harmful, even lethal, biological cultures among human populations. Among the purposeful biological attacks that have been perpetrated, perhaps the one with which the most Americans are familiar is the case in which letters containing the bacterium that causes anthrax were sent to addresses in New York City, Washington, D.C., and Boca Raton, Florida, in October and November of 2001, shortly following the September 11 terrorist attacks on the World Trade Center and the Pentagon. This case, which remains unsolved, greatly increased awareness of the need for government agencies (including the U.S. Postal Service) to learn how to identify and respond effectively to any biological crisis. The outbreak of severe acute respiratory syndrome (SARS) in Canada in 2002-2003, which quickly spread from one to more than two hundred persons in Toronto-area hospitals and resulted in thirty-three deaths among patients and health workers, also demonstrated the need for improvements in government and health care responses to epidemic and pandemic disease outbreaks. The investigation and prevention of biological terrorism have become foremost components of nations' efforts to improve their homeland security.

Bioterrorist attacks can target human populations directly or indirectly, through food and water supplies. Agroterrorism—biological terrorism that targets agricultural food sources—is a very real threat to national security in some countries because modern agricultural systems are tightly integrated, and many points in the harvesting, processing, and distribution systems represent potentially "soft" targets for terrorists and difficult targets to defend from terrorist acts. The routine transport and commingling of production and processing systems greatly aid the dissemination of any biological pathogens. It is estimated that 75 percent of the value production in U.S. agriculture occurs on just 6.7 percent (143,500) of U.S. farms, so a successful attack on any of these locations would be catastrophic.

History

The use of biological weapons can be easily traced back to ancient times. Soldiers used to dip their weapons in animal excrement or known plant toxins before battle so as to cause infection in whomever they stabbed or shot with arrows. In both ancient and medieval times, poisoning water supplies with dead animals was a favorite tactic, as was slinging or firing dead animal or human carcasses over defender walls in the hopes of spreading disease. Although few records exist to prove that European settlers in the New World purposely spread disease among Native Americans, sufficient evidence is found in the form of a letter from Colonel Henry Bouquet to Lord Jeffrey Amherst in 1763 to suggest that the British attempted to spread smallpox to their Native American opponents during the French and Indian War. Emperor Napoleon I drew on the expertise of French scientists to visit swamp fever on his opponents in the eighteenth century, and Confederate soldiers were known to poison ponds as they retreated from the advancing Union Army during the American Civil War.

By the time World War I began in 1914, science was sufficiently advanced that the mechanisms of the spread of disease were understood, and serious consideration was given to making use of biological agents during this global conflict. The German government formally and repeatedly refused to deploy biological agents against humans during the war, however, and the Allied Powers followed Germany's lead in

Emergency personnel in chemical and biological protective suits respond to the simulated injuries of a volunteer "victim" who has just passed through a decontamination shower. This emergency training exercise, which simulated a terrorist attack on Baltimore Ravens Stadium, was held by the University of Maryland Medical Center and the U.S. Air Force. *(AP/Wide World Photos)*

this regard. Nevertheless, German saboteurs deployed anthrax against horses and mules that were to be sent to Allied soldiers on the front lines. During World War II, as ample surviving film footage and written evidence shows, the Japanese tested biological agents extensively on Chinese prisoners and Chinese civilians. Whether the Japanese employed these agents as weapons of war, as some scholars allege, has not been proved. The Geneva Protocol, signed by various nations in 1925, outlaws the use of biological weapons, but such prohibitions are only as good as the resolve of nations to follow the protocol.

A number of terrorist organizations have at least discussed the use of biological weapons, including the Italian Brigate Rosse (Red Brigades) and the German Rote Armee Fraktion (Red Army Faction), earlier known as the Baader-Meinhof Gang. Members of cults in the United States have poisoned restaurants with agents such as salmonella to cause sickness. The Japanese group Aum Shinrikyo (known as Aleph since 2000) actively acquired and cultured *Bacillus anthracis* (the bacterium that causes anthrax) and Ebola virus, both of which were found in significant quantities when police raided the group's headquarters in 1995 following its sarin gas attack on the Tokyo subway. The group purportedly released botulinum toxin as well as anthrax in the same period, but these attempts were not successful. Experts are not sure why these attacks failed; possible reasons include the method of delivery, manufacturing problems, and that the group may have released an anthrax vaccine and a slowly reproducing botulinum toxin rather than more potent varieties of these pathogens.

Since 1996, the Federal Bureau of Investigation (FBI) has opened numerous cases involving the potential use of biological agents. Many have amounted to mere threats, but some have included attempts to produce such pathogens as botulinum toxin, anthrax, and ricin.

Types of Agents

Because the variety of biological agents available for use in terrorist acts is quite extensive, stockpiling vaccines that may be needed in the event of biological attacks is extremely difficult; it is virtually impossible to have safeguards in place against every potential type of biological agent. Some of the most dangerous pathogens that may potentially be used by bioterrorists, as categorized by the Centers for Disease Control and Prevention, are anthrax, pneumonic plague, botulinum toxin, smallpox, and ricin.

Anthrax is perhaps the biological pathogen most likely to be used in a bioterrorist attack. It is relatively easy to cultivate the spores of *B. anthracis*, and the spores are fairly stable under a variety of conditions, so dissemination of the pathogen is not particularly difficult. When inhaled, the agent works into the lungs and causes fever, shock, and, ultimately, death. Anthrax can also cause sores on the skin of people working with infected livestock, which can result in other bodily infections. Approximately ten thousand spores of *B. anthracis* must be inhaled to prove deadly, but a mere gram of the bacterium contains millions of lethal doses.

The possibility of the use of pneumonic plague in a biological attack is high on the list of such threats maintained by first responders because this disease is incredibly virulent. Its killing potential in an uninoculated population is extremely high, close to 90 percent, and lethal exposure requires far fewer spores (around three thousand) than does anthrax. Pneumonic plague first appears as a fever accompanied by coughing, which progresses into hemorrhaging in the lungs. If left untreated for a relatively short period, the disease is almost always fatal.

Botulinum toxin is also fairly easy to cultivate. The potential of this toxin for use in aerosol form makes it very attractive as a biological weapon because the pathogen can be spread rapidly over a wide area. Botulinum toxin attacks the muscle nerves, paralyzing the nerve endings and preventing the muscles from responding to the brain. The paralysis begins near the head and works its way down through the body.

Smallpox is considered to be high on the list of potential bioterrorism pathogens because many people in the United States and around

The Danger of Developing Biological Weapons

In April of 1979, Sverdlovsk, Russia, was afflicted by an outbreak of anthrax during which at least sixty people died. At the time, the government of the Soviet Union claimed that the deaths and illness were caused by tainted meat, thoroughly denying any connection between the outbreak and the development of biological weapons.

In 1992, after the dissolution of the Soviet Union, a team of experts in pathology, biology, anthropology, and veterinary science traveled to Sverdlovsk, now known as Yekaterinburg, to ascertain what had happened there in 1979. In the course of the team's investigation, anthropologist Jeanne Guillemin discovered, through interviews with victims' families, a pattern regarding those who became infected with the anthrax virus. Guillemin ascertained where each victim had been on April 2, 1979, when the outbreak began, and subsequently compared this information with data on wind direction for that day. She found that the wind was blowing only from the northwest and that the victims' positions on that day placed them in the path of the wind. A biological weapons factory operated by the Soviet government was also directly in line with the wind, northwest of the city. Given this information, Guillemin concluded that the anthrax deaths did not result from tainted meat; the specific pattern of illness in Sverdlovsk pointed to the biological weapons factory as the source of the anthrax outbreak.

the world are no longer immunized against the disease, ever since aggressive vaccination programs let to its global eradication, which was verified and announced in December, 1979. The *Variola major* virus, which causes the most deadly form of smallpox, is relatively easy to cultivate and is easily spread using aerosols. Smallpox is contracted through inhalation, and after it incubates, the infected person normally experiences headache, fever, and other common signs of the flu. Next a rash develops, followed by pus-filled bumps on the skin. The mortality rate is approximately 30 percent for victims who have not been inoculated.

Ricin is a toxic protein found in castor beans; it is extracted from the waste produced in the manufacture of castor oil. Ricin is relatively easy to acquire and also much easier to stockpile than most other biological pathogens. A large dose is required to kill, but the toxin can be either ingested or inhaled. When employed in conjunction with other pathogens, ricin can enable other pathogens to attack an already afflicted body. Ricin can cause respiratory problems, fever, cough, abdominal pain, and, when ingested, damage to organs such as the liver and kidneys. Ricin prevents cells in the body from making protein, which causes the cells to die off.

Methods of Investigation

Perhaps the greatest difficulty in the investigation of biological attacks is the fact that many of the initial symptoms caused by intentionally introduced agents are very similar to the symptoms of common diseases, such as influenza. Most often, the only way first responders are even aware that a biological attack has potentially taken place is the presence of a massive influx of people with the same symptoms. Such attacks are not usually discovered until after the pathogens have been widely disseminated and have infected large numbers of people.

The teams that investigate biological attacks need to include persons with knowledge of both biology and chemistry, who can understand the interplay between the body and the pathogen. Other areas of knowledge that are extremely important in the investigation of such attacks include the disciplines of anthropology and geography. An understanding of human living, interaction, and moving patterns, combined with meteorological data, can help investigators to track a disease back to where it may have originated, particularly in the case of aerosol dissemination.

Much of the investigative strategy used in determining whether biological agents have been intentionally spread involves the review of medical diagnoses and the employment of effective vaccines against the various agents. Investigators usually trace such agents back to their sources by comparing strains of genetic material with a database that catalogs various strains and the laboratories or environments in which the strains originated. Many materials used in the manufacture of biological agents are sold commercially, and investigators try to track where such materials may have been purchased and by whom. Scientists have been working on developing a system of biological agent detection that will be able to identify pathogens through size, nucleic acid sequence, and antigen recognition.

It is clear that the modern world has seen neither the end of bioterrorist activities nor the full range of bioterrorism possibilities yet displayed. It is equally certain that just as formal counterterrorism measures evolve and successfully propogate, so will the methods, means, and modes of bioterrorism.

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Further Reading

Anderson, Burt, Herman Freedman, and Mauro Bendinelli, eds. *Microorganisms and Bioterrorism*. New York: Springer, 2006. Provides comprehensive coverage of infectious diseases, including smallpox, anthrax, tularemia, brucellosis, pneumonic plague, Q fever (caused by *Coxiella bernetii*), and rickets.

Cordesman, Anthony H. *Terrorism, Asymmetric Warfare, and Weapons of Mass Destruction: Defending the U.S. Homeland*. Westport, Conn.: Praeger, 2002. Extremely comprehensive work addresses potential terrorist attacks. Includes sections on specific biological weapons as well as extensive suggestions for improvements in the area of homeland security. Provides a good overview of the difficulties in responding to biological attacks.

Foster, George T., ed. *Focus on Bioterrorism*. New York: Nova Science, 2006. Presents a well-written overview of the topic with discussion of attention to vaccine stockpiles, the U.S. Postal Service, responses to bioterrorism, and existing laws on proliferation sanctions in the United States and internationally.
Katz, Linda B., ed. *Agroterrorism: Another Domino?* New York: Novinka Books, 2005. Surveys threats, preparedness, and continuing challenges of biological actions against American agriculture. Topics include the specific challenges that the tightly interlocking system of modern agriculture presents to counterterrorism efforts and the ease with which various aspects of the food supply could be assaulted with biological weapons.
Pilch, Richard F., and Raymond A. Zilinskas, eds. *Encyclopedia of Bioterrorism Defense*. Hoboken, N.J.: Wiley-Liss, 2005. Large reference work includes essays by noted experts on the many dimensions of bioterrorism and how various strategies, organizations, and individuals are used to counter the many different types of bioterrorist threats in the modern world.
Ursano, Robert J., Anne E. Norwood, and Carol S. Fullerton, eds. *Bioterrorism: Psychological and Public Health Intervention*. New York: Cambridge University Press, 2004. Provides an excellent overview of the psychological and public health dimensions of bioterrorism. Includes an extensive case study of the 1918 influenza pandemic as well as chapters that discuss the psychological effects of bioterrorism on individuals and communities and the role of public health in communication, prevention, and management response.
Wagner, Viqi, ed. *Do Infectious Diseases Pose a Serious Threat?* New Haven, Conn.: Greenhaven Press, 2005. Collection of essays addresses the potential use of infectious diseases in terrorism and which agents are the most serious threat to the United States.
Wheelis, Mark, Lajos Rózsa, and Malcolm Dando, eds. *Deadly Cultures: Biological Weapons Since 1945*. Cambridge, Mass.: Harvard University Press, 2006. Discusses developments in biological warfare since World War II and addresses the issue of why states acquire biological weapons.

See also: Airport security; Anthrax; Anthrax letter attacks; Bacterial biology; Biodetectors; Biological warfare diagnosis; Biological Weapons Convention of 1972; Biosensors; Bubonic plague; Centers for Disease Control and Prevention; Chemical Biological Incident Response Force, U.S.; Chemical terrorism; Decontamination methods; Pathogen transmission; U.S. Army Medical Research Institute of Infectious Diseases; Viral biology.

Biological warfare diagnosis

Definition: Determination of the specific nature of disease-producing agents used as weapons.

Significance: The use of deadly organisms as weapons is perhaps more feared than chemical warfare because biotoxins have the potential of wreaking havoc on plants, animals, and humans. Detailed genomic determinations of these agents are critical parts of forensic analyses for the detection, diagnosis, and prosecution of biocrimes, bioterrorism, and biological warfare.

A large number of infectious organisms exist in nature, and many of them can be pathogenic (disease-causing) to humans. Microbiologists have developed bioengineering tools to increase the numbers and virulence of these organisms. Because biological weapons could cause catastrophic harm to a nation's population and economy, some political and military leaders have confessed that they fear the use of biological weapons more than the use of nuclear weapons. This anxiety has led several countries to develop techniques for detecting the use and diagnosing the nature of biological weapons in order to assist in the medical treatment of victims as well as in the prosecution of those who use these weapons.

The ideal agent of biological warfare is easy and cheap to produce, aerosolizable for effective delivery, and highly infectious for rapid person-to-person transmission. Although microbiologists have not yet developed the perfect biological weapon, they have discovered ways of manufacturing microorganisms that have the potential for creating mass casualties. For example, the following microbes have been developed into biological weapons: *Bacillus anthracis*, the bacterium that causes anthrax; *Variola major*, the virus that causes smallpox; *Yersinia pestis*, the bacterium that causes pneumonic (or bubonic) plague; *Francisella tularensis*, the bacterium that causes tularemia; and viruses that cause hemorrhagic fevers. Because of the secrecy surrounding research on potential biological weapons, specific examples of new, highly virulent strains of naturally occurring organisms or artificial pathogens are hard to come by.

Detection and Diagnosis

By the early twenty-first century, more than 140 nations had signed and ratified the 1972 Biological Weapons Convention, which prohibits the development, manufacture, and stockpiling of bacteriological weapons. Although this treaty did lead some countries to destroy their stockpiles of biological weapons, the advent of modern bioengineering made several of the convention's provisions obsolete.

After an exercise simulating a germ attack on Denver in 2000 revealed weaknesses in state and federal responses to such a threat, and particularly after the terrorist attacks against the United States on September 11, 2001, the U.S. government developed new organizations to deal with the assessment of and reaction to threats of biological warfare. The Department of Homeland Security established the National Biodefense Analysis and Countermeasures Center to help Americans anticipate, prevent, respond to, and recover from biological attack (previous countermeasures had been erroneously based on models for chemical warfare).

Because of the necessity of medical involvement in diagnostics and forensics, the National Response Plan developed in 2004 focused on the U.S. Department of Health and Human Services as the primary agency to deal with bioterrorist events. The Centers for Disease Control and Prevention developed the Labora-

The Laboratory Response Network

The Centers for Disease Control and Prevention provides the following information about the Laboratory Response Network (LRN).

The LRN's purpose is to run a network of labs that can respond to biological and chemical terrorism, and other public health emergencies. The LRN has grown since its inception. It now includes state and local public health, veterinary, military, and international labs. . . .

The LRN Structure for Bioterrorism

LRN labs are designated as either national, reference, or sentinel. Designation depends on the types of tests a laboratory can perform and how it handles infectious agents to protect workers and the public.

National labs have unique resources to handle highly infectious agents and the ability to identify specific agent strains.

Reference labs, sometimes referred to as "confirmatory reference," can perform tests to detect and confirm the presence of a threat agent. These labs ensure a timely local response in the event of a terrorist incident. Rather than having to rely on confirmation from labs at CDC, reference labs are capable of producing conclusive results. This allows local authorities to respond quickly to emergencies.

Sentinel labs represent the thousands of hospital-based labs that are on the front lines. Sentinel labs have direct contact with patients. In an unannounced or covert terrorist attack, patients provide specimens during routine patient care. A sentinel lab could be the first facility to spot a suspicious specimen. A sentinel laboratory's responsibility is to refer a suspicious sample to the right reference lab.

tory Response Network to detect and diagnose biological agents. Also, because biological attacks cause more fatalities the longer they remain undetected, the U.S. government established BioWatch, a network of air samplers around metropolitan areas, and BioShield, a program designed to accelerate medical countermeasures against biological hazards. The information gathered from these and other organizations and programs is also intended to be used by experts at the National Bioforensic Analysis Center to discover the sources of any biological agents used in attacks.

Forensic Analysis

A bioterrorist attack creates problems not only for early and rapid detection and diagnosis but also for forensic analysis. To deal with such problems, the Federal Bureau of Investigation (FBI) established the Scientific Working Group for Microbial Genetics and Forensics in 2002 to facilitate the identification of any organism used in a biocrime or bioterrorist attack.

Because the diagnostic requirements of microbial forensics are much more stringent than those of public health, experts at the location of a biological attack and in laboratories have to document sample collection with great care and perform detailed genomic analyses of the biological agent while maintaining a clear chain of custody for all evidence to be used in future legal proceedings. Advanced technologies, such as miniaturized immunoassay devices that can collect data in the area of an attack, have improved the chances for convictions of the attackers, but the cooperation of medical professionals, military personnel, law-enforcement officials, and forensic scientists is necessary to minimize deaths immediately after an attack as well as in the later identification and conviction of those responsible for it.

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Further Reading

Clinics in Laboratory Medicine 26 (June, 2006). Special issue titled "Biological Weapons and Bioterrorism" includes articles that examine the laboratory and forensic aspects of deadly biological agents.

Croddy, Eric A., with Clarisa Perez-Armendariz and John Hart. *Chemical and Biological Warfare: A Comprehensive Survey for the Concerned Citizen*. New York: Copernicus Books, 2002. Detailed overview for the layperson includes sections on the nature, history, detection, and control of biological weapons.

Dudley, William, ed. *Biological Warfare: Opposing Viewpoints*. Farmington Hills, Miss.: Greenhaven Press, 2004. Collection discusses differences of opinion among scientists and other experts on how to understand, prepare for, and prevent biological warfare.

Lederberg, Joshua, ed. *Biological Weapons: Limiting the Threat*. Cambridge, Mass.: MIT Press, 1999. Compendium of historical and technical essays includes information on the detection of biological agents and responses to biological attack. Intended for both doctors and students.

Mauroni, Al. *Chemical and Biological Warfare: A Reference Handbook*. 2d ed. Santa Barbara, Calif.: ABC-CLIO, 2007. Addresses the history of chemical and biological weaponry and presents information on experts and related organizations as well as case studies.

See also: Anthrax; Anthrax letter attacks; Bacteria; Biodetectors; Biological terrorism; Biological weapon identification; Biological Weapons Convention of 1972; Biotoxins; Blood agents; Chemical warfare.

Biological weapon identification

Definition: Identification of weapons of mass destruction that are based on bacteria, viruses, fungi, and toxins produced by these microorganisms.

Significance: Heightened concerns regarding the possibility of bioterrorist attacks have led to increased emphasis on microbial forensic science. Microbial forensic data may be presented in court as evidence in cases of terrorist attacks.

Virtually all disease-causing microorganisms are potentially useful as biological weapons. The most important candidates for biological weapons are microorganisms that cause diseases with high human mortality rates, such as anthrax, smallpox, plague, encephalitis, and hemorrhagic fever. In addition, biological weapons that are designed to wipe out crops or kill livestock could cause mass starvation and devastating economic losses.

In 2001, the general public in the United States became aware of biological weapons as a result of a series of attacks involving mail containing *Bacillus anthracis* (the bacterium that causes anthrax). Since that time, the possibility that terrorists might employ biological weapons, many of which are easily produced and spread, has been a growing concern. In response to the threat of terrorist attacks, the U.S. government has led efforts to develop quick and efficient methods of biological weapon identification, ultimately leading to the establishment of the new scientific discipline of microbial forensics. In general, the identification of microorganisms is based on techniques that rely on microscopic examination, analysis of the growth and metabolic functions of the microbes (growth-dependent and biochemical tests), and immunological and genetic tests.

Growth-Dependent and Biochemical Tests

Classic methods of microbial identification involve preliminary examination of stained specimens under a microscope, followed by growth-dependent tests. Growth-dependent tests are based on the growth patterns of microorganisms on artificial food sources (media). Particular media can be selected that will produce microbial populations—known as colonies—that have distinctive appearance and color. By comparing the reactions on these media with the known characteristics of different species of microorganisms, scientists can usually identify which microbe is present. However, most growth-dependent tests do not provide results that are extremely specific; that is, they may not distinguish among closely related microorganisms.

To aid in definitive microorganism identification, scientists have developed a series of biochemical tests that can be used to differentiate even the most closely related microbes. These tests are based on the identification of various metabolic reactions and products of different microbes. Microbial species can often be identified on the basis of fermentation patterns and the production of different chemical compounds, such as indole or hydrogen sulfide. Microorganisms are not easily identified by a single biochemical test, so it is usually necessary to perform several tests. A number of rapid identification systems are available that allow several (approximately twenty) biochemical tests to be performed quickly on a particular microorganism.

Immunological Tests

Immunological tests utilize antibodies that are produced in response to the presence of a specific microorganism; actually, they respond to the presence of specific molecules, called antigens, on the microorganism cell surfaces. Antibodies are proteins produced by the body that recognize and bind to those antigens. Specific antibodies for many known disease-causing microorganisms are commercially available. Immunological tests vary in the ways they make the antigen-antibody reaction visible; some show obvious clumps and precipitates, whereas others show color changes or the release of fluorescence.

An example of an immunological test is the agglutination test, which is performed routinely in hospitals to determine blood types. In an agglutination test, antibody-antigen complexes form visible clumps on a test glass slide. Extremely sensitive immunological tests called immunoassays permit rapid and accurate measurement of trace bioweapon agents. These methods are being used increasingly in criminology. A good example of such an immunoassay is the enzyme-linked immunosorbent assay (ELISA). A positive result in this immunoassay is the appearance of a colored product. ELISA is a common screening test for the antibodies to toxins and bacteria that may be used as bioweapons. In radioimmunoassays, antibodies are labeled with radioactive isotopes and traced. Immunological methods are especially important for the identification of viruses, as other identification methods are not suitable to them, and growth times are long.

Genetic Tests

Genetic tests of microorganisms are based on the detection of the unique DNA (deoxyribonucleic acid) sequences of potential weapon microorganisms. Certain viruses maintain their genetic material in the form of RNA (ribonucleic acid), which can be converted into corresponding DNA for detection purposes. One particular technique has been widely used for identifying microorganisms based on their DNA sequences: polymerase chain reaction (PCR).

Two variations of the PCR technique have been adopted for identification: PCR and real-time PCR. Both utilize specific sets of primers (short DNA sequences) to amplify and detect DNA sequences unique to a particular microorganism. In PCR, amplified DNA sequences are subjected to separation by electrophoresis, where negatively charged DNA fragments move toward the positive pole. Separated DNA fragments can be classified by the distance they traveled depending on their molecular size. Each microorganism exhibits a characteristic DNA moving pattern by which it can be identified. In real-time PCR, detection of a microorganism's amplified DNA and confirmation of that microorganism's presence are sensed by activation of a fluorescent dye. Officials of the United Nations used portable PCR detectors when they conducted their 2002-2003 inspections of Iraqi facilities for weapons of mass destruction. These detectors can identify a single *B. anthracis* bacterium in an average kitchen-sized room.

Ongoing Challenges

Although, in most cases, agents used as biological weapons could be identified easily within twenty-four hours, prosecutors may have difficulty proving that microorganisms identified in the homes or laboratories of suspects are in fact the same microorganisms used as weapons or intended for such use. One problem with making legal arguments based on weapon microbe identification is that some potentially dangerous microorganisms, such as *B. anthracis*, are found widely in soil. A prosecutor thus must prove that the microbes submitted as evidence in a given case are the same microbes used in the attack in question, and not simply microorganisms that have been transported into the suspect's home or lab accidentally.

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Further Reading

Cowan, Marjorie Kelly, and Kathleen Park Talaro. *Microbiology: A Systems Approach*. 2d ed. Boston: McGraw-Hill, 2008. General microbiology text focuses on the health sciences. Includes a chapter devoted to description of microbial identification techniques.

Fritz, Sandy, comp. *Understanding Germ Warfare*. New York: Warner Books, 2002. Collection of materials describes twenty-first century bioterrorism and germ weapons, including anthrax, smallpox, plague, viral fevers, and toxins. Also discusses methods of delivery of biological agents and their identification, symptoms, and treatment.

Lindler, Luther E., Frank J. Lebeda, and George W. Korch, eds. *Biological Weapons Defense: Infectious Diseases and Counterbioterrorism*. Totowa, N.J.: Humana Press, 2005. Prominent experts in biodefense research—many from the U.S. Army Medical Research Institute of Infectious Diseases—describe how to identify the presence of biological weapons through proteomic and genomic analysis.

Madigan, Michael T., John M. Martinko, Paul V. Dunlap, and David P. Clark. *Brock Biology of Microorganisms*. 12th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2008. Widely respected basic microbiology textbook includes information about biological weapons and methods of microbial identification.

Peruski, Anne Harwood, and Leonard F. Peruski, Jr. "Immunological Methods for Detection and Identification of Infectious Disease and Biological Warfare Agents." *Clinical and Diagnostic Laboratory Immunology* 10 (July, 2003): 506-513. Technical article describes immunological methods of biological weapon identification.

See also: Anthrax; Bacterial biology; Biological terrorism; Biological warfare diagnosis; Biosensors; Biotoxins; Bubonic plague; DNA analysis; Ebola virus; Polymerase chain reaction; Smallpox; Tularemia; Viral biology.

Biological Weapons Convention of 1972

Dates: Opened for signature April 10, 1972; entered into force March 26, 1975

The Convention: International agreement designed to ban the development, production, and stockpiling of a variety of biological weapons.

Significance: Seeking to increase international security, the Biological Weapons Convention of 1972 outlawed all biological weapons and delivery systems for such weapons. The openness required by this treaty can assist forensic scientists who investigate crimes that involve such organisms.

Early in human history, people in certain hunting societies learned how to use plant or animal poisons to make their weapons more deadly. As human beings gained more detailed knowledge of diseases and biological processes, they developed other, more efficient, means of using biological agents to infect or kill their enemies. After more than one million casualties in World War I, mainly from chemical weapons, the international community adopted the Geneva Protocol in 1925; this agreement limited the first use of chemical or biological weapons in future wars. The method of conducting warfare was thus recognized as being subject to international law.

The United States researched and developed biological weapons on a large scale until 1969, when President Richard M. Nixon ordered a halt to these programs and instructed the Department of Defense to design a plan to dispose of the weapons. Around the same time, the British govenment proposed international negotiations on banning biological weapons. In 1971, an agreement was reached, and in 1972, the process of signing and ratification of the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction began. According to the convention, also known as the Biological and Toxin Weapons Convention or simply the Biological Weapons Convention, biological weapons were supposed to be destroyed beginning in 1975. This was at the height of the Cold War, however, and verification procedures that required countries to allow international observers into their military facilities were not acceptable to many signatories. Enforcement of the provisions of the convention was impossible because no system existed for verifying that countries were adhering to those provisions.

Adding to the enforcement problem since the convention entered into force in March, 1975, has been the fact that virtually everything that is needed to develop biological weapons also has a peaceful use. The existence of sealed biological research facilities, for instance, does not necessarily indicate that biological weapons research is being conducted. Sealing such a facility is a common procedure to keep contamination, in either direction, from affecting a biology experiment. Those who seek to enforce the terms of the treaty must use indirect means to verify that nations are following those terms. A series of Review Conferences have been held to clarify certain aspects of the treaty and generally assist with its implementation in an ever-changing world. The Fourth Review Conference directed a working group to develop a protocol for a mandatory multinational verification process. In 2002, at the last meeting prior to the protocol's going to the Fifth Review Conference for adoption, the United States effectively vetoed the proposed protocol as not being strong enough to guarantee that it would be completely effective.

Posttreaty Incidents

Although the Biological Weapons Convention allows countries to keep small quantities of biological agents for medical or defensive purposes, the treaty prohibits active work on the development of such agents. Many people were surprised when, in April, 1979, an outbreak of anthrax killed more than sixty people in the Soviet city of Sverdlovsk (now Yekaterinburg, Russia). Soviet authorities denied any relationship of the outbreak to biological weapons, but given that anthrax is a commonly produced biological agent and the disease has been virtually wiped out, the rest of the world was certain that the anthrax deaths had resulted from an accident at a biological research facility. Without a mandatory inspection process in place, however, international observers were unable to investigate the situation fully and determine the cause of the outbreak with complete certainty.

The possible use of biological agents by terrorists was dramatically demonstrated in September and October, 2001, when letters containing anthrax spores were mailed to five news media operations in New York City and Boca Raton, Florida, and later to two U.S. senators. As a result of these attacks, twenty-two people became ill, five of whom died. Although law-enforcement investigators were eventually able to track the letters to a specific mailbox in New Jersey, the case remains unsolved. Forensic scientists have spent countless hours trying to determine the source of the anthrax, focusing on the slight differences that distinguish the various samples of anthrax spores stored at different locations. One early analysis indicated that the anthrax used in the attacks came from a U.S. military base, although this was never officially confirmed, and dozens of sites have been searched.

As a result of the possible contamination of multiple sites owing to the method the terrorist used, sending the anthrax spores through the mail, the U.S. government has spent hundreds of millions of dollars cleaning up various locations, especially postal facilities. The fact that even after years of intensive investigation the perpetrator of the crime has not been found indicates how difficult it is to track weapons of this type. If the signatories of the Biological

First Four Articles of the Biological Weapons Convention

Article I

Each State Party to this Convention undertakes never in any circumstances to develop, produce, stockpile or otherwise acquire or retain:

1. Microbial or other biological agents, or toxins whatever their origin or method of production, of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes;
2. Weapons, equipment or means of delivery designed to use such agents or toxins for hostile purposes or in armed conflict.

Article II

Each State Party to this Convention undertakes to destroy, or to divert to peaceful purposes, as soon as possible but not later than nine months after entry into force of the Convention, all agents, toxins, weapons, equipment and means of delivery specified in article I of the Convention, which are in its possession or under its jurisdiction or control. In implementing the provisions of this article all necessary safety precautions shall be observed to protect populations and the environment.

Article III

Each State Party to this Convention undertakes not to transfer to any recipient whatsoever, directly or indirectly, and not in any way to assist, encourage, or induce any State, group of States or international organizations to manufacture or otherwise acquire any of the agents, toxins, weapons, equipment or means of delivery specified in article I of this Convention.

Article IV

Each State Party to this Convention shall, in accordance with its constitutional processes, take any necessary measures to prohibit and prevent the development, production, stockpiling, acquisition, or retention of the agents, toxins, weapons, equipment and means of delivery specified in article I of the Convention, within the territory of such State, under its jurisdiction or under its control anywhere.

President Richard M. Nixon at his first inauguration in January, 1969. Later that same year, Nixon ordered the discontinuation of biological weapon development in the United States. As other world powers followed suit, a movement began that led to an international ban on such weapons. *(NARA)*

Weapons Convention follow the intent of the treaty and reduce the amount of stored biological materials available for misuse by terrorists and closely guard what remains, incidents such as the 2001 anthrax attacks may not happen in the future.

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Further Reading

Cirincione, Joseph, Jon B. Wolfsthal, and Miriam Rajkumar. *Deadly Arsenals: Nuclear, Biological, and Chemical Threats*. Rev. ed. Washington, D.C.: Carnegie Endowment for International Peace, 2005. Provides an overview of the range of chemical weapon threats facing the United States.

Gillemin, Jeanne. *Biological Weapons: From the Invention of State-Sponsored Programs to Contemporary Bioterrorism*. New York: Columbia University Press, 2006. Discusses biological weapon programs from before World War II through the 1990's, with special attention to the remnants of those programs that later became "available" to terrorists.

Hoover Institution on War. *The New Terror: Facing the Threat of Biological and Chemical Weapons*. Palo Alto, Calif.: Hoover Institution Press, 1999. Covers a wide range of issues, including the constitutional constraints on U.S. law enforcement in combating chemical weapons and suggestions for reducing the damage from such weapons.

Lederberg, Joshua, ed. *Biological Weapons: Limiting the Threat*. Cambridge, Mass.: MIT Press, 1999. Examines the dangers posed by biological weapons as well as the ways in which the United States has tried to decrease those dangers.

Tucker, Jonathan B., ed. *Toxic Terror: Assessing Terrorist Use of Chemical and Biological Weapons*. Cambridge, Mass.: MIT Press, 2000. Presents twelve case studies of the use of chemical and biological agents by terrorist groups. Identifies terrorists' patterns of behavior and discusses strategies to combat them.

See also: Anthrax; Anthrax letter attacks; Biological terrorism; Biological warfare diagnosis; Biological weapon identification; Biotoxins; Chemical Weapons Convention of 1993; Pathogen genomic sequencing; Smallpox; U.S. Army Medical Research Institute of Infectious Diseases.

Biometric eye scanners

Definition: Imaging technologies that use the iris or retina of the eye to identify individuals.

Significance: Biometric eye scanning can facilitate the automated control of access to areas where high levels of security must be maintained, such as correctional institutions and military and government installations that house sensitive materials.

The goal of biometric identification systems is to provide automated identity assurance—that is, the capability to recognize individuals accurately—with reliability, speed, and convenience. The complex nature of the human eye provides two of the most accurate biometric measures available. The iris and the retina, located on the front and back of the eye, respectively, are individually distinguishing structures. Retinal recognition became commercially available in the early 1980's, preceding iris recognition systems by about five years.

The iris is the round, pigmented membrane that surrounds the pupil of the eye. The intricate pattern of furrows and ridges in the iris is randomly formed prior to birth and remains stable from early childhood until death. In a typical iris scan, the person being identified aligns one eye close to a wall-mounted scanner for a few seconds. The scanner uses a near-infrared light to scan an image of the eye, and computer software then isolates the iris in the image and performs size and contrast corrections. Computer software then compares the final digital image with other iris images stored in a database; when a match is made, the person is identified.

Prisons throughout the United States use iris-scanning technology to verify the identities of convicts before release. Correctional facilities also enroll visitors in their iris image databases and scan the irises of people leaving the facilities to be certain they are visitors, not inmates. Some organizations use small, semiportable iris scanners to control access to sensitive computer files and information.

Retina biometric identification is based on the individually distinguishing characteristics of blood vessel patterns on the back of the eye. These patterns are thought to be created by a random biological process and remain unchanged throughout life in a healthy individual. During retina scanning, the person being identified aligns one eye with a wall-mounted scanner for several seconds. The scanner illuminates the retina with a low-intensity infrared light and creates an image of the patterns formed by the major blood vessels. The image is then digitally encoded, stored, and compared using computer software.

Because the retina is located on the back of the eye, this type of scan requires a high degree of cooperation from the user to ensure proper illumination and alignment. Given that retina scanning is more complex than the iris-scanning process, retina-scanning technology is best deployed in high-security, controlled-access environments where user convenience is not a priority. Employees in military weapons facilities, power plants, and sensitive laboratory environments are commonly required to undergo retina scanning to gain access.

Ruth N. Udey

Further Reading

Coats, William Sloan, et al. *The Practitioner's Guide to Biometrics*. Chicago: American Bar Association Publishing, 2007.

Nanavati, Samir, Michael Thieme, and Raj Nanavati. *Biometrics: Identity Verification in a Networked World*. New York: John Wiley & Sons, 2002.

Woodward, John D., Jr., Nicholas M. Orlans, and Peter T. Higgins. *Biometrics*. New York: McGraw-Hill, 2003.

See also: Airport security; Biometric identification systems; Facial recognition technology; Imaging; Iris recognition systems.

Biometric identification systems

Definition: Technologies that use automated measurements and database comparisons of physiological and behavioral characteristics to identify target individuals.

Significance: Biometric identification systems are becoming increasingly important given heightened concerns with security in many contexts. Compared with many other means of authorization and authentication, including password recognition, biometric technologies represent a significant advance in terms of ease of use, reliability, and validity.

The constantly evolving science of biometrics has produced a wide variety of systems capable of comparing hand, facial, eye, signature, vocal, and brain measures of given individuals against profiles of such measures stored in large databases. The applications of this technology for law-enforcement purposes are extensive. Biometric systems have been used to identify offenders who are using aliases, to fight illegal immigration, and to identify inmates as they are moved through various phases of the correctional system. Biometric data can be used to verify identity claims or to screen for persons who have been identified as potential security risks.

Accuracy

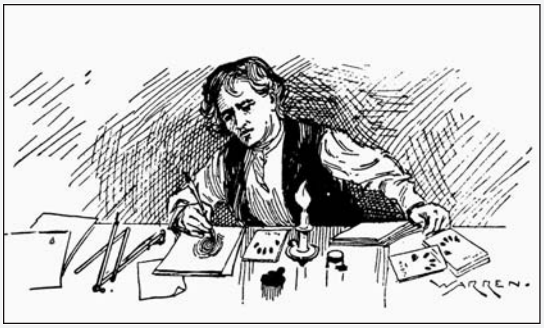
Biometric identification systems represent a huge improvement over the traditional "token" (credit card or document) and password systems. Credit cards can be lost or stolen and then used as false identification. Similarly, passwords can be "cracked," forgotten, or stolen. Biometric characteristics, on the other hand, are much more stable and permanent. Their inherent complexity renders them difficult or impossible to replicate, and the person being identified usually needs to be physically present at the time of the verification attempt. In addition, biometric systems can couple identifying information with other important background data, such as health or employment records (a fact that has led some to criticize the use of these systems as infringing on civil liberties).

The components of the typical biometric system are relatively straightforward; they consist of a sensor and a computer. The sensor is the device that gathers the biometric data from the individual being evaluated. The computer then processes the data collected; in some cases, the computer may refine the data by removing irrelevant information and background "noise" that may interfere with the interpretation of the results. The computer captures the biometric features being measured and creates a template, which it then compares to a database of biometric information on known individuals, looking for an identification match, or "hit." The consequences of a successful identification are as varied as the systems themselves. At the point of identification, an individual might be allowed into a restricted area, picked up for further questioning in a specific investigation, or observed further for any suspicious behavior.

The accuracy of a biometric system is typically assessed using one or more of the following measures: the failure-to-acquire rate (a measure of the percentage of unsuccessful attempts by the system to obtain specific biometric information from subjects), the false accept rate (also known as the false positive rate, a measure of the percentage of incorrect matches of subjects' biometric profiles to profiles already included in the database), and the false reject rate (also known as the false negative rate, the percentage of failures to match subjects' biometric profiles with identical profiles already included in the database). Minimization of all these kinds of error rates reduces the numbers of suspects who

Mark Twain and Fingerprints

Although Mark Twain never knew the word "biometrics," he might fairly be credited with introducing that science to fiction in *Pudd'nhead Wilson* (1894)—the first novel to use fingerprint evidence as a plot device. During the mid-nineteenth century, the novel's title character, attorney David Wilson, mystifies and amuses the simple people of Dawson's Landing, Missouri, by collecting their fingerprints on glass slides. For years, the villagers dismiss him as a "pudding-headed" fool—until the final chapter, when he displays his legal brilliance in a murder trial. Wilson creates a sensation by using his slides to prove the innocence of the murder suspect whom he is defending. That revelation is minor, however, compared to his second use of fingerprint evidence at the trial. Drawing on glass slides he has collected over more than two decades, he proves that the culprit in the murder case is a man who was born a slave and somehow got switched with the infant son of his master in infancy. The theme of switched identities that are sorted out by fingerprint evidence gives the novel a strong claim to being called the first application of biometrics in fiction.



David Wilson examining his fingerprint collection in the first edition of *Pudd'nhead Wilson.*

are needlessly detained, restricted from air travel, or otherwise affected by law-enforcement "false alarms" while maximizing the appropriate identification of true security threats.

Applications

Law-enforcement agencies employ biometric technologies in many ways, including for facial recognition, fingerprint identification, iris recognition, and voice recognition. Facial recognition systems use specific aspects of facial features from scanned photographs to make identifications. The features analyzed may include the physical distance between specific features, skin color, thermal patterns of blood flow, and facial lines. One application of facial recognition technology is the establishment by police departments of archives containing many thousands of offender photographs. These are matched with suspects' pictures or used to produce photo lineups that can be shown to crime victims or witnesses.

Numerous evaluations of facial recognition technology have produced mixed results. One Australian system, for example, tested in the Sydney airport, was found to have a false reject rate of 2 percent. This rate was confirmed by tests sponsored by the U.S. government. Although this error rate seems low, major world airports typically service several million passengers annually, which means that the systems could potentially falsely reject many thousands of people. A meta-analysis of facial recognition systems produced accuracy rates ranging from 51 percent to 94 percent. Factors affecting the rates included lighting, the quality of the photographs taken, movements of the subjects, the angles of the poses in the photographs, and the presence of eyeglasses on subjects. In general, male subjects and older persons were more easily recognized than were female and younger subjects. An inverse relationship was also found between accuracy and the size of the database against which the subjects' facial features were compared.

Fingerprint identification is the oldest form of biometric identification, having been in use for more than one hundred years. The Federal Bureau of Investigation (FBI) established a central database of fingerprints in 1924 against which law-enforcement agencies can seek to match the prints of crime suspects and victims.

With modern electronic and laser technology, fingerprint images are often taken and transmitted "live" to the database. Efforts to automate the analysis and identification of fingerprints began in the 1960's.

Fingerprint identification systems use electronic fingerprint readers to locate where the ridges of fingerprints start, end, or split up. These areas, known as minutiae points, form the basis for the identification. Each fingerprint typically contains thirty to forty minutiae points, and no two people's prints will match on more than eight such points.

In terms of accuracy, the false accept rates of fingerprint identification systems have generally been less than one in one million, and false reject rates have been 2 percent or less. The accuracy of the analysis of fingerprints taken from crime scenes, however, is often reduced because of the poor quality of the prints themselves. In addition, although it is often assumed that fingerprints are stable over a lifetime, research has shown that they in fact can change in response to physiological growth, activity, or intentional alteration; it has also been shown that many fingerprint matching systems can be "spoofed." Despite some limitations, fingerprinting is less controversial and more highly developed than any other type of biometric identification system. This is reflected in court acceptance of fingerprinting evidence.

Recognition by this electronic fingerprint reader is required for entry into a secure room at the Alpharetta, Georgia, Disaster Preparedness Center. *(AP/Wide World Photos)*

In iris recognition identification systems, an image of the iris of the eye (the colored ring surrounding the pupil) of the person to be identified is recorded by a digital camera and then converted into a template, which is checked for matches against an existing database. False positive rates for such systems have averaged 0.1 percent, and false negative rates have averaged 1.5 percent. An advantage of using this biometric technique is that, unlike fingerprints, the structure of the iris is permanent by the age of one and is unique for each person (this includes comparisons between identical twins and even between the left and right eyes of the same person). Unlike with fingerprint identification, however, no large databases yet exist for iris templates, and iris evidence is not left at crime scenes. In addition, failure rates as high as 15 percent have been found when iris-scanning technology is used in brightly lit settings. This technology has many potential applications, including security screening at airports and borders, passport and immigration control, and identification for banking and issuance of drivers' licenses.

Voice recognition systems use physical and behavioral aspects of the voice to identify individuals; the voice features measured are based on the physiology of the windpipe, nasal cavity, and vocal cords. A digital "voice signature" is recorded, and a computer measures the features and compares them against known samples for identification and verification. One drawback to the use of voice biometrics is that voice patterns can vary with age, and they can also be affected by medical problems (including even a cold) and the emotional state of the examinee. Background noise can also be a problem with the use of this identification technology.

Another biometric identification technology that has been investigated is hand geometry scanning, which involves more than ninety measurements of different parts of the hand. To detect forgery, dynamic signature identification has been developed; in this system, the specific dimensions of the pen strokes a person makes while writing his or her signature (including pressure, speed, and direction) are recorded and stored for later matching. This technology is prone to high false negative rates, however, because even though signatures are ubiquitous in daily transactions, only specific parts of a person's signature remain constant across every signing. Gait analysis, which focuses on people's unique walking patterns, is another type of biometric technique. Limitations to gait analysis include the fact that making gait measurements may be invasive; also, gait can be affected by injury or by a change in shoes.

Eric Metchik

Further Reading

Crompton, Malcolm. "Biometrics and Privacy: The End of the World as We Know It or the White Knight of Privacy?" In *Biometrics: Security and Authentication*. Sydney: Biometrics Institute, 2003. Presents psychological and sociological perspectives on the civil rights implications of increased use of biometrics.

Jain, Anil K., Arun Russ, and Sharath Pankanti. "Biometrics: A Tool for Information Security." *IEEE Transactions on Information Forensics and Security* 1, no. 2 (2006): 125-143. Provides a comprehensive technical analysis of several of the major biometric approaches.

Krishnan, K. N., with D. R. Berwick. *Developing a Police Perspective and Exploring the Use of Biometrics and Other Emerging Technologies as an Investigative Tool in Identity Crimes*. Payneham, S.Aust.: Australasian Centre for Policing Research, 2004. International review of basic biometric technology use includes recommendations for law-enforcement applications.

Mansfield, A. J., and J. L. Wayman. *Best Practices in Testing and Reporting Performance of Biometric Devices: Version 2.01*. Teddington, Middlesex, England: National Physical Laboratory, 2002. Emphasizes comparison of evaluation methodologies and data for the leading biometric instruments.

Mills, Kelly. "University Opts for Biometric Security." *Computerworld*, January 25, 2002, 3-4. Describes the adaptation of biometric technology to ensure the security of institutions of higher education.

Vacca, John R. *Biometric Technologies and Verification Systems*. Burlington, Mass.: Elsevier, 2007. Comprehensive, well-organized text includes discussion of how biometrics works, analysis of biometric data, and uses of biometric data.

See also: Airport security; Anthropometry; Biometric eye scanners; Biosensors; Brain-wave scanners; Ear prints; Electronic voice alteration; Facial recognition technology; Fingerprints; Integrated Automated Fingerprint Identification System; Iris recognition systems; National Institute of Justice; Voiceprints.

Biosensors

Definition: Devices that use biological molecules or cells to detect and measure chemicals, biological agents, or physical conditions and then use nonbiological components to convert the data into signals or readouts.

Significance: Biosensors have attracted a lot of interest for their potential in countering the use of chemical and biological weapons by terrorists and for their applications as on-site forensic analytical devices at crime scenes. Biosensors potentially offer sensitive and rapid detection of harmful organisms and substances in food and water supplies. Such instruments have demonstrated usefulness for measuring many substances that are of interest to forensic science, such as toxins, drugs of abuse, poisonous chemicals, and DNA.

Biosensor devices differ in the biological components they use for sensing chemicals. Examples are enzymes, antibodies, receptors, and whole

Research scientist Daniel P. Campbell holds a portable biosensor that he and his team developed at Georgia Tech in 2003 using parts from a CD player and a Webcam, among other items. The inexpensive device can be used to detect harmful chemical and biological agents in the field. *(AP/Wide World Photos)*

cells. The most common biological components used in biosensors are enzymes and antibodies. Different types of biological components result in different types of signals that must be converted into readouts.

Biosensors can be classified according to the ways in which the detection that is mediated by their biological components is converted into measurable signals. After the initial recognition of a chemical species by the biological component, a biosensor generates a readout signal in a process called transduction. At least five different kinds of transducers are used in biosensors: Amperometric transducers involve the movement of electrons resulting from a biorecognition event among three electrodes; potentiometric transducers exploit biological sensor-induced changes in the movement of ions, which results in the generation of an electric potential; thermal transducers utilize heat from biorecognition events that are endothermic reactions; optical transducers make use of the production or absorption of light resulting from biological recognition of detected chemicals or biological molecules; and piezoelectric transducers react to changes in mass produced by biological recognition of target chemicals or biological molecules.

The physical component of a biosensor's transducer, which is in contact with the biological sensor, may comprise electrodes, semiconductors, and optical constructions such as fiber optics and nanoparticles. Most biosensors use electrochemical types of transduction, such as amperometric and potentiometric methods, and enzymatic, antibody, or DNA biological recognition components.

Working and Organization

A biosensor contains an external and an internal interface. In the first step, at the external interface of the device, the substance being measured (analyte) binds with the biological recognition component of the biosensor. In the second step, at the internal interface, the biological recognition system interacts with the transducer component, and this produces a physical or chemical response. This response may involve the production of hydrogen ions, other ions, or electrons for amperometric, potentiometric, and conductimetric biosensors. A second type of transducer response may involve the biologically coupled production or absorption of light (fluorescence, chemiluminescence, or visible wavelength). A third type of transducer response would be a change in mass at the transducer such as occurs in piezoelectric (or microelectromechanical) systems. A fourth type of transducer response involves changes in temperature for thermal or calorimetric systems. The physical or chemical response produced by the transducer is processed and amplified to produce a readout signal that serves to indicate the presence and amount of a substance of interest.

Applications

Nanotechnology—that is, the application and study of the structuring and behavior of materials at nanometer scale—has also been used in making biosensors. Gold, cadmium selenide, and zinc selenide nanoparticles and single-walled carbon nanotubes are among the nanoscale substances that are being used to make biosensors to detect metal ions, biological molecules, and even viruses such as those responsible for strains of influenza (such as influenza A and the avian flu virus H5N1).

Challenges in the uses of biosensors arise from the need for small, portable devices, the inherent instability of most biological molecules and cells, and the need for highly sensitive devices that can measure a wide range of substances simultaneously. Biosensors used at crime scenes by forensic investigators and in national defense applications must perform reliably and produce quick results under field conditions. In the United States, in addition to their uses by law-enforcement personnel and by national security agencies for the detection and prevention of bioterrorist attacks, biosensors are used for environmental monitoring, for quality control during food processing and the processing of pharmaceuticals, and for monitoring of agriculture.

Oluseyi A. Vanderpuye

Further Reading

Cooper, Jon, and Tony Cass, eds. *Biosensors: A Practical Approach*. 2d ed. New York: Oxford University Press, 2004. Provides multidisciplinary coverage of biosensor research, construction, and operation, with descriptions of practical methods in the field.

Eggins, Brian R. *Biosensors: An Introduction*. New York: John Wiley & Sons, 1996. Offers an overview of the various classes of biosensors and describes the methods used in their manufacture.

Hall, Elizabeth A.H. *Biosensors*. Englewood Cliffs, N.J.: Prentice Hall, 1991. Provides an approachable introduction to the concepts behind biosensors as well as information on their construction and applications.

Kress-Rogers, Erika, ed. *Handbook of Biosensors and Electronic Noses: Medicine, Food, and the Environment*. Boca Raton, Fla.: CRC Press, 1997. Discusses both the design and the practical uses of biosensors. Includes informative figures and tables.

See also: Air and water purity; Biodetectors; Biological terrorism; Biological warfare diagnosis; Biological weapon identification; Immune system; Pathogen genomic sequencing; Toxicological analysis; Tularemia.

Bioterrorism. *See* Biological terrorism

Biotoxins

Definition: Toxic substances that originate from biological sources, including viruses, bacteria, fungi, algae, and plants.

Significance: Biocrimes present law-enforcement agencies with serious challenges, as the perpetrators of such crimes can use numerous pathogens that exist naturally and do not require sophisticated expertise or technology to prepare. Further, because the effects of biotoxins are as diverse as the substances' multiple origins, it can be difficult for investigators to ascertain the types of biotoxins employed in particular crimes or terrorist attacks.

The use of biological agents and their toxins in criminal acts and as weapons of war has a long history. In the Far East, opium was the poison used for murder and suicide for several centuries. In the fourteenth century, Mongol warriors used plague-infected bodies as weapons of war, triggering an outbreak that killed thousands. During the French and Indian War (1754-1763), the British approved a plan to distribute to Native American tribes blankets contaminated with smallpox. These examples, however, pale in comparison with the chilling prospects of modern bioterrorism aided by a rapidly expanding knowledge of biological agents, biotoxins, and their potential to wreak havoc in complex, interdependent societies.

Common Microbial Agents

Various microbes can be the sources of biotoxins, including viruses, bacteria, and fungi. It is relatively easy to propagate bacteria and fungi with small samples, but the propagation of viruses for use in biocrimes requires certain training and access to specific technologies. Some of the common viruses that produce devastating effects include smallpox, Ebola, and Marburg. Smallpox, a highly contagious virus, is transmitted easily and carries a high mortality rate. By the 1970's, a worldwide vaccination program had eradicated smallpox. Three decades later, only two places in the world still officially maintained live cultures of the virus: a laboratory of the Centers for Disease Control and Prevention (CDC) in the United States and a lab in Russia. The Ebola and Marburg viruses are also extremely lethal; both cause hemorrhagic fever and profuse bleeding from bodily orifices. No cure or effective treatments for either virus have yet been found.

Bacterial biotoxins include anthrax, botulism, plague, and tularemia. *Bacillus anthracis*, the bacterium that causes anthrax, produces spores that are extremely resistant to the environment and are highly infectious when inhaled. Botulism is caused by a potent neurotoxin produced by the bacterium *Clostridium botulinum*. Once inhaled or ingested, the toxin causes respiratory failure and paralysis. Plague is also highly contagious; it causes a type of pneumonia and can be fatal if not treated early. *Francisella tularensis* causes tularemia, a generally nonlethal disease that is extremely incapacitating; symptoms include weight loss, fever, and headaches.

Many fungi produce remarkable amounts of toxic secondary metabolites, some of which are toxins. Fungal toxins are grouped into two categories: mycotoxins, which are produced by common molds, and mushroom toxins, which are formed in the fleshy fruiting bodies of sac or club fungi. Mycotoxins are major contributing factors to many cases of food poisoning. Some mycotoxins, such as aflatoxins, are believed to be among the most potent known carcinogens. Ingestion of even minute amounts of aflatoxins over long periods of time through contaminated food can cause liver cancer. In 1974, hundreds of people were poisoned by aflatoxin-contaminated corn in India; more than one hundred died. Several members of the mushroom genus *Amanita* contain amanitin, one of the deadliest poisons found in nature. The poison contained in false morels, monomethyl hydrazine (MMH), can cause diarrhea, vomiting, and severe headaches; ingestion of this poison occasionally results in death.

Marine and Plant Biotoxins

Many plants produce poisonous secondary metabolites that induce toxic effects when the plants or their extracts are consumed. Although sensitivity to plant toxins may vary among individuals, a good correlation generally exists between the amount of poison ingested and the severity of the clinical symptoms. Some highly toxic substances derived from plants include ricin (derived from castor beans), aconitine (from monkshood), strychnine (from the vomit nut), and huratoxin (from jimsonweed, also known as thorn apple). Ricin has been employed as a murder weapon in many cultures. In South America, native tribes have long used various plants to prepare curare, a common name for a deadly poison used on the tips of arrows or darts.

Harmful algal blooms represent a real threat to virtually all U.S. coastal and fresh waters. Potential impacts range from devastating economic effects to public health risks to ecosystem alterations. The phenomena commonly known as "red tides" produce extremely potent biotoxins. When such toxins accumulate in marine food chains, they cause mass mortalities of birds, fish, and marine mammals and often lead to closures of commercial and recreational fisheries. When humans accidentally consume seafood contaminated with algal toxins, illness develops and even death occurs in extreme cases. Two classes of algal toxins have been well studied: the paralytic shellfish poisoning (PSP) toxins and domoic acid, both of which act on nerve systems.

Although smallpox is one of the most virulent and most easily transmitted viruses known to humankind, it was also one of the first biotoxins to be eradicated. During the 1790's, the British physician Edward Jenner developed a vaccine from material taken from infected cows that effectively protected people against smallpox. Despite the early success of Jenner's procedure, it was slow to win public acceptance. This British cartoon from 1802 caricatures a scene at a public hospital in which Jenner is vaccinating a frightened woman as cows emerge from the bodies of people already vaccinated. *(Library of Congress)*

Microbial Forensics

Criminal investigations involving biotoxins rely on forensic scientists who work in the cross-discipline known as microbial forensics. It can be challenging at times to distinguish symptoms and signs that may be caused by toxins from those that are just variants of normal health. Physicians and forensic scientists may not be able to recognize early symptoms associated with particular pathogens or biotoxins. Often, the identification of particular biotoxins requires the careful study of highly skilled professionals using sophisticated analytical instruments. Furthermore, confirmation of the presence of biological agents or toxins in evidence samples is generally not enough to guarantee conviction of a suspect without other supporting evidence.

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Further Reading

Beasley, Val Richard, et al. "Diagnostic and Clinically Important Aspects of Cyanobacterial (Blue-Green Algae) Toxicoses." *Journal of Veterinary Diagnostic Investigation* 1 (October, 1989): 359-365. Scholarly article focuses on the diagnosis of biotoxins in animals.

Breeze, Roger G., Bruce Budowle, and Steven E. Schutzer, eds. *Microbial Forensics*. Burlington, Mass.: Elsevier Academic Press, 2005. Reviews the relationships between microbe physiology and forensics.

Cooper, Marion R., Anthony W. Johnson, and Elizabeth A. Dauncey. *Poisonous Plants and Fungi: An Illustrated Guide*. 2d ed. London: TSO, 2003. Comprehensive volume describes the many varieties of poisonous plants and fungi.

Garrett, Laurie. *The Coming Plague: Newly Emerging Diseases in a World Out of Balance*. New York: Farrar, Straus and Giroux, 1994. Discusses the increase in outbreaks of infectious diseases in the late twentieth century as well as ways to prevent such outbreaks.

Nelson, Lewis S., Richard D. Shih, and Michael J. Balick. *Handbook of Poisonous and Injurious Plants*. 2d ed. New York: Springer, 2007. Provides useful information on many different plant biotoxins.

See also: Bacterial resistance and response to antibacterial agents; Biological terrorism; Biological warfare diagnosis; Biological weapon identification; Biological Weapons Convention of 1972; Botulinum toxin; Centers for Disease Control and Prevention; Chemical agents; Mycotoxins; Poisons and antidotes; Ricin; Smallpox; Toxicological analysis; Viral biology.

Bite-mark analysis

Definition: Examination and comparison of wounds caused by biting during physical attacks.

Significance: The bite marks analyzed by forensic scientists may include marks made by attackers on victims and marks made by victims on attackers. Also, in some cases, crime victims and the perpetrators of crimes leave bite marks on objects found at crime scenes. Bite-mark analysis can sometimes provide important physical evidence linking an offender to a victim or crime scene.

The reliability of the evidence resulting from bite-mark analysis depends greatly on the skill and experience of the forensic odontologist who conducts the analysis. The occurrence of bite marks in criminal cases is not common; when bite marks are found, they are seen most often in cases of violent sexual crimes or child abuse.

Procedures

When investigators suspect that a particular wound is a bite mark, they record every detail about it, including its appearance, color, location on the body, and size, and whether the bite seems to be human or animal. They also photograph the mark from all possible angles, laying a ruler alongside the mark in each photo to show both the mark's length and its width. If a ruler is not available, another object of known size, such as a coin, is included in the photographs to clarify the size of the mark.

If the indentation of the bite mark is suffi-

Forensic odontologist Dr. Richard Souviron points to an enlarged photograph of the teeth of accused murderer Ted Bundy during Bundy's murder trial in Miami, Florida. Souviron testified that only Bundy's teeth could have made the bite marks discovered on the body of one of the victims in the Chi Omega murder case. *(AP/Wide World Photos)*

cient, an impression is made of the mark before the skin is able to smooth over or change shape. Obtaining a good impression of a bite mark can be difficult, particularly if the skin was distorted before being bitten or the teeth slid across the skin while biting. The suspected bite-mark area is also wiped with sterile cotton swabs to collect any saliva or other evidence left behind by the biter that might yield DNA (deoxyribonucleic acid) for analysis; the swabs are placed in sterile tubes to preserve the evidence.

If a suspect has been identified, a dentist or forensic odontologist then makes an impression of the suspect's teeth. From this impression, a transparency or computer image of the bite mark that would be left by that suspect's teeth is created. The dentist also examines the suspect's bone and muscle structure to determine if any unusual factors are present that would affect the suspect's bite. Also taken into account in the analysis of a suspect's bite are factors such as fillings, lost teeth, the curve of the teeth, and any spaces between teeth.

The American Board of Forensic Odontology has set specific guidelines regarding the presentation of bite-mark evidence in court. In testifying as expert witnesses regarding such evidence, forensic odontologists are held to the standard of "reasonable medical certainty," which means that they must be confident in their conclusions.

Questionable Evidence?

In a study conducted in 1999, a member of the American Board of Forensic Odontology found that bite-mark analyses wrongly identified the persons who made the bite marks about 63 percent of the time. This study concluded that bite-mark analysis is always subjective and that no standards are accepted across the forensic odontology field.

Some widely publicized cases of men wrongly convicted based at least in part on bite-mark evidence include those of Ray Krone, Roy Brown, and Ricky Amolsch. Krone was convicted of murdering a woman based on a bite mark on the victim's breast; he was later released when DNA evidence showed another man had left the bite mark. Brown was also convicted of murder but was freed after serving fifteen years in prison when DNA analysis of the saliva left in the bite marks on the murder victim showed that the saliva was not his. Based on the flawed testimony of a forensic dentist, Amolsch spent ten months in jail, during which time he lost his life savings, his home,and his children. He was freed when the work of the same dentist was called into question in another case involving bite-mark evidence.

Marianne M. Madsen

Ted Bundy and Bite Marks

When the infamous serial rapist and murderer Ted Bundy was finally convicted, his conviction owed a great deal to bite-mark analysis. During the attack and murder of two young women at Florida State University, distinctive bite marks were left on the breast and buttocks of one of the women. After Bundy was arrested and charged with the murders, investigators asked Bundy to submit to the making of a dental impression for a forensic odontologist to use for comparison with the bite marks. Bundy refused, but the investigators were given a search warrant to get Bundy's dental impression in any way possible, as he was suspected of attempting to grind his teeth in a way that would eventually make a match impossible. Dr. Richard Souviron, a dentist, took photos of Bundy's teeth and gums, noting that he had an unusually uneven bite pattern that could improve the likelihood of matching his teeth to bite marks.

At Bundy's trial, Souviron was able to show how the bite marks matched Bundy's unusual teeth. During his testimony, Souviron placed a transparent overlay showing an impression of Bundy's bite mark on top of an enlarged photograph of the bite mark left on the victim's buttock, leaving no doubt in the minds of the jurors that Bundy had left the mark. Souviron had an unusual amount of evidence with which to work: The attacker had bit, turned sideways, and bit again. These two bite marks left plenty of evidence to match with Bundy's teeth, and he was convicted and sentenced to death.

Further Reading

Bowers, C. Michael. *Forensic Dental Evidence: An Investigator's Handbook*. San Diego, Calif.: Elsevier Academic Press, 2004. Discusses the management of dental evidence, including the collection and documentation of bite-mark evidence.

Dorion, Robert B. J., ed. *Bitemark Evidence*. New York: Marcel Dekker, 2005. Focuses on the anatomy and physiology of bite marks and on the process of bite-mark analysis. Includes information on landmark cases involving bite-mark evidence.

Johansen, Raymond J., and C. Michael Bowers. *Digital Analysis of Bite Mark Evidence*. Santa Barbara, Calif.: Forensic Imaging Institute, 2000. Hands-on reference book for forensic scientists discusses how to use and understand digital photography and computer imaging in bite-mark analysis.

Libal, Angela. *Fingerprints, Bite Marks, Ear Prints: Human Signposts*. Philadelphia: Mason Crest, 2006. Brief work discusses bite marks along with other types of evidence that may be found at crime scenes and used to identify suspects.

See also: Animal evidence; Child abuse; Crime scene documentation; Crime scene measurement; DNA analysis; DNA fingerprinting; Evidence processing; Forensic odontology; Innocence Project; Rape kit; Saliva; Tool marks.

Blast seat

Definition: Point of detonation of an explosive device.

Significance: The blast seat is generally the area that suffers the most damage when an explosion takes place. It is very important that the investigators at an explosion scene locate the blast seat, because that area provides many clues about the nature of the explosion.

After an explosion, prompt identification of the blast seat (also known as the seat of explosion, blast hole, or epicenter) makes it possible for investigators to locate evidence quickly and to determine the type of explosion that occurred. The type of crater formed at the blast seat depends on the type and quantity of explosives used, how the device was placed, and whether the explosives were in a container, such as in a pipe. Depending on the magnitude of the explosion and the amount of explosives used, the process of finding the crater can be easy or difficult.

Blast seats are characterized as either point source, such as when a large crater is produced, or diffuse. This characterization is one of the most important determinations for investigators to make when a major explosion occurs, because it can provide information about what caused the blast, such as whether the explosive materials were concentrated or dispersed. A concentrated explosive will typically excavate

An agent of the U.S. Bureau of Alcohol, Tobacco and Firearms measures the crater at the blast seat of a pipe-bomb explosion that took place at Centennial Olympic Park in Atlanta, Georgia, on July 27, 1996, while Atlanta was hosting the Summer Olympic Games. *(AP/Wide World Photos)* the blast seat and form a crater. In fact, a distinct crater is usually a very good indication that an explosive device was used. In such a case, thermal imaging cameras can detect a thermal effect surrounding the blast seat. Other types of explosions, such as those that are caused by fuel gas, vapors, or dust explosives, do not produce craters or have definite blast seats. With dispersed explosives, a thermal effect near the immediate blast seat is also absent.

The type of surface on which an explosion takes place can affect the blast seat that forms. When an explosion occurs on the ground, dirt, rock, and other debris are blasted out to form a crater. These materials land near the top of the crater, with some rock and debris falling back into the crater. When a blast is caused by large amounts of explosives, the debris that falls back into the crater can cover it completely, making it difficult for investigators to find the blast seat. Explosions that take place on hard surfaces such as concrete also produce craters, but these are generally not as deep as the craters formed by explosions on open ground.

C. J. Walsh

Further Reading

Beveridge, Alexander, ed. *Forensic Investigation of Explosions*. New York: Taylor & Francis, 1998.

Ellis, John W. *Police Analysis and Planning for Homicide Bombings: Prevention, Defense, and Response*. Springfield, Ill.: Charles C Thomas, 2007.

Horswell, John, ed. *The Practice of Crime Scene Investigation*. Boca Raton, Fla.: CRC Press, 2004.

National Institute of Justice. *A Guide for Explosion and Bombing Scene Investigation*. Washington, D.C.: Author, 2000.

Thurman, James T. *Practical Bomb Scene Investigation*. Boca Raton, Fla.: CRC Press, 2006.

See also: Bomb damage assessment; Bombings; Bureau of Alcohol, Tobacco, Firearms and Explosives; Crime scene investigation; National Church Arson Task Force; Oklahoma City bombing; Structural analysis; World Trade Center bombing.

Blood agents

Definition: Chemical agents that affect the body by being absorbed into the blood.

Significance: Forensic investigators must be aware of the signs and symptoms of the presence of blood agents when these chemical substances are involved in homicides or other deaths. The possibility that such agents may be used in terrorist attacks is also of concern to law-enforcement agencies.

Chemical agents are toxic substances that are classified by their primary sites of effect; blood agents are thus chemical agents that exert their primary effects in the blood. Known blood agents are either cyanide- or arsenic-based. Examples of cyanide-based blood agents include hydrogen cyanide and cyanogen chloride. Arsine is an example of an arsenic-based blood agent.

Characteristics

Blood agents are fast-acting, potentially deadly chemicals. Cyanide can be a highly volatile colorless gas, such as hydrogen cyanide or cyanogen chloride, or can exist in crystal forms, such as sodium or potassium cyanide. Cyanogen chloride is slightly less volatile than hydrogen cyanide. Arsine exists as a colorless gas. As gases, blood agents are lighter than air and quickly dissipate. Consequently, these agents are more toxic in confined areas than in open areas.

Blood agents typically have a slight odor detectable at higher concentrations. Cyanide gas, for example, may have a smell of peach kernels or bitter almonds, but the odor can be faint and many people cannot detect it—only about half of all persons have the ability to smell cyanide gas. Arsine has a mild garlic odor that can be detected only at concentrations greater than those that are fatal.

Exposure Routes

Blood agents are difficult to detect, volatile, and fast-acting, features that render such compounds potentially useful in chemical warfare. When these agents are used as chemical weapons, they are typically disseminated as aerosols, and inhalation is one of the deadliest exposure routes.

Cyanide occurs naturally in the environment, and small amounts are present in certain foods and in cigarette smoke. Both cyanide and arsine are used in various manufacturing processes, so some people may be exposed at their workplaces. Cyanide is present in the chemicals used to make paper, textiles, and plastics and to develop photographs; it is also used in metallurgy, electroplating, and mining. Because cyanide gas can be released when synthetic fabrics and polyurethane burn, cyanide poisoning may contribute to fire-related deaths.

Cyanide gas has been used to exterminate pests. Arsine, which was developed initially as an insecticide, is used in the manufacture of computer chips. Arsine gas forms when arsenic encounters an acid, and most common reports of arsine exposure have resulted from accidental formation of arsine in the workplace.

Effects

Blood agents poison the blood quickly and can result in very rapid death. Often, powerful gasping for breath occurs, followed by violent convulsions. Death from cyanide poisoning is painful, and it takes a few minutes to die from blood agent poisoning.

Blood agents are taken into the body either by ingestion or by inhalation. Cyanide-based blood agents irritate the eyes and respiratory tract. Arsine, in contrast, is nonirritating. Respiratory failure is usually the cause of death. Blood agents interfere with oxygen utilization at the cellular level by preventing exchange of oxygen and carbon dioxide between blood and tissues, causing cells to suffocate from lack of oxygen. Arsine works by damaging red blood cells, which also impairs the ability of cells to deliver oxygen throughout the body. The lack of oxygen to tissues and cells can quickly lead to death unless the victim is immediately removed from the toxic atmosphere.

Symptoms of blood agent exposure depend on concentration and duration. Breathing in or ingesting very small amounts of cyanide may have no effects, whereas exposure to somewhat higher concentrations may result in dizziness, weakness, and nausea. If removed from exposure, the person generally will begin to feel better. Over time, exposure to low concentrations can produce mild symptoms followed by permanent brain damage and muscle paralysis. Moderate exposure can result in headache, dizziness, and nausea, symptoms that can last for several hours, and may be followed by convulsions and possible coma. Higher concentrations or longer exposure may also result in convulsions and coma. With very high concentrations, severe toxic effects begin in seconds, and death occurs rapidly.

Detecting Blood Agents as Causes of Death

Because blood agents prevent adequate utilization of oxygen, the blood of persons exposed to these chemicals is a rich red rather than blue-red. Cyanogen chloride injures the respiratory tract, which results in severe congestion and inflammation in the lung. A smell of bitter almonds may be detected. The presence of thiocyanate or cyanide in the blood can also be used to detect cyanide poisoning. Arsine may leave a garlic smell on the victim's breath, but no specific tests have been developed to determine arsine poisoning.

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Blood Agents in Chemical Warfare

The cyanide-based blood agents hydrogen cyanide and cyanogen chloride were studied extensively as potential chemical weapons and used sporadically during World War I. In practice, these compounds were rarely used in military situations because their effectiveness was limited by quick dispersion. Arsine was considered as a potential warfare agent during World War I, but because of the substance's high volatility and chemical instability, weaponization of arsine was abandoned, and arsine has never been used in chemical warfare. During World War II, Nazi Germany used hydrogen cyanide, under the name Zyklon B, as a genocidal agent. Hydrogen cyanide gas, along with other chemical agents, may also have been used during the Iran-Iraq War (1980-1988).

Further Reading

Crippen, James B. *Explosives and Chemical Weapons Identification*. Boca Raton, Fla.: CRC Press, 2005. Provides useful information for first responders on identifying chemical weapons.

Ellison, D. Hank. *Handbook of Chemical and Biological Warfare Agents*. 2d ed. Boca Raton, Fla.: CRC Press, 2007. Excellent reference source for information on agents used in chemical and biological warfare, including blood agents.

Hoenig, Steven L. *Compendium of Chemical Warfare Agents*. New York: Springer, 2007. Describes and discusses the use of various agents that may be employed in chemical warfare, including how they can be identified at scenes of release and in the laboratory.

Wecht, Cyril H., ed. *Forensic Aspects of Chemical and Biological Terrorism*. Tucson, Ariz.: Lawyers & Judges Publishing, 2004. Resource designed for personnel involved in public health and safety includes discussion of the symptoms of chemical exposure.

See also: Blood residue and bloodstains; Chemical agents; Chemical terrorism; Chemical warfare; Chemical Weapons Convention of 1993; Crime scene cleaning; Nerve agents; Presumptive tests for blood.

Blood residue and bloodstains

Definition: Wet or dry remnants and areas of discoloration on surfaces resulting from the shedding of blood.

Significance: Analysis of bloodstains and other blood residue found at a crime scene can help investigators identify objects used as weapons, reconstruct the events that took place at the scene, and link suspects to the crime.

Blood consists principally of plasma and blood cells. Plasma is the yellowish fluid that carries suspended blood cells called erythrocytes and leukocytes. Erythrocytes, commonly known as red blood cells, get their color from the hemoglobin that carries oxygen from the lungs to the organs and periphery of the body. Mammalian red blood cells do not have nuclei and do not contain DNA (deoxyribonucleic acid), but they do have antigens on their outer membranes that can be used to type the blood. Leukocytes, commonly known as white blood cells, do contain nuclei and do contain DNA that is unique to an individual (with the exception of identical twins, who carry identical DNA); this DNA can be isolated and characterized to identify the source of the blood.

Because blood accounts for 8 percent of a healthy person's weight, typically 5 liters (a little more than 5 quarts), and it circulates near the surface of the skin, almost all kinds of trauma to the body result in the loss of blood. At crime scenes, blood's red color generally makes it readily apparent; in cases where attempts have been made to remove it, residues are difficult to eliminate completely. Blood residue has been identified on 100,000-year-old stone tools, and bloodstains left by Confederate soldiers wounded at the Battle of Gettysburg in 1863 have been recovered from between the floorboards of an attic where the soldiers had been hiding.

Examining a Crime Scene

A dried, but relatively fresh, bloodstain is generally reddish-brown in color and glossy. The gloss eventually disappears under the action of sunlight, wet weather, or attempts to remove the stain, and the color turns gray. The color and gloss of blood may also be affected by the surface on which it is found.

At a crime scene, investigators' search for bloodstains is facilitated by the use of flashlights, which are held so that the light falls at an angle to the surfaces being examined. Presumptive tests for blood are sometimes used when small quantities of fluids suspected to be blood are present, especially if it appears that an attempt has been made to clean the area; these tests are also used to differentiate blood from other stains, such as rust, ketchup, or chocolate syrup.

A crime scene search for blood extends beyond the immediate area of the crime, because bloody fingerprints may have been left in other areas, such as on doorknobs, drawers, or sinks. Towels, draperies, or other fabrics may have been used to wipe blood off hands. If a floor has been cleaned, blood may be found in the cracks or joints in the floor or under the edges of carpets or linoleum. Investigators must search clothing at the scene carefully; even clothes that have been cleaned can contain blood residue in seams or linings, or inside sleeves or pockets. Persons who were present at the scene during the crime may also have bloodstains on their bodies.

Compared with indoor crime scenes, crime scenes that are open to the elements pose many more difficulties for the search for blood. Blood residues may have been obliterated by the weather or may have changed color in contact with soil. At outdoor crime scenes, investigators need to pay special attention to damp areas on the ground and to surfaces such as blades of grass, leaves, and tree branches.

Description and Recording of Bloodstains

Crime scene investigators record descriptions of all bloodstains found, including information on their forms, colors, sizes, and positions. Information on the physical appearance of bloodstains is best preserved through photography; photographs are usually taken at wide range, medium range, and close up. A scale is included in all close-up shots to show the sizes of the bloodstains or drops pictured.

A rough sketch of the crime scene is also often created to show the relationship of the bloodstains and other blood residue to other elements of the scene. At violent crime scenes, blood spatter evidence is often present, and its analysis can be invaluable in reconstructing how the crime occurred.

Collection and Preservation

After crime scene bloodstain patterns and distribution have been well documented, the collection and preservation of blood residue and stains may proceed. Because these substances present the possibility of blood-borne disease, such as hepatitis or human immunodeficiency virus (HIV), investigators must be careful to protect themselves from infection. Also, they must take proper care to avoid contaminating the scene or cross-contaminating the samples collected. For collecting blood and other biological samples, investigators wear multiple layers of latex gloves, which they change frequently. Clean equipment is also essential to prevent contamination.

Blood is fragile, and to maintain its properties, investigators must ensure that blood evidence samples are properly preserved. If wet or damp bloodstains are stored in airtight containers, the blood will putrefy and be useless for forensic examination in a matter of days. In contrast, air-dried samples stored at room temperature or, better, under refrigeration will retain their usefulness for a much longer period.

A technician performs a bloodstain analysis in the New Jersey State Police crime laboratory in Totowa. *(Custom Medical Stock Photo)*

Ideally, biological samples should be stored in a frozen state, especially if they cannot be analyzed immediately.

Wet blood may be collected with a sterile disposable pipette or syringe and placed in a tube containing an anticoagulant to keep it from clotting any further. Alternatively, wet blood may be collected from pools of liquid blood with pieces of absorbent material such as filter paper, cotton fabric, or cotton-tipped applicators. Each swab with absorbed blood is placed inside a clean, unstoppered tube to permit it to air-dry. With large bloodstained items, such as carpets or mattresses, investigators may cut out bloodstained areas to transport them to the lab for analysis. As with all evidence collected at a crime scene, each sample must be clearly labeled with information on who collected it and when.

An investigator may collect dried blood by scraping the surface on which it is found with a clean razor blade, scalpel, or pocketknife, placing the scrapings in a clean tube. If dried blood cannot be scraped, it may be collected with a fabric swab or cotton-tipped applicator moistened with distilled water (or saline solution). The area of interest is swabbed, and the sample is placed in a clean tube that is left unstoppered to allow the swab to air-dry. The investigator swabs an unaffected area nearby as well, to provide a control sample for analysis. Bloodstains may also be "lifted" using gel lifter or fingerprint tape if it is determined that the gel or tape will not interfere with subsequent tests.

Bloodstained clothing and other items, such as possible weapons, that can be transported from the scene are often best submitted to the laboratory whole for analysis. Investigators generally air-dry such objects and pack them in wrapping paper or paper bags for transport. They should never be tightly rolled or stored in plastic bags, as this may result in cross-contamination.

Blood Typing

If presumptive tests indicate the presence of blood at a crime scene, further tests are performed to establish whether it is of human or animal origin. Reaction to appropriate antibody serum definitely establishes the species of origin. In addition, the blood group to which a human blood sample belongs can be established. Although more than twenty-nine human blood group systems are known, the ABO and Rh (or rhesus) groups are commonly used. With respect to the former, blood may be typed as A, B, AB, or O, characterized by the presence of antigen A, antigen B, both antigens, or neither antigen on the surface of red blood cells, respectively. With respect to the Rh group, a sample is either positive or negative for Rh antigen. A person's blood type is inherited and hence unchangeable. Although ABO and Rh blood group analysis does not link a sample to a particular person, it can enable investigators to include or exclude a person of interest as a suspect or victim. Because blood group antigens deteriorate with age or improper storage, samples that have not been collected and stored with care often cannot be typed.

Blood also contains DNA, however, which is less subject to deterioration. Given that DNA testing of bloodstains and other blood residues can provide positive identification of the source of the blood, law-enforcement agencies around the world rely on DNA analysis of any blood and other biological samples recovered from crime scenes.

James L. Robinson

Further Reading

Fisher, Barry A. J. *Techniques of Crime Scene Investigation*. 7th ed. Boca Raton, Fla.: CRC Press, 2004. Standard text in the field includes a chapter on blood and other biological evidence.

Geberth, Vernon J. *Practical Homicide Investigation: Tactics, Procedures, and Forensic Techniques*. 4th ed. Boca Raton, Fla.: CRC Press, 2006. Text used in many U.S. police academies provides full coverage of all aspects of homicide investigations, including the collection of blood evidence.

Lee, Henry C., Timothy Palmbach, and Marilyn T. Miller. *Henry Lee's Crime Scene Handbook*. San Diego, Calif.: Academic Press, 2001. Practical guide to crime scene procedures includes a section on the collection, preservation, and analysis of blood.

Tilstone, William J., Kathleen A. Savage, and Leigh A. Clark. *Forensic Science: An Encyclo-*

pedia of History, Methods, and Techniques. Santa Barbara, Calif.: ABC-CLIO, 2006. Comprehensive work covers the role of blood analysis in forensic investigations, including blood groups, bloodstain identification, blood spatter analysis, and presumptive tests for blood.

See also: Biohazard bags; Blood agents; Blood spatter analysis; Blood volume testing; Control samples; Crime scene cleaning; Crime scene investigation; Crime scene protective gear; Crime scene search patterns; DNA typing; Luminol; Multisystem method; Petechial hemorrhage; Presumptive tests for blood; Trace and transfer evidence.

Blood spatter analysis

Definition: Application of the principles of projectile motion to the examination of patterns of human bloodstains.

Significance: By analyzing bloodstain patterns (blood spatter) found at crime scenes, forensic scientists can determine such details of crimes as where victims were located when they received the wounds that produced the blood spatter, whether victims were standing or seated when the wounds were inflicted, and even sometimes whether the assailants wielded the weapons in their right or left hands.

Blood spatter analysis is a valuable tool of forensic investigators in the determination of the events that transpired during crimes in which victims received wounds that resulted in bloodstains. Investigators can apply the physical principles of the motion of blood through the air to the patterns of blood droplets found at crime scenes, as well as the droplets' overall shapes, to ascertain the exact locations where victims' wounds were received.

Blood Spatter Ballistics

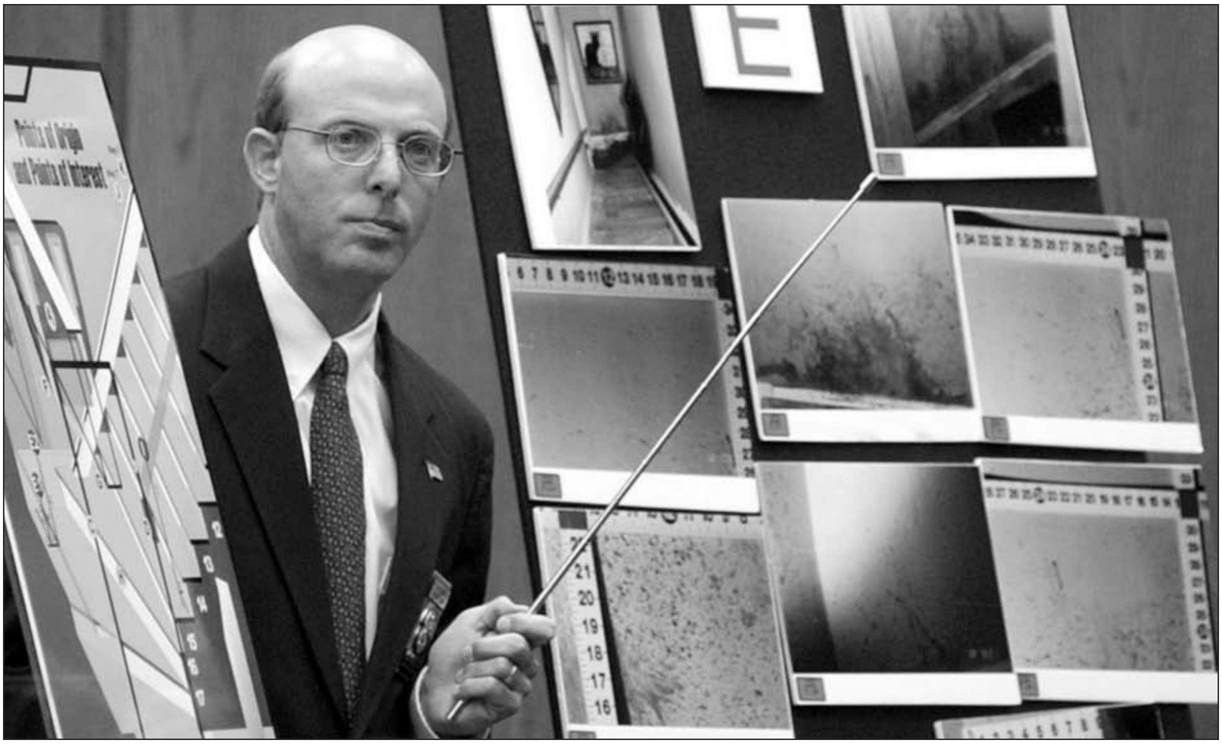
Blood is a fluid of constant density that is not affected by temperature, pressure, or other atmospheric conditions when it is in flight. The large surface tension of blood drops holds them together during their time of flight, and as they move through the air, the drops assume a spherical shape. Blood spatter patterns are influenced by the distance the blood travels through the air and the material with which it comes in contact.

A blood drop that falls straight down from its ejection point will project a circular stain on the material that absorbs it. In contrast, a blood drop that travels an extended distance from the source of the wound will follow a parabolic path, striking any surface it meets at an angle. When this angle of impact is not 90 degrees measured with respect to the horizontal surface (which would be a straight-down motion), the blood drop will leave an elongated (elliptical-shape) stain on the surface that it strikes. The more pointed end of the stain will be in the direction the blood drop was traveling.

Analysis of Blood Spatter

The patterns of bloodstains observed on surfaces provide evidence of the points of impact of wounds and the force of the punctures. Crime scene investigators can use the directionality of bloodstain patterns to work backward toward the two-dimensional point on the surface level with the blood spatter to identify the point of ejection and distance from the wound. (Given that the pointed ends of blood drops indicate the direction of travel, the more rounded ends converge toward the point of origin.) In the early days of blood spatter analysis, crime scene investigators laid out series of strings or wooden rods in the diverging direction of a blood spatter pattern to determine the convergent point. Modern forensic tools include computer software packages that use the data of the coordinates of blood spatter to determine the point of emergence of the blood drops.

In addition to the two-dimensional determination of the victim's position when the injury occurred, the blood spatter analyst can estimate the vertical position of the wound from the angle of impact of the blood spatter. This can provide evidence in terms of whether the victim was standing, sitting, or lying down at the time of the injury. In examining a bloodstain, a forensic



North Carolina State Bureau of Investigation agent Duane Deaver, a blood spatter expert, testifies during the murder trial of author Michael Peterson, explaining how tests of blood spatters found inside Peterson's home strengthened his opinion that Peterson's wife was beaten to death and did not die as the result of a fall, as Peterson claimed. In October, 2003, Peterson was found guilty and was sentenced to life in prison without the possibility of parole. *(AP/Wide World Photos)*

investigator measures its length and width. The angle of impact is then determined by the trigonometric relation involving the sine of the angle:

$$\mathrm{Sin}(a) = w/l,$$

where w is the width of the bloodstain, l is its length, and a is the angle of impact. Solving this equation for the angle a (inverse sine) can determine where above the surface level the wound was inflicted. Using the results from the two-dimensional analysis that identifies how far away the victim was from the blood spatter pattern, the analyst can use this equation to solve for the height (third coordinate) where the point of puncture occurred. (In actuality, this can determine only the maximum height the victim was at the moment the wound occurred, because the action of gravity tends to change the shape of the blood's trajectory from straight-line motion.)

Analysis of bloodstains that are determined to have come from the tip of a weapon, such as a knife, can provide another kind of evidence. Passive bloodstains are drops caused only by the action of gravity, with no external force projecting the droplets forward. Such blood spatter appears as small circular drops. If these drops show a rotational sense (that is, if they curve either right or left), this directionality can indicate which of the assailant's hands the weapon was in at the time of the assault, providing information on whether the attacker was right-handed or left-handed.

Obstacles to Useful Analysis

The major problem faced by forensic scientists attempting to conduct blood spatter analysis is that many crime scenes lack well-defined blood spatter patterns even when blood is present. Difficulties may arise because of the effects of blood on different surfaces, because smaller blood droplets have broken off from larger droplets, because the victim moved after the injury and disturbed the initial spatter pattern, or simply because of the overall chaos of an environment where a violent crime has been committed. In such cases, often the only substantive evidence that can be gained from bloodstains involves identification of victims and possibly assailants through the blood types found at the crime scene and through analysis of DNA (deoxyribonucleic acid) extracted from the blood found.

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Further Reading

Adams, Thomas F., Alan G. Caddell, and Jeffery L. Krutsinger. *Crime Scene Investigation*. 2d ed. Upper Saddle River, N.J.: Prentice Hall, 2004. Handbook for law-enforcement professionals includes a chapter titled “Evidence Collection” that has an informative section on blood and blood analysis.

Bennett, Wayne W., and Kären M. Hess. *Criminal Investigation*. 8th ed. Belmont, Calif.: Wadsworth/Thomson Learning, 2007. Comprehensive textbook provides in-depth discussion of forensic techniques and procedures. Includes checklists and questions at the ends of chapters to highlight the most important ideas presented.

Camenson, Blythe. *Opportunities in Forensic Science Careers*. Chicago: VGM Career Books, 2001. Presents accounts of professionals working in forensic science and identifies the education needed and the job responsibilities related to various disciplines within forensics.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005. Comprehensive introductory textbook uses many case studies to illustrate crime investigation methodologies. Includes a section on recognition of bloodstain patterns.

Nickell, Joe, and John F. Fischer. *Crime Science: Methods of Forensic Detection*. Lexington: University Press of Kentucky, 1999. Very thorough examination of forensic investigative work includes discussion of blood spatter analysis.

See also: Ballistics; Biohazard bags; Blood residue and bloodstains; Blood volume testing; Crime scene investigation; Crime scene sketching and diagramming; Defensive wounds; Gunshot wounds; Knife wounds; Luminol; Presumptive tests for blood; Puncture wounds; Serology; Simpson murder trial.

Blood volume testing

Definition: Technique used to determine how much blood has been shed at crime scenes and accident scenes.

Significance: Forensic examiners can learn much about the wounds inflicted on victims of crimes from the volume of blood found at crime scenes. Blood volume testing may also be used to determine whether wounds were inflicted on victims at locations other than where the victims were ultimately found.

When blood is present at a crime or accident scene, a forensic team attempts to collect the blood or at least to determine how much blood was spilled at the scene. The human body generally contains about 5 liters (a little more than 5 quarts) of blood, but this amount is affected by factors such as body size and amount of fat tissue. The volume of blood present at a crime scene—and, sometimes, the blood spatter pattern—can inform investigators as to the types, depths, and seriousness of the wounds that caused the blood loss. Blood volume testing may also help to determine whether a victim has been moved—that is, if the amount of blood found at the scene is not consistent with the victim’s loss of blood, it is likely the victim was moved after the wounds were inflicted.

Any blood present at a crime scene is collected (or collection is at least attempted) and sent to a forensic laboratory for typing and identification. Fresh blood is collected in plastic containers. Dried blood may be collected in various ways: Fabrics with dried bloodstains may be transported to the lab, and sticky tape, such as fingerprint tape, may be used to peel spots of dried blood away from hard surfaces. Dried blood may also be collected with swabs or pieces of sterile cloth that have been moistened with distilled water or saline solution.

At the laboratory, a forensic scientist can estimate the blood volume found at the crime scene by determining how many red blood cells are present in the collected blood and then calculating how much whole blood would contain that many red blood cells. Alternatively, the scientist can determine how much plasma was left behind and calculate a blood volume from that figure.

When no body or victim is found at a crime scene where blood is present, knowing the volume of blood shed at the scene can help investigators determine what kind of wound was inflicted; for example, a minor cut produces only a small volume of blood, whereas a deep stab wound or an arterial puncture is likely to produce copious amounts of blood. A blood volume test can also help determine how much time was necessary for the amount of blood present to be left behind.

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Further Reading

Geberth, Vernon J. *Practical Homicide Investigation: Tactics, Procedures, and Forensic Techniques*. 4th ed. Boca Raton, Fla.: CRC Press, 2006.

Genge, N. E. *The Forensic Casebook: The Science of Crime Scene Investigation*. New York: Ballantine, 2002.

Platt, Richard. *Crime Scene: The Ultimate Guide to Forensic Science*. New York: Dorling Kindersley, 2003.

See also: Blood residue and bloodstains; Blood spatter analysis; Crime scene investigation; Crime scene search patterns; Crime scene sketching and diagramming; Presumptive tests for blood.

Bloody Sunday

Date: January 30, 1972

The Event: During a civil rights march in the Roman Catholic section of Londonderry, Northern Ireland, British army troops shot twenty-six marchers, thirteen of whom died immediately. A fourteenth shooting victim died several months later.

Significance: One of the most significant episodes in the long, violent conflict between the Catholic and Protestant factions in Northern Ireland, Bloody Sunday was met with outrage in both local and international communities and led to a dramatic increase in support for the Irish Republican Army (IRA) in Northern Ireland. Meanwhile, in response to charges that the British soldiers had fired without provocation, the British government quickly launched an investigation to determine who had fired the first shots. The official report that came from the investigation exonerated the soldiers, but its findings were criticized because of the commission's questionable handling of forensic evidence.

Two days after the Bloody Sunday shootings, the British parliament ordered an investigation under Baron Widgery, the lord chief justice of England and Wales. The report of the Widgery Tribunal supported the account of the event given by the army, which claimed that marchers began the incident by firing weapons and hurling explosives at the soldiers. The evidence considered by the tribunal included the results of paraffin tests used to identify bullet-lead residues from the weapons that fired the fatal shots, along with nail bombs that had been recovered from one of the bodies. Preliminary tests for traces of explosives on the clothes of all but one of the victims of the shootings proved negative. The clothes of the remaining victim could not be tested as they had already been compromised by careless handling. The report offered no analyses of the individual shots fired by the soldiers.

The Bloody Sunday massacre intensified the campaign of the Provisional Irish Republican

Army (PIRA) against British occupation of Northern Ireland and helped to win more public support for PIRA among Roman Catholics. The massacre helped to aggravate two decades of anti-British rioting in Northern Ireland and attacks on British economic targets and social institutions.

The findings of the Widgery Tribunal remained controversial in the 1990's. In 1998, British prime minister Tony Blair ordered the formation of a second commission of inquiry to reevaluate evidence from Bloody Sunday. Assembled under the chairmanship of Lord Saville, the new commission completed its hearings in November, 2004. Although the full report of the Saville Inquiry was not published as late as mid-2008, it is considered to be a more comprehensive study than that of the Widgery Tribunal. Its evidence, which included witness testimonies from local residents, soldiers, journalists, and politicians, appears to call into question the credibility of the Widgery Tribunal's report. At the center of the controversy is the new report's finding that forensic evidence collected from shooting victims' bodies may have been contaminated when bodies of shooting victims were placed alongside weapons and explosives. That finding appears to contradict the original report's conclusion that trace evidence found on the bodies indicated that the shooting victims had themselves used firearms or explosives.

Investigations

The march that ended in the Bloody Sunday shootings began as a protest rally organized in Londonderry by the Northern Ireland Civil Rights Association to demand an end to the internment without trial of suspected IRA terrorists. Reports of the number of participants in the march are conflicting. Some observers estimated there were twenty thousand marchers; however, the Widgery Report estimated there were only three to five thousand marchers.

The marchers initially walked toward the Bogside area of Londonderry (which is also known as Derry). There, local residents joined the protest, and the marchers were redirected to another street to avoid army blockades. A planned highlight of the march was to have been a speech by the Irish nationalist Bernadette Devlin, who then held a Northern Ireland seat in Great Britain's Parliament. Around 3:30 P.M., however, a small number of young men began throwing stones and hurling insults at troops manning the army barricades that had been erected to contain the march. The troops initially responded with tear gas grenades, fire hoses, and rubber bullets. When the paratroopers began crossing the barricades to arrest demonstrators, they met such strong resistance that they feared for their own safety and began firing real bullets into the crowd. Within twenty minutes, thirteen young, unarmed men were dead. At least eighteen other people were seriously injured. The paratroopers later justified their actions by claiming that they had been fired on, but evidence in support of their claim was controversial.

Pallbearers carry one of thirteen coffins of Bloody Sunday victims during a funeral in Derry, Northern Ireland, on February 2, 1972. About ten thousand people shared in the funeral services for those killed by British army troops. *(AP/Wide World Photos)*

Forensic Issues

The central question in the Bloody Sunday massacre that remains to be resolved is whether the solders who shot the marchers were attacked by firearms and nail bombs before they began shooting into the marchers. The weight of known evidence says no. Eyewitness accounts by civilians do not support that finding; no soldiers were injured during the confrontation, and no civilian firearms were found. Additionally, the initial investigation into the shootings found no conclusive proof that the marchers who were shot had even handled firearms. Moreover, there was no evidence that the Irish Republican Army was then planning to provoke the British military. Nevertheless, the initial investigation did not call eyewitnesses and did not take testimony from survivors. The investigation's interpretation of forensic evidence was believed to be inaccurate and incomplete. Nonetheless, Lord Widgery concluded from the traces of firearm residue found on the bodies of the men who had been shot to death that some of them, at least, had been in close contact with firearms or explosives.

Elizabeth K. Hayden

Further Reading

Coates, Tim. *Bloody Sunday: Lord Widgery's Report 1972*. London: Stationary Office Books, 2001. Reprints the report of the first government commission to investigate the shootings.

Dunn, Seamus, ed. *Facets of the Conflict in Northern Ireland*. New York: St. Martin's Press, 1995. Collection of scholarly articles highlights fundamentals of politics in Northern Ireland. Selected authors—funded by the Centre for the Study of Conflict, University of Ulster—address the social, legal, political, and economic ramifications of the events that have shaped Irish history.

Hayes, Patrick Joseph, and Jim Campbell. *Bloody Sunday: Trauma, Pain, and Politics*. Ann Arbor, Mich.: Pluto Press, 2005. Covers the political and psychological aspects of the incident. Based on interviews with families of those killed by British soldiers.

Holland, Jack. *Hope Against History: The Course of Conflict in Northern Ireland*. New York: Henry Holt, 1999. Engaging narrative covers the origins of IRA and loyalist paramilitary groups, the events of Bloody Sunday, the Northern Ireland civil rights movement, and attempts to settle the conflict. Illuminates the experiences of both Protestant and Catholic communities in Northern Ireland.

McClean, Raymond. *The Road to Bloody Sunday*. 2d ed. Londonderry, Northern Ireland: Guildhall Press, 1997. Presents the eyewitness account of a medical doctor who treated shooting victims on Bloody Sunday.

Mullan, Don, and John Scally, eds. *Eyewitness: Bloody Sunday*. Rev. ed. Dublin, Ireland: Merlin, 2002. Contains testimonies by both soldiers and marchers at the incident. Many of the eyewitness accounts in this collection dispute the conclusions of the Widgery Report. Includes a foreword written by film director Paul Greengrass, whose 2002 film *Bloody Sunday* is based on this work.

See also: Ballistic fingerprints; Ballistics; Bombings; Bullet-lead analysis; Firearms analysis; Gunshot residue; Improvised explosive devices; Interrogation.

Blunt force trauma

Definition: Trauma caused to a body part by a blunt instrument or surface through physical impact, injury, or attack.

Significance: By examining the types of injuries incurred by a victim of blunt force trauma, forensic scientists may be able to determine the cause of the accident or crime that resulted in the injuries as well as what type of instrument caused the injuries.

"Blunt force trauma" is a general term that covers trauma to the body from a variety of sources. Blunt force trauma, also known as blunt trauma, results when the body is struck by an object or when the body strikes an object. When a forensic scientist is asked to investigate blunt force trauma, it is usually to determine what instrument or event caused the injuries—for example, to determine whether the injuries resulted from a beating as opposed to a fall. Blunt force trauma to the body is not always life-threatening (unless organs or blood vessels rupture), but blunt force trauma to the head may cause death. Injuries that indicate blunt force trauma include lacerated blood vessels (including major vessels such as the aorta), lacerated or crushed organs, hematomas, contusions, crushed or fractured bones, and severed spinal cord.

Causes

Blunt force trauma is often caused by motor vehicle accidents in which the body is slammed into a steering wheel or dashboard. This slamming action, caused by the rapid deceleration of the vehicle, may cause contusions or rupturing of internal organs. Another common type of blunt force trauma is an accidental fall. The many other possible causes of blunt force trauma include assault by another person (through clubbing with an object, hitting, kicking, or punching) and sporting accidents.

When blunt force trauma is caused by a beating or clubbing, the type of weapon used by the assailant can often be identified by the characteristics of the wound. If the wound shows characteristics that can identify only a class of instrument (as opposed to the specific type of instrument) as the weapon, such as a bone fracture showing smooth, curved lines that could have been made by any smooth weapon, these are called "class characteristics" of the weapon. At times, however, a specific weapon can be identified by the distinctive marks it has left on skin, bone, or other tissues. For instance, a hammer that had individualized marks of wear on it before it was used to inflict wounds could leave those specific marks on the victim. These are called "individual characteristics" of the weapon.

A single weapon can also cause a variety of wounds. For example, if a shovel is used as a weapon, it may cause a large flat wound if the back of the shovel is used. The same shovel wielded so that its side or blade struck the victim would produce a sharp, linear wound.

In addition to examination of the victim's injuries, blood spatter analysis can provide clues as to the type of weapon used in a situation involving blunt force trauma, the strength of the person wielding the weapon, and the relative spacing of the victim and the attacker.

Injuries

Abdominal trauma is the most common type of blunt force trauma, and the liver, spleen, and small intestine can be affected. This often happens during a car accident, which may cause organ rupture.

Abrasions, or scrapes, are also often seen in cases of blunt force trauma. These injuries result when the skin is forcefully rubbed away by a rough surface, such as asphalt. Abrasions are usually only surface injuries. Lacerations may also occur; these can be either external or internal injuries, damaging the skin and penetrating into other tissues deeper within the body, such as muscles or organs.

In addition to other head injuries, such as skull fracture, that can result from blunt force trauma, the brain can also be damaged by the force of the blow. This can cause damage to the nerve cells deep inside the brain, even when there is no breaking of the skin.

Contusions, or bruises, from blunt force trauma can be either internal or external injuries. Bruises happen when blood vessels are damaged and begin to leak blood into surrounding tissues. Bruising on the skin surface shows up as swelling of the tissues and dark shades of color (blue, red, or purple). The amount of discoloration can vary with a person's age and weight: Older people and those who are heavier may show more bruising than younger and less heavy people. Deep bruising caused by extreme blunt force can occur so far inside the body that nothing shows on the surface; such injuries can be seen only with the aid of technologies such as magnetic resonance imaging (MRI). Contusions of the brain may not be noticeable at all from surface injuries; they may manifest themselves only through neurological symptoms such as confusion and weakness.

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Further Reading

DiMaio, Vincent J. M., and Suzanna E. Dana. *Handbook of Forensic Pathology*. 2d ed. Boca

Raton, Fla.: CRC Press, 2007. Comprehensive volume discusses common issues in forensic pathology, including determination of instruments in blunt force trauma situations.

Ferllini, Roxana, ed. *Forensic Archaeology and Human Rights Violations*. Springfield, Ill.: Charles C Thomas, 2007. Collection of essays by experts in various disciplines includes discussion of the forensic examination of bodies subjected to blunt force trauma and other deadly injuries in human rights violation cases.

Moore, Ernest E., Kenneth L. Mattox, and David V. Feliciano. *Trauma Manual*. 4th ed. New York: McGraw-Hill, 2003. Focuses mostly on trauma surgery, but discusses blunt force trauma in surgical situations.

Shkrum, Michael J., and David A. Ramsay. *Forensic Pathology of Trauma: Common Problems for the Pathologist*. Totowa, N.J.: Humana Press, 2007. Addresses common trauma patterns, including determination of blunt force trauma, in forensic settings.

Wilson, William C., Christopher M. Grande, and David B. Hoyt, eds. *Trauma: Critical Care*. Vol. 2. New York: Informa Healthcare, 2007. Discusses the determination of types of blunt force trauma and wound analysis.

See also: Antemortem injuries; Blood residue and bloodstains; Blood spatter analysis; Child abuse; Crime scene investigation; Defensive wounds; Driving injuries; Forensic anthropology; Osteology and skeletal radiology; Peruvian Ice Maiden; Physical evidence; Skeletal analysis.

Body farms

Definition: Outdoor facilities that allow forensic anthropologists to study postmortem decomposition of human remains.

Significance: Research conducted at body farms helps the practitioners of a number of forensic disciplines—including medical examiners, crime scene investigators, and law-enforcement personnel—with the identification of human remains.

The first body farm was established in 1972 by Dr. William M. Bass at the University of Tennessee in Knoxville. Shortly after he moved to Tennessee, Bass was asked to join the staff of the state's medical examiner's office as state forensic anthropologist. Part of Bass's duties in this position included consulting on death investigations being conducted by federal, state, and local law-enforcement agencies. Although Bass had extensive training in forensic anthropology, he did not have a lot of knowledge about or experience with the decomposition of human remains. In addition, research in this area was nearly nonexistent. This need led Bass and his colleagues to open the University of Tennessee Anthropological Research Facility, which came to be known as the Body Farm.

Purpose of Body Farms

The research conducted on body farms allows forensic anthropologists to study the postmortem decomposition of human remains. This work is important for a number of reasons. First, it helps scientists to gain a more comprehensive understanding of what occurs to the body after death and thus to develop better methods of determining the "time since death" in specific cases. Time since death, or the postmortem interval, is a critical element in homicide investigations, as law-enforcement officers or crime scene investigators must often confirm or disprove the alibis of potential suspects.

Second, the research on body farms provides information that is useful to forensic anthropologists and medical examiners who must identify bodies from skeletal remains. By examining a set of skeletal remains, a forensic anthropologist or medical examiner can determine a great deal about the decedent, including age, sex, stature, ancestry, and the presence of unique features. Body farm research also provides information that can help examiners to determine the cause of death in individual cases. In homicide investigations, law-enforcement officers or crime scene investigators need to know whether the decedents have died of natural causes or whether they have been the victims of foul play.

When the University of Tennessee's Anthropological Research Facility first began its work, almost no research had been done documenting

Author Patricia Cornwell, whose best-selling crime novels feature forensic pathology, shakes hands with Dr. William M. Bass, founder of the first body farm in the United States, the University of Tennessee Anthropological Research Facility. Cornwell is wearing a special outfit because of her participation in a mock airplane crash event staged for a crime scene investigation training exercise in July, 2005. *(AP/Wide World Photos)*

what happens to the human body after death. Even the most rudimentary questions—for example, When do blowflies show up on a body? How long does it take for a corpse to become a skeleton?—could not be answered. As the Body Farm's studies progressed, the questions became more sophisticated: How do decomposition rates differ between sunshine and shade? How do climate differences (cool versus hot) affect decomposition rates? How is decomposition affected when bodies are buried in shallow graves as opposed to left on top of the ground? Do bodies decompose faster in water than they do on land? How do bodies decompose in vehicles? What effects do other variables—such as clothing, body weight, and condition of the body—have on rates of decomposition?

What Happens to Bodies

The University of Tennessee's body farm occupies a three-acre tract of land situated near the University of Tennessee Medical Center; it is surrounded by razor wire and a wooden privacy fence. When a corpse arrives at the facility, it is assigned an identification number to ensure the confidentiality of the donor. The body is then examined and its condition is thoroughly documented. Bodies are placed in various environmental conditions across the property. For example, some bodies are placed in car trunks, some are left lying in the sun or shade, some are buried in shallow graves, some are covered with brush, and some are submerged in water.

Two things happen when a body decays. At death, enzymes in the digestive system, having no more nutrition, begin to eat on the body and the tissues liquefy. This process is known as putrefaction. Insects gather on the body, and maggots consume the rotting flesh. At the University of Tennessee, forensic anthropologists Dr. Richard Jantz and his wife, Dr. Lee Meadow Jantz, document such insect activity and how long it takes the insects to do their work. Most of the characteristics used to determine time since death are related to insect activity.

After the bodies at the Tennessee facility have completed the decomposition process, the bones are cleaned and measured, and the data are entered into the University of Tennessee's Forensic Anthropology Data Bank, which was created by Dr. Richard Jantz. This database is the primary tool that forensic anthropologists use to determine age, sex, stature, ancestry, and other unique characteristics from skeletal remains. The database is the central component of a computer program called FORDISC (for Forensic Discrimination). The FORDISC software is used all over the world as a tool to assist in the identification of bodies. For example, a medical examiner or anthropologist can enter a few skeletal measurements and the program can predict with a fairly high degree of accuracy the age, race, sex, height, and ancestry of the decedent. The bones are then cataloged and added to the William M. Bass Donated Skeletal Collection, which is the largest modern bone collection in the United States.

Sources of Bodies

The bodies studied at body farms come from three primary sources. First, bodies are often donated through state medical examiners' offices. For instance, if a body comes through a county medical examiner's office and it ends up unclaimed—either because the decedent is never identified or because the decedent had no friends or relatives to claim the body—the medical examiner may choose to send it to a body farm for decomposition research or for addition to the facility's skeletal collection. Second, family members who are aware of the valuable research conducted at body farms and who are genuinely interested in furthering the cause of science may choose to donate the bodies of loved ones. Third, some people make the decision before their deaths to donate their bodies to body farms; by completing donor consent forms, they ensure that their wishes are carried out.

Body farms do not accept the corpses of persons who were infected with the human immunodeficiency virus (HIV), with hepatitis, or with antibiotic-resistant bacteria. These facilities will accept the donation of anyone's bones, however.

Impact of the University of Tennessee's Body Farm

The success of the research conducted at the Body Farm in Tennessee inspired the opening of other body farms in the United States and abroad. Western Carolina University in Cullowhee, North Carolina, created a body farm in 2006 as part of the Western Carolina Human Identification Laboratory. The facility is run by the university's forensic anthropology program on several acres of land near the campus. Like the original Body Farm, the North Carolina facility studies the decomposition of human remains. Researchers at the facility hope to learn more about the decomposition of bodies in the

The Body Farm in Popular Culture

The University of Tennessee's Anthropological Research Facility came to widespread public attention, and gained its nickname, with the 1994 publication of Patricia Cornwell's novel *The Body Farm*. In 2003, the nonfiction book *Death's Acre: Inside the Legendary Forensic Lab the Body Farm Where the Dead Do Tell Tales*, by Bill Bass and Jon Jefferson, increased the public's knowledge of the work done on body farms. In addition, author Mary Roach visited the Tennessee facility and included discussion of its work in a chapter of her 2003 nonfiction book *Stiff: The Curious Lives of Human Cadavers*. Since coming to the attention of television writers, body farms have figured as settings in several episodes of crime and suspense shows, including *CSI: Crime Scene Investigation*, *Law & Order: Special Victims Unit*, and *The Dead Zone*.

western Carolina mountain terrain, which is very different from the terrain of eastern Tennessee. They are interested in discovering whether these differences may affect rates of decomposition and suggest that it is important to study postmortem decomposition in a variety of geographic locations.

Texas State University planned to have a body farm operational by the fall of 2007, but completion of the facility, which will be run by the San Marcos Department of Anthropology, part of the Forensic Anthropology Center at Texas State, was delayed by objections from residents in the area and concerns about the presence of buzzards, which might interfere with flight operations at a nearby airport. Researchers at Texas State are interested in learning about rates of decomposition in Texas, where both geography and climate are significantly different from those of western Carolina and eastern Tennessee. Differences in climates may well be found to affect the rates of decomposition in human remains.

Other body farms are in various stages of planning and development across the United States, including in California, Florida, Kansas, and Iowa. In India, a student, Roma Kahn, who received a master's degree in forensic archaeology from Bournemouth University in England, has been conducting preliminary work on the decomposition of cattle. She hopes to open a facility to study human decomposition in India, modeled along the lines of the body farms operating in the United States.

Dr. Bass and the faculty of the University of Tennessee's Department of Anthropology have played a key role in shaping the field of forensic anthropology. It has been estimated that as of 2007, the University of Tennessee was responsible for the education of some 25 percent of the board-certified forensic anthropologists in the United States. Entry into the forensic anthropology program at the University of Tennessee is highly competitive, with roughly sixty students applying for the fewer than ten doctoral positions available annually.

The University of Tennessee's Forensic Anthropology Center also inspired the formation of the National Forensic Academy (NFA), one of the leading law-enforcement investigation training centers in the United States. The NFA offers an intensive ten-week training program designed to educate law-enforcement agents in evidence identification, collection, and preservation. The primary goal of the NFA is to prepare law-enforcement officers to recognize crucial components of crime scenes and improve the process of evidence recovery and submission.

Opposition to Body Farms

Although the research conducted at body farms has undoubtedly contributed a great deal to the field of forensic anthropology, some people are disturbed by the idea of such facilities in their neighborhoods. At the heart of many debates is the placement of body farms. Residents who live near proposed sites often protest the opening of these facilities for a variety of reasons, including fears that insects will be attracted to the area or that scavenging animals will carry off body parts, perhaps dropping them in residents' backyards. When Texas State University proposed placing its body farm about two miles from the San Marcos Outlet Mall, one of the biggest tourist attractions in the area, local government officials objected, saying that the mall's businesses would likely be hurt by their proximity to such a facility.

The University of Tennessee's Body Farm was subject to similar opposition in its early days. Members of a local health care advocacy group called Solutions to Issues of Concern to Knoxvillians (SICK) protested at the research facility, holding up signs proclaiming, "This makes us SICK." A number of local residents also complained about the odor emitted from the Body Farm. The primary point of contention, however, was that the facility was not completely fenced in, and some people could see the decaying bodies from their homes. The university solved this problem by agreeing to install a privacy fence.

Kimberly D. Dodson

Further Reading

Bass, Bill, and Jon Jefferson. *Beyond the Body Farm: A Legendary Bone Detective Explores Murders, Mysteries, and the Revolution in Forensic Science*. New York: William Morrow, 2007. Examines the forensic science employed in a number of cases and discusses advances in forensic anthropology.

_______. *Death's Acre: Inside the Legendary Forensic Lab the Body Farm Where the Dead Do Tell Tales*. New York: G. P. Putnam's Sons, 2003. Traces the development of the University of Tennessee's body farm and presents real-life accounts of forensic cases.

Hallcox, Jarrett, and Amy Welch. *Bodies We've Buried: Inside the National Forensic Academy, the World's Top CSI Training School*. New York: Berkley Books, 2006. Describes the National Forensic Academy's ten-week training course for law-enforcement agents. Topics of the training include the identification, collection, and preservation of evidence.

Roach, Mary. *Stiff: The Curious Lives of Human Cadavers*. New York: W. W. Norton, 2003. Discusses the evolution of the study of human decomposition as well as the use and handling of corpses. Profiles the University of Tennessee's Anthropological Research Facility.

See also: Adipocere; Autopsies; Crime scene investigation; *CSI: Crime Scene Investigation*; Decomposition of bodies; Evidence processing; Forensic anthropology; Forensic entomology; Forensic pathology; Osteology and skeletal radiology; Skeletal analysis; Taphonomy; University of Tennessee Anthropological Research Facility.

Bomb damage assessment

Definition: Assessment of the severity of blast effects caused by explosions.

Significance: By conducting bomb damage assessment, investigators can aid in the identification of explosive devices or explosive propellants. Such analysis can also provide information on bomb delivery systems and their targeting accuracy.

An explosive device is designed to release large amounts of energy quickly from a concentrated source. The explosion results from the reaction of a solid or liquid chemical or vapor that forms highly pressurized gases, propagating an outward-moving pressure wave. In a high-explosive detonation, the speed of the reaction is faster than the speed of sound, 5,000 to 8,000 meters (about 16,000 to 26,000 feet) per second. Such an explosion produces an intense shock wave that expands within milliseconds of detonation. The effects of explosions vary, but the initial destructive effects on targets are directly related to stress-wave propagation, pressure-driven phenomena resulting in the impact and penetration of propelled objects, ground-transmitted shock, and explosion-generated effects such as fire, smoke, dust, and pressure damage to organs and tissue.

A bomb detonation can have catastrophic effects, destroying or severely damaging its intended human or material targets. The amount of damage done by a detonated bomb depends on the nature and size of the explosive device and its location relative to its target. Additional factors relate to specifics of the target, such as materials and construction, surroundings, and the proximity of potential victims. Bomb damage to targets is the direct result of explosive detonation involving shock-wave blast pressure and high-speed impact from ejected target materials, shrapnel, and debris. The postdetonation distribution of these materials reflects physical processes and properties that can be measured and correlated directly to the initiating explosive device.

The physical and chemical characteristics of explosions and their structural by-products are well defined by known scaling laws and equations of state, and any explosion can ultimately be referenced by its geometry, density, and temperature. As the result of more than one hundred years of testing, a large cross-referenced database has been compiled regarding the major and minor damage potential of shock waves generated by explosions. Most blast data come from unclassified war documentation, industrial records, scientific and engineering research, and forensic analyses. These data correlate explosive type and quantity to blast pressure, detonation velocity, target strata, ground shock, atmospheric conditions, target distance, target materials, above- or below-ground penetration, and confined or unconfined conditions. Blast injuries from explosive shock waves include body displacement, dismemberment, ruptured eardrums and internal organs, and tissue destruction from propelled objects; the extent of such injuries has been well documented, cataloged, and correlated according to detonation proximity.

As explosions involve predictable quantitative chemical and physical signatures, after a bombing forensic scientists can determine the size and type of device detonated and its effectiveness. In addition to conducting trace chemical analyses to identify the explosives used, the scientists examine such elements as the dimensions of the blast area and crater, the target's materials, weather conditions at the time of the explosion, the fallout distance of blast-propelled objects, and the extent of bodily harm caused by the blast.

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Further Reading

Cooper, Paul W. *Explosives Engineering*. New York: Wiley-VCH, 1996.

Fannelöp, Torstein K. *Fluid Mechanics for Industrial Safety and Environmental Protection*. New York: Elsevier, 1994.

Thurman, James T. *Practical Bomb Scene Investigation*. Boca Raton, Fla.: CRC Press, 2006.

Zukas, Jonas A., and William P. Walters, eds. *Explosive Effects and Applications*. New York: Springer, 1998.

See also: Ballistics; Blast seat; Bombings; Bureau of Alcohol, Tobacco, Firearms and Explosives; Crime scene reconstruction and staging; Improvised explosive devices; Oklahoma City bombing; Structural analysis; World Trade Center bombing.

Bombings

Definition: Incidents involving weapons that explode and release destructive shock waves and shrapnel that damage buildings and other property and injure and kill people.

Significance: In modern society, law-enforcement agencies are increasingly faced with the investigation of crimes involving explosives. Forensic scientists and law-enforcement officers use a number of different techniques to detect explosives before they can be used in bombs, and, after bombings have taken place, they examine the resulting debris for evidence that can link the explosions to the perpetrators.

Bombs create destructive shock waves, flying shrapnel, and intense heat and flame capable of destroying objects and killing people. As the materials needed for bomb making (especially such dual-use products as fertilizer) and the technical information needed to construct and detonate bombs have become more readily available than in the past, in large part because of the advent of the Internet, bombings have increased in frequency. The availability of potentially explosive chemicals, dynamite, and, in some countries, military explosives has provided the criminally disposed with the ability to wield very destructive and deadly weapons. Furthermore, the news coverage that inevitably follows bombing incidents may inadvertently embolden those so inclined to carry out additional bombing attacks.

Types of Explosives

Every bomb has an igniter, a primer or detonator, and a main charge. Most kinds of bombs are confined within some sort of shell, such as a pipe or a box. The igniter may be either a fuse or a primer. A primer is a small explosive charge that may be ignited by flame, electrical spark, or friction. When the primer is ignited, it explodes, causing the bomb's main charge to detonate. A firearm cartridge, for example, is an explosive that is set off when a shock-sensitive primer located at one end of the cartridge is struck by a pin. When a gun's firing pin strikes the primer on a firearm cartridge, the primer explodes and ignites the main charge, the smokeless black powder located behind the bullet. The explosion of the main charge is what forces the bullet to travel through the barrel of the gun and downrange.

The speed at which an explosive detonates determines whether it is classified as a low or high explosive. Low explosives, such as black and smokeless powder, are typically used as propellants for ammunition and rockets because they burn relatively slowly. Most homemade bombs tend to be low explosives because they are often constructed with black powder, which is easy to obtain from gun stores. High explosives such as dynamite and C-4, in contrast, produce more of a smashing, shattering effect.

High explosives may be divided into two types, primary and secondary. Primary high explosives tend to be sensitive to heat, shock, and friction and detonate very easily. Because of this, they are generally used in primer devices to set off larger, secondary explosives. Secondary high explosives tend to be relatively insensitive to heat, shock, and friction and usually require a primary charge explosion to detonate. In most cases, this involves the use of a blasting cap, initiated by a burning fuse or by an electrical current. Homemade bombs are usually initiated by an electronic blasting cap wired to a battery that is switched on by a device such as a clock, mercury switch, vehicle ignition switch, or cell phone ring.

Dynamite is a high explosive known for producing a quick shattering effect. It is mainly used for construction, mining, and demolition. When it was first developed in 1866, it was made from nitroglycerin, diatomaceous earth (soft, chalklike sedimentary rock), and sodium carbonate wrapped in distinctive red paper. The "kick" that is produced by dynamite is derived from the nitroglycerin it contains. Nitroglycerin is a very powerful shock-sensitive explosive, meaning that vibrations may cause it to explode. This makes it very dangerous to handle. However, when diatomaceous earth and sodium carbonate are combined with nitroglycerin to create dynamite, the nitroglycerin becomes more stable and safe to handle.

The explosive strength of a stick of dynamite is designated by the percentage of nitroglycerin it contains; for example, in a 60 percent grade stick of dynamite, 60 percent of the stick consists of nitroglycerin. The actual blasting power of a stick of dynamite, however, is not in proportion to its grade percentage markings. That is, a 60 percent grade stick of dynamite is not three times as powerful as a 20 percent grade stick; it is only about one and one-half times as strong.

By the early years of the twenty-first century, the use of nitroglycerin-based dynamite had all but disappeared. Dynamite was replaced by ammonium nitrate-based explosives, which are more stable and useful in wet conditions. Ammonium nitrate/fuel oil (ANFO) explosives are high explosives that are often used in the mining and construction industries. They consist of ammonium nitrate soaked in fuel oil and require a primer explosive to detonate. About 80 percent of the explosives used in North America are ANFO explosives. The availability of ammonium nitrate in the form of fertilizer makes it a readily obtainable ingredient for homemade explosives, and its use in bombs has become a trademark of various criminal and terrorist groups around the globe. Timothy McVeigh used a variation of an ANFO bomb when he attacked the Alfred P. Murrah Federal Building in Oklahoma City in 1995, killing 168 people and injuring hundreds more.

The explosive known as RDX is currently the high explosive most commonly used by the U.S. military. It is second in strength only to nitroglycerin. RDX is widely used in plastic explosives, detonators, artillery rounds, Claymore mines, and demolition kits. It is combined with plasticizers to make C-4, which is a pliable, puttylike explosive that can be molded into a variety of shapes and has a long shelf life. It is believed that al-Qaeda used C-4 in 1996 to blow up the Khobar Towers (a military housing complex) in Saudi Arabia and again in 2000 in its attack on the military destroyer the USS *Cole*. In the Khobar Towers bombing, nineteen U.S. service personnel were killed. In the bombing of the *Cole*, seventeen sailors were killed and thirty-nine others were injured.

Triacetone triperoxide (TATP) is an explosive created through the combination of the common ingredients of acetone and hydrogen peroxide with a catalyst such as hydrochloric acid. Persons who are so inclined can purchase its base ingredients (drain cleaner, bleach, and acetone) easily and without attracting suspicion, and instructions for making TATP can be found on the Internet. In its finished form, this explosive is almost undetectable by substance-detection dogs or by conventional bomb-detection systems. Because of this, the Palestinian militant organization Hamas has favored TATP for use by suicide bombers sent into Israel. Al-Qaeda has also used it when conducting terror missions abroad. TATP was included as a trigger in the shoe bomb that Richard Reid intended to detonate on a flight from Paris, France, to Miami, Florida, in 2001. It is also the type of explosive that was used in the 2005 public transit bombings in London, England, which killed fifty-two commuters and injured seven hundred people. The drawback of TATP, from a criminal or terrorist's point of view, is that it is highly unstable and sensitive to heat and friction.

Detecting Explosives at Airports

Terrorists around the globe have successfully used explosives to end lives and undermine public confidence in air travel. In response to such threats, airports and their cargo terminals employ a number of different techniques and technologies to aid in the identification and interdiction of explosives.

X-ray machines are used to scan large numbers of people and items to identify hidden suspicious shapes that could indicate the presence of bombs. Because it is possible that such explosive devices could be hidden inside electronic equipment, such as laptop computers, security measures often include chemical analyses. In such a test, a swab is wiped across a piece of electronic equipment, such as a laptop, and is then placed into a device that heats it up and performs a spectrographic analysis of the resulting vapors. The machine searches for traces of nitrogen, which is found in the majority of explosives.

Trace-detection machines (sniffers), which look like metal detectors, search for explosives

Investigators carefully sift for evidence in rubble on the ground at the site of the Alfred P. Murrah Federal Building bombing in Oklahoma City in April, 1995. *(AP/Wide World Photos)* by blowing air over persons or their luggage. The blowing air releases particles from the surface of the person or object of interest, and the machine then processes the air and analyzes it for traces of known explosives. Airport security measures also include the use of dogs that have been trained to alert their handlers by sitting near any objects or persons that give off the telltale odors of explosives.

Responding to Bomb Threats

Most bomb threats turn out to be nothing more than prank phone calls from misguided individuals who take pleasure in causing others fear and inconvenience. Unfortunately, those whose true intent is to kill, maim, and destroy are unlikely to notify their intended victims prior to the detonation of their bombs. When a bombing does occur, individuals who have specialized training in bomb disposal, bomb-site investigation, forensic analysis, and criminal investigation work together to determine what happened so that those who are responsible may be apprehended.

When a bomb threat is called in, the authorities who are given the task of responding to the scene (the first responders) need to enlist the assistance of people who are familiar with the area, such as building managers and employees, because such persons may be more adept at determining whether something is out of place than someone who is not as familiar with the surroundings. Those participating in a search for a bomb must turn off all their radios and transmitters before they begin the search, because the signals these devices emit may set off an explosion. When searchers first enter a room in a location where a bomb may have been planted, they pay special attention to items such as unattended bags, boxes, baby carriers, briefcases, trash cans, flowerpots, incoming mail, and panels in the ceiling that may be easily pushed up. Experts also recommend that when searchers enter a room, they should stand quietly in the room's center, close their eyes for several seconds, and listen. Unusual noises may indicate the location of a bomb.

If a bomb is found, the searchers are careful

Bomb Scene Equipment

Because first responders and investigators may not know the details of a situation involving explosives until they arrive at the scene, prior preparation is vital. The following is a list of the kinds of tools and other equipment frequently used by investigative teams at bombing scenes. This list is not exhaustive, and all of the items listed may be not applicable to every situation.

- First-aid kit
- Biohazard materials (bags, tags, labels)
- Respiratory equipment
- Hard hats, safety glasses, protective safety boots, and kneepads
- Protective outerwear (disposable suits, shoe covers)
- Heavy, disposable cotton gloves
- Barrier tape
- Flashlights, flares, and auxiliary lighting
- Hand tools (rakes, shovels, trowels, screwdrivers, crowbars, hammers)
- Brushes and brooms
- Ladders
- Sifters/screens
- Swabbing kits
- Vacuum
- Evidence collection kits
- Writing equipment (notebooks, pens, permanent markers)
- Drawing equipment (sketchbooks, pencils)
- Measuring equipment (tape measure, tape wheel)
- Photography and video equipment
- Computer and computer-aided design program
- Consent-to-search forms
- Audio recorders
- Evidence flags or cones, placards, and tags
- Bags and corrugated or fiberboard boxes
- Chemical test kits and vapor detectors
- Trace explosives detectors (sniffers) and detection canines

not to touch it, because contact may cause it to explode. Only bomb disposal personnel are tasked with handling any suspected devices that are located. Bomb squads in larger police departments use robots to approach and detonate certain bombs. After a bomb is found, the area is cleared and the crime scene is secured to prevent further contamination. Emergency services are requested from bomb technicians, firefighters, emergency medical personnel, and law-enforcement officers, and a search for secondary explosive devices is then conducted.

Investigating Bomb Explosions

When an explosion occurs, law-enforcement personnel must identify scene hazards such as the possibility of building collapse, hazardous chemicals, and secondary explosives. Bombing scenes may contain secondary explosive devices specifically designed to kill or maim public safety responders. If a suspected secondary device is located, the area must be evacuated immediately and bomb disposal personnel must be contacted. As soon as conditions permit, investigators need to establish a security perimeter that restricts access into and out of the scene; they also begin documenting the scene (taking notes, identifying witnesses, and videotaping bystanders).

During an initial scene walk-through, investigators pay special attention to various safety concerns, such as structural damage, the possibility of the presence of secondary devices and unconsumed explosive materials, failed utilities, and hazardous materials. Following this walk-through, the investigators meet with available emergency responders and investigative personnel to determine what resources, equipment, and additional personnel may be needed.

The search for evidence typically starts at the seat of the blast, which is usually indicated by a crater, and spirals out in ever-increasing circles. The scene is documented with both written and photographic records before anything is removed or disturbed. The material at the scene is then sorted in an attempt to recover the materials that were used to construct the bomb. All of the personnel involved in the search must wear disposable gloves, shoe covers, and overalls so that they do not contaminate evidence and compromise the investigation.

To uncover clues to the construction and thus the origin of a bomb, investigators usually sift material from the blast scene through a series of increasingly finer mesh screens to collect portions of the explosive device for analysis. For instance, if a pipe bomb was used, a forensic investigator may find the bomb's end cap; in many cases, this part of a pipe bomb will retain small specks of unexploded material that becomes trapped in the threading. These small specks of explosive may then be used to trace the origins of the materials used to construct the bomb. Investigative leads may also develop from tool marks left on a pipe from a vise used in cutting and threading. Other clues that may aid an investigation include the type of wire that was used, the type of timing device used, the particular type of wrapper paper (indicating the origin of a piece of dynamite), or a unique method of bomb construction.

The materials from the scene that are collected for laboratory examination are placed in sealed containers and labeled. Soil and other soft materials are placed in metal containers or plastic bags. Evidence samples that are packaged in plastic bags must not be kept next to each other, because it has been demonstrated that some explosives can diffuse through plastic and contaminate nearby containers.

Bombing victims should also be examined for evidence, as bomb component fragments may be found on or in their clothing or bodies. Autopsies should include full-body X rays.

When the debris evidence from a bomb scene arrives at the laboratory, it is examined microscopically, and an acetone wash is often used to extract explosives from the debris. Chromatographic techniques (which can separate and identify the components in chemical mixtures) may then be used to determine the types of explosives that were used.

Explosive residues are often collected at bomb scenes with a portable machine called an ion mobility spectrometer (IMS). The IMS uses a vacuum to suck in explosive residues from surfaces. Depending on the types of surfaces found at a bomb scene, however, investigators may collect explosive residues more efficiently by

Explosive Incidents Investigated by ATF, 2000-2003

	2000	*2001*	*2002*	*2003*
Incidents	807	763	711	386
Persons injured	81	98	80	55
Persons killed	19	12	13	7
Damage	$5,634,681	$7,279,023	$5,153,448	$267,000

Source: Bureau of Alcohol, Tobacco, Firearms and Explosives.

wiping the surfaces down with paper disks and then using the IMS to collect the residues off the disks. Once the residues are in the IMS, they are vaporized into electronically charged molecules or ions. Identification of the size and structure of the molecules and ions enables investigators to determine the types of explosives that were detonated at the bomb scene.

Investigators often examine bomb blast craters using an ultraviolet light and magnetic probe in the hope of finding small particles, called taggants, that are sometimes put into explosives by manufacturers. Taggants are tiny color-coded magnetic fluorescent chips the size of sand grains. The color of the fluorescent chips indicates where an explosive was made and when it was produced. Switzerland requires all explosives manufacturers in that nation to add taggants to their products. The U.S. government has not taken such a step, but increasing concerns about terrorism may eventually result in a similar requirement for American manufacturers.

Daniel Pontzer

Further Reading

Bennett, Wayne W., and Kären M. Hess. *Criminal Investigation*. 8th ed. Belmont, Calif.: Wadsworth/Thomson Learning, 2007. Introduces the challenges encountered by criminal investigators and discusses investigators' basic responsibilities. Details the work involved in the investigation of violent crimes such as death, assault, rape, and robbery as well as property offenses such as burglary, arson, and crimes using explosives.

Gaensslen, R. E., Howard A. Harris, and Henry C. Lee. *Introduction to Forensic Science and Criminalistics*. New York: McGraw-Hill, 2008. Addresses the types of forensic science techniques used in crime laboratories in criminal cases and by private examiners in civil cases. Discusses various crime scene procedures and analyses, physical pattern evidence, biological evidence, and chemical and materials evidence.

Martin, Gus. *Essentials of Terrorism: Concepts and Controversies*. Thousand Oaks, Calif.: Sage, 2008. Addresses the topic of modern-day terrorism by reviewing different types of terrorism and the nations, movements, and individuals who have engaged in terrorist violence.

National Institute of Justice. *A Guide for Explosion and Bombing Scene Investigation*. Washington, D.C.: Author, 2000. Outlines the tasks that investigators should consider at every explosion scene and provides guidance on the procurement of equipment and tools, prioritization of initial response efforts, evaluation of the scene, documentation of the scene, and processing of evidence at the scene.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007. Comprehensive introductory textbook addresses the role of science in the criminal justice system. Includes in-depth discussion of the technologies that law-enforcement agencies use to apprehend criminals and the use of trace evidence to link perpetrators to crime scenes.

Simonsen, Clifford E., and Jeremy R. Spindlove. *Terrorism Today: The Past, the Players, the Future*. 3d ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007. Provides background on the history and legal issues associ-

ated with terrorism and discusses the types of terrorism and terrorist groups found around the world. Includes suggestions regarding counterterrorism tactics and speculation on the directions terrorism may take in the future.

Trimm, Harold H. *Forensics the Easy Way*. Hauppauge, N.Y.: Barron's, 2005. Presents information on the applications of physics and chemistry in the criminal justice system by focusing on forensics, including discussion of physical evidence, body fluids, explosives and incendiaries, firearms, fingerprints, and DNA evidence.

See also: Atomic absorption spectrophotometry; Blast seat; Bomb damage assessment; Bureau of Alcohol, Tobacco, Firearms and Explosives; Canine substance detection; Chromatography; Driving injuries; Illicit substances; Improvised explosive devices; Mass spectrometry; National Church Arson Task Force; Oklahoma City bombing; Unabomber case; World Trade Center bombing.

Borderline personality disorder

Definition: Disorder in which personality characteristics are maladaptive in nature, including chronic difficulties in maintaining stable interpersonal relationships, severe mood swings that are reactive in nature, impulsivity, hostility, feelings of emptiness, and propensity to engage in self-harm behaviors.

Significance: Persons with borderline personality disorder are at high risk for engaging in criminal and antisocial behavior and tend to be overrepresented in prison populations. Because of their often violent and aggressive demeanor, such individuals are extremely disruptive to forensic settings and tend to pose additional risks to themselves and others when placed within these environments.

It has been estimated that from 1 to 2 percent of the world's population qualify for a diagnosis of borderline personality disorder (BPD) based on the guidelines in the fourth edition, text revision, of the American Psychiatric Association's *Diagnostic and Statistical Manual of Mental Disorders* (*DSM-IV-TR*). A disproportionate number of the people diagnosed with BPD found in psychiatric inpatient, psychiatric outpatient, and forensic settings are female.

Individuals with BPD exhibit enduring patterns of emotional and behavioral instability. The pervasive and often inflexible nature of their behavior can result in actions that are harmful and, sometimes, criminal in nature. These erratic behaviors are believed to result from a dangerous combination of extreme affective instability and high levels of impulsivity. Although self-destructive in nature, these behaviors—including reckless driving, sexual promiscuity, substance abuse, and aggressive acts—may result in legal repercussions. People with BPD are highly likely to exhibit symptoms of additional psychopathology and often warrant additional comorbid diagnoses of depression, anxiety, and other Axis II personality disorders (disorders classified in the *DSM-IV-TR* as underlying pervasive or personality conditions), most predominantly of the histrionic or antisocial types.

An intense fear of abandonment, often stemming from psychosocial factors during development (such as sexual abuse, neglect, separation or loss, or parental psychopathology), is believed to contribute to the manipulative behaviors exhibited by persons with BPD. To avoid either real or imagined abandonment, persons with BPD put forth significant effort to thwart others' attempts to leave them. In these situations, they may engage in flagrantly manipulative behaviors, including significant threats of self-harm or attempts at suicide. These behaviors, although intended to keep others from departing, can result in life-threatening or lethal injuries. In addition to such self-harm behaviors, persons with BPD often engage in self-mutilating acts such as repetitive cutting or burning; most often, they perform these acts on their forearms or legs, but sometimes they may mutilate their faces, chests, or genitals.

In addition to exhibiting unstable behavior, individuals with BPD tend to have extreme difficulty with interpersonal relationships, self-image, and moods. They often report histories of intense but stormy relationships, typically involving severe fluctuations between overidealization of friends or lovers and bitter disappointment, frustration, and disillusionment with these persons, which, at times, may lead to violence. These drastic mood shifts and difficulties modulating and controlling anger can lead individuals with BPD to display intense behavioral and emotional outbursts with little provocation.

Neva E. J. Sanders-Dewey and Seth G. Dewey

Further Reading

Friedel, Robert O. *Borderline Personality Disorder Demystified: An Essential Guide for Understanding and Living with BPD*. New York: Marlowe, 2004.

Kreisman, Jerold J., and Hal Straus. *Sometimes I Act Crazy: Living with Borderline Personality Disorder*. Hoboken, N.J.: John Wiley & Sons, 2004.

Mason, Paul T., and Randi Kreger. *Stop Walking on Eggshells: Taking Your Life Back When Someone You Care About Has Borderline Personality Disorder*. Oakland, Calif.: New Harbinger, 1998.

See also: ALI standard; Child abuse; *Diagnostic and Statistical Manual of Mental Disorders*; Forensic psychiatry; Guilty but mentally ill plea; Insanity defense; Irresistible impulse rule; Minnesota Multiphasic Personality Inventory; Psychopathic personality disorder; Suicide.

Bosnian war victim identification.

See Croatian and Bosnian war victim identification

Botulinum toxin

Definition: Highly toxic substance produced by the *Clostridium botulinum* bacterium that targets nerve tissue and blocks neuromuscular transmission of impulses in the body, causing the paralytic disease botulism.

Significance: Botulinum toxin is one of the most lethal known toxic substances; a few grams of the toxin introduced into the food supply could kill millions of people, making it an attractive agent for potential use as a biological weapon. In addition to that possibility, nonintentional poisonings sometimes occur through the consumption of food containing the toxin or through contamination of wounds with the toxin. Whenever botulinum toxin is suspected in cases of poisoning, law-enforcement agencies are concerned with identifying the toxin and its source.

Although the possibility that botulinum toxin could be used in biological warfare has been acknowledged for many years, no uses of the poison as a weapon have been reported in any major wars. Despite the Biological Weapons Convention of 1972, however, it is generally believed that many countries have stockpiles of the *Clostridium botulinum* bacterium and toxin as part of their biological warfare programs.

The most common form of botulinum poisoning occurs through the ingestion of foods containing the toxin. Food products contaminated with *C. botulinum* spores that are stored at room temperature can cause poisoning if they are consumed without first being adequately heated. Canned cheeses, ham, and sausage are common sources of the toxin. In a typical incident that took place in Italy in 1996, eight people contracted the poison by eating commercial cream cheese. One died, and the others had prolonged medical recoveries. In a 1995 incident in Canada, a sixteen-year-old girl was poisoned when she ate smoked fish. She died a few months later despite having received intensive medical treatment. In September, 2006, four cases of botulism in the United States and two cases in Canada were traced to the consumption of contaminated carrot juice.

Mechanism of Toxicity

The toxin, which was first isolated from *C. botulinum* in 1944 by Edward Schantz, must come into contact with nerve tissue to cause damage. The toxin attaches to the axon terminal of nerve endings, where it blocks the release of the principal neurotransmitter in the body, acetylcholine. This blockage prevents transmission of nerve impulses, resulting in loss of muscle contractility and flaccid paralysis.

In food-related poisoning, symptoms occur six to thirty-six hours after ingestion of food containing the toxin. Symptoms include excessive dry mouth, diarrhea, and vomiting. These may be followed by blurred vision, droopy eyelids, generalized muscle weakness, and progressive difficulty in breathing. Death may occur as a result of paralysis of the respiratory muscles. Symptoms of botulinum poisoning may occur more rapidly if the toxin is inhaled rather than ingested.

Medical and Cosmetic Uses

Some medical treatments have been developed that take advantage of the botulinum toxin's neuromuscular blocking action; tiny concentrations of the toxin are used, for example, in the treatment of involuntary eye muscle contractions (blepharospasm). The toxin is also used in the treatment of migraine headaches and cervical dystonia, a neuromuscular condition involving the head and neck. Another important medical use of the toxin is in the treatment of excessive underarm perspiration (severe primary axillary hyperhidrosis). The toxin has also been employed at times in the treatment of the following ailments and symptoms, although it is not approved by the U.S. Food and Drug Administration (FDA) for these uses: overactive bladder, anal fissure, stroke, multiple sclerosis, Parkinson's disease, excessive salivation, neurological complications of diabetes mellitus, and muscle problems affecting the limbs, face, jaw, and vocal cords.

Commercial botulinum toxins, marketed under the names Botox and Dysport, among others, are used cosmetically to remove facial wrinkles and improve facial appearance. The toxin works on wrinkle lines that have been formed in the upper part of the face, particularly the forehead and around the eyes. Because very low concentrations of the toxin are used in these cosmetic preparations, treatment is usually safe. However, occasional adverse effects—such as allergic reactions and paralysis of the wrong muscles—have been reported. Four cases of poisoning caused by cosmetic use of a type of botulinum toxin that had not been approved by the FDA were reported in Florida in 2004.

Investigation of Botulinum Poisoning

When deaths or illnesses are suspected to be attributable to botulinum toxin poisoning, both forensic scientists and public health experts are usually involved in investigating the incidents. The immediate goal in any case is to identify the source of the toxin as quickly as possible to prevent any further harm. In the United States, law-enforcement agencies are required to re-

Diagnosing Botulism

The U.S. Centers for Disease Control and Prevention (CDC) provides this information on the diagnosis of botulinum poisoning.

Physicians may consider the diagnosis if the patient's history and physical examination suggest botulism. However, these clues are usually not enough to allow a diagnosis of botulism. Other diseases such as Guillain-Barré syndrome, stroke, and myasthenia gravis can appear similar to botulism, and special tests may be needed to exclude these other conditions. These tests may include a brain scan, spinal fluid examination, nerve conduction test (electromyography, or EMG), and a tensilon test for myasthenia gravis. The most direct way to confirm the diagnosis is to demonstrate the botulinum toxin in the patient's serum or stool by injecting serum or stool into mice and looking for signs of botulism. The bacteria can also be isolated from the stool of persons with foodborne and infant botulism. These tests can be performed at some state health department laboratories and at CDC.

A lab technician with the Centers for Disease Control and Prevention grinds food with a mortar and pestle to enable the extraction of botulinum toxin. The CDC treats every case of food-borne botulism as a public health emergency. *(Centers for Disease Control and Prevention)*

port all cases of such poisoning to the Centers for Disease Control and Prevention (CDC).

Evidence at the suspected poisoning site must be preserved so that it can be analyzed for clues that may point to the source of the toxin. Apart from food, botulinum toxin and the toxin-producing *C. botulinum* bacterium may be found in the blood and feces of patients suffering from botulinum poisoning. In some fatal cases, forensic examination of tissue samples and suspensions of body fluids have been used to demonstrate the presence of the toxin even after advanced putrefaction.

Edward C. Nwanegbo

Further Reading

Balkin, Karen F., ed. *Food-Borne Illnesses*. San Diego, Calif.: Greenhaven Press, 2004. Collection of essays offers a variety of perspectives on issues of food safety.

Breeze, Roger G., Bruce Budowle, and Steven E. Schutzer, eds. *Microbial Forensics*. Burlington, Mass.: Elsevier Academic Press, 2005. Details the importance of forensic microbiology and discusses its uses. Includes discussion of botulism.

Scott, Elizabeth, and Paul Sockett. *How to Prevent Food Poisoning: A Practical Guide to Safe Cooking, Eating, and Food Handling*. Hoboken, N.J.: John Wiley & Sons, 1998. Provides thorough information on the causes and symptoms of food poisoning, including botulism.

Smith, Louis D. S., and Hiroshi Sugiyama. *Botulism: The Organism, Its Toxins, the Disease*. 2d ed. Springfield, Ill.: Charles C Thomas, 1988. Textbook covers virtually every aspect of botulism.

Tucker, Jonathan B., ed. *Toxic Terror: Assessing Terrorist Use of Chemical and Biological Weapons*. Cambridge, Mass.: MIT Press, 2000. Collection of case studies discusses var-

ious uses of chemical and biological agents by terrorist groups. Identifies terrorists' patterns of behavior and discusses strategies to combat them.

See also: Biological terrorism; Biological Weapons Convention of 1972; Chemical agents; Chemical terrorism; Food poisoning; Food supply protection; Forensic toxicology; Poisons and antidotes.

Bovine spongiform encephalopathy. *See* Mad cow disease investigation

Brain-wave scanners

Definition: Instruments used to map regions of the brain or to measure brain responses to stimuli.

Significance: Brain-wave scanners can be used to monitor brain activity to determine whether or not a person is telling the truth and to perform postmortem mapping of the brain to determine whether death may have resulted from trauma to the head.

Brain-wave scanners are used to map activity in the brain. The patterns seen in the three-dimensional images produced by brain-wave scanning are indicative of whether or not a person is lying. The images are formed using magnetic resonance imaging (MRI). When experts examine the images to determine which areas of a person's brain become active in response to questions, pictures, or other stimuli, this method is referred to as functional magnetic resonance imaging (fMRI). The subject is placed inside the scanning machine and allowed to interact with a computer screen to answer specific questions related to a crime. The MRI machine is interfaced with special computer software that recognizes specific brain patterns. When a person is telling a lie, the brain has to expend more energy than it does when the person is telling the truth. Even when a lie has been rehearsed in the mind of the subject, the subject uses more brain energy to think beyond the truth and access the lie. The extra brain activity shows up as a "bright" region on the brain-scanned image. In tested case studies, the fMRI method has shown an accuracy of more than 90 percent in detecting lies.

Although still undergoing development and refinement, the fMRI technique has many possible forensic applications. These include situations that involve libel, slander, fraud, or terrorist activities; the technology may also be useful in the security screening of potential employees for important government positions. The technique might be used in the interrogation of criminal suspects or in the assessment of the intentions of prisoners before they are released. Because individuals involved in terrorist plots have detailed knowledge of plans and activities that innocent persons do not have, brain scans might be used to identify persons who have terrorist training and knowledge of terrorist activities.

The primary ethical issue that needs to be addressed in regard to the use of brain-wave scanners as lie detectors is that of the invasion of personal privacy. This problem may be resolved by safeguards that ensure that subjects are fully informed about brain-wave scanning and agree to be examined in this way.

For examination of the brain after death, postmortem multislice computed tomography (PMSCT) provides detailed in situ images of the brain. These are useful for screening corpses for foreign matter in the brain or for identifying whether head trauma resulting in skull fractures or cerebral hemorrhaging was the cause of death. Both two-dimensional cross-sectional images and postprocessed three-dimensional images of the skull can be made. Postmortem computed tomographic (PMCT) scans of an infant's brain can reveal signs that are indicative of shaken baby syndrome. This type of child abuse is accompanied by subdural hemorrhage of ruptured cerebral bridging veins, which can be identified in PMCT images but is difficult, if not impossible, to detect in a typical autopsy.

Alvin K. Benson

Further Reading

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007.

Tilstone, William J., Kathleen A. Savage, and Leigh A. Clark. *Forensic Science: An Encyclopedia of History, Methods, and Techniques*. Santa Barbara, Calif.: ABC-CLIO, 2006.

White, Peter, ed. *Crime Scene to Court: The Essentials of Forensic Science*. 2d ed. Cambridge, England: Royal Society of Chemistry, 2004.

See also: Biometric identification systems; Forensic psychiatry; Forensic psychology; Interrogation; Nervous system; Polygraph analysis; Psychological autopsy.

Breathalyzer

Definition: Device used to measure ethanol in the breath of a subject as an indication of blood alcohol concentration. Breathalyzer is also the trade name of a series of instruments designed to analyze breath alcohol.

Significance: Police officers commonly conduct analyses of the breath of drivers suspected of driving under the influence of alcohol, and Breathalyzer results are often used as grounds for arrest in cases of impaired driving. Such analyses are increasingly used also in workplace drug-testing and research applications. The accuracy and precision of the measurements produced by Breathalyzer testing, which are related to physiological and instrumental variables, are often debated in court.

A man blows into a portable device that measures ethanol in the breath to indicate blood alcohol concentration. *(© iStockphoto.com/Marjan Laznik)*

Police officers often ask drivers whom they suspect are under the influence of alcohol to provide samples of their breath by blowing into instruments—at the roadside or at police detachments—that can determine the concentration of alcohol in their breath. Such breath analysis is valuable because the sample collection is minimally invasive, especially in comparison with direct analysis of blood. Breath samples are analyzed upon collection, which establishes sample continuity. When the results are properly documented, and when the instrument is properly calibrated and in good working order, the measurements are typically used as evidence in court.

The instruments used in breath alcohol analysis are based on a variety of designs. The Breathalyzer 900/900A uses oxidation of ethyl alcohol (ethanol) in a fixed volume of breath by potassium dichromate in a standard solution to cause a shift in the solution absorbance spectrum (that is, a color change); the change in absorbance is correlated with the alcohol concentration in the breath sample. Newer instrument designs typically rely on ethanol detection based on absorbance of infrared radiation at selected wavelengths or on electrochemical reaction of the ethanol in the breath sample. Some instruments are portable, and small, handheld units are often used as screening devices; that is, law-enforcement personnel use them to determine whether alcohol is present in subjects within a concentration range that warrants further evidentiary breath testing. Different designs often vary in terms of accuracy and in their susceptibility to other interfering compounds in the breath.

Breath alcohol concentration (BrAC) is correlated with blood alcohol concentration (BAC). Henry's law states that, at a given temperature, the ratio of the concentration of a volatile substance in solution to that of the substance in the vapor above the solution is fixed. Physiologically, such a system exists in the capillaries within the alveoli (air sacs) of the lungs. Volatile compounds, including alcohol, are exchanged between the alveolar air and the blood within these capillaries. BAC is thus determined by multiplication of the measured BrAC by this ratio, termed the blood/breath ratio (BBR). Reported BBR averages typically fall within the range 2,200-2,500.

To be detected in the breath, a compound must be sufficiently volatile, present at sufficient blood concentrations, and measurable by the detection scheme of the instrument. To characterize potential interferences, the response of evidentiary instruments to volatile compounds (such as acetone, isopropanol, methanol, and toluene) should be measured in vitro at toxicologically relevant fluid concentrations (that is, those associated with occupational or environmental exposure, a disease state such as diabetes mellitus, or nonfatal substance abuse). The influence of such compounds on BrAC measurements depends on their chemical properties and the detection scheme of the instrument. Further safeguards against falsely elevated results are provided by careful observation of the subject by the test administrator and by the collection of a detailed history of the subject being tested.

James Watterson

Further Reading

Garriott, James C., ed. *Medical-Legal Aspects of Alcohol*. 4th ed. Tucson, Ariz.: Lawyers & Judges Publishing, 2003.

Karch, Steven B., ed. *Forensic Issues in Alcohol Testing*. Boca Raton, Fla.: CRC Press, 2007.

Levine, Barry, ed. *Principles of Forensic Toxicology*. 2d ed., rev. Washington, D.C.: American Association for Clinical Chemistry, 2006.

See also: Alcohol-related offenses; Analytical instrumentation; Chain of custody; Drug and alcohol evidence rules; Forensic toxicology; Infrared detection devices; Sobriety testing; Toxicological analysis.

Brockovich-PG&E case

Date: Settled out of court in 1996

The Event: A law firm filing clerk instigated an investigation into the contamination of a small California town's water supply with a chemical toxin known as chromium 6 by the Pacific Gas and Electric Company (PG&E) that led to the largest settlement ever paid in a lawsuit in the United States up to that time.

Significance: Because the terms of the PG&E settlement have never been made public, details of the forensic investigation leading to that settlement are mostly unknown. Nevertheless, the commercial and critical success of the motion picture *Erin Brockovich* (2000) helped elevate public awareness of the importance of forensic science in identifying toxic pollutants in the environment. The case itself was regarded as a precedent for future litigation for similar cases.

Thanks to a major Hollywood film using her name for its title, Erin Brockovich is indelibly associated with one of the biggest water-contamination cases in U.S. history. While working as a filing clerk in a Southern California law firm, she investigated medical records connected with a real estate case and found evidence that a PG&E facility connected with a natural gas pipeline had contaminated the drinking water of the tiny Mojave Desert community of Hinkley, California, from the 1960's through the 1980's. Brockovich's investigation helped trigger the class-action suit brought against PG&E, and she received a significant share of the money that came out of the case's settlement. However, much of the impetus for the case was provided by residents of Hinkley themselves. Brockovich's name is closely tied to the case largely because of the unusual circumstances of her personal involvement, which was magnified by the film made about the case.

Erin Brockovich during an appearance at California's De Anza College, where she spoke on behalf of the Silicon Valley Toxics Coalition in late 2000. *(AP/Wide World Photos)*

Brockovich's interest in environment cases began after she had been seriously injured in a traffic accident in Nevada. To represent her interests in the legal suit emerging from that accident, she engaged the Thousand Oaks, California, law firm of Masry & Vititoe. Soon afterward, the firm hired her to work as a file clerk, although she was not a college graduate and had no legal training.

While filing papers for a real estate case concerning the community of Hinkley during the early 1990's, Brockovich found information in medical records of Hinkley residents that piqued her curiosity. With her employer's permission, she began researching the matter. Her investigation found that the health of many people who lived in and around Hinkley during the three preceding decades had been damaged by exposure to hexavalent chromium, also known as chromium 6, a suspected carcinogen that had leaked into the groundwater from PG&E's nearby repressurization station. Brockovich's investigation eventually led to a class-action lawsuit against PG&E, which settled most of the cases out of court by paying $333 million in damages to more than six hundred Hinkley residents.

Background

Hinkley, California, is the site of a repressurization, or compressor, station built by PG&E in 1952 to help push natural gas through a long pipeline that connects Texas with Northern California. As gas moves through pipelines, friction causes it to lose the pressure it requires to keep it moving. Compressor stations like that of Hinkley raise the pressure within pipelines to facilitate the transmission of the gas. The gas compressors themselves require cooling, which is done with oil and water. To prevent rust from corroding the cooling system PG&E, PG&E put chromium 6 in the water. Chromium 6 is one of the cheapest and most efficient corrosion inhibitors but is also a highly toxic chemical that many scientists believe is a carcinogen. Between 1952 and 1966 alone, the runoff of fluids from Hinkley's pumping station's cooling system poured about 370 million gallons of chromium-tainted water into the open and unlined ponds near the community.

The Complex Geography of PG&E

The Brockovich-PG&E case revolved around the Southern California community of Hinkley, a tiny, unincorporated town about fourteen miles west of Barstow, on the fringes of the Mojave Desert. One of the largest energy utilities in the United States, PG&E services Northern California and supplies no energy to the southern part of the state. However, much of the natural gas that the company supplies to its Northern California customers comes to it from the Texas Panhandle, through long pipelines that pass through Southern California. To move the gas the great distances it must travel, PG&E maintains repressurization, or pumping, stations every several hundred miles. Leakage of water mixed with chromium 6, a rust inhibitor, from the station near Hinkley contaminated the town's underground water supplies.

During an environmental assessment in 1987, PG&E discovered that chromium 6 had entered Hinkley's groundwater supply and contaminated ten private drinking wells with concentrations of the chemical that exceeded the safety standard set by the state. In December, 1987, PG&E notified the Lahontan Regional Water Quality Board (LRWQB), which managed local water sources, about the contamination. The LRWQB quickly ordered PG&E to clean up the contaminated groundwater. PG&E began to comply, but, after spending $12.5 million on the effort, it approached the owners of three farms and ten houses drawing on the groundwater to inquire about buying their property. When the company offered to pay ten times fair market value for one property, other Hinkley residents became suspicious and took measures to file suit against PG&E.

For the first time, Hinkley residents began to believe that PG&E's use of chromium 6 was causing severe health problems within their town. Many residents cited such health problems as cancer, tumors, and birth defects. PG&E countered by arguing that the incident rates of the health problems the residents cited were not statistically significant in a population the size of Hinkley, even though residents were drinking, bathing in, and inhaling vapor from water contaminated with chromium 6 every day.

Eventually, with the help of Brockovich and the firm for which she worked, approximately 650 plaintiffs claimed that PG&E had failed to warn them adequately of the potential health risks associated with the chromium 6 exuded by the company's compressor plant. Their lawyers also alleged that two PG&E employees who had become whistle-blowers had been instructed by PG&E to dispose of all records from the Hinkley compressor station. The lawsuit the residents filed in 1993 was eventually settled for a $333 million payment in an undisclosed arbitration agreement. Other cash settlements were made over the ensuing decade.

PG&E's out-of-court settlement may have allowed the company to escape a finding of liability by a court, as settlement offers cannot be used in court as evidence of one party's wrongdoing. Because the arbitration was closed to the public, it remains unclear exactly what scientific proof of harm plaintiffs in the case presented or whether PG&E's actions actually damaged the health of Hinkley residents. However, in the public's perception, PG&E's $333 million settlement was equivalent to a conviction. PG&E's alleged cover-up of its activities and the sheer size of the settlement dramatically increased the intrigue of the story and helped to focus public attention on the potential dangers of chromium 6. Despite the size of the settlement, the Hinkley case and the dangers of chromium 6 might have been quietly forgotten, had the story not become the subject of a major Hollywood film.

The *Erin Brockovich* Film

Erin Brockovich's role in the PG&E case inspired a film in the year 2000 that used her name for its title and starred Julia Roberts as Brockovich. The film was an instant box-office hit and eventually grossed almost as much money as PG&E had paid out in its 1996 settlement. The film also received many major awards, including five Academy Award nominations, and won Roberts the Oscar for Best Actress in a Leading Role. More important, the film did a great deal to raise public awareness of the dangers of chromium 6 but did not do so without controversy. PG&E downplayed the film's message, claiming that the story had been highly dramatized for entertainment value, and it sent a memo to its employees warning them that not everything in the film was true. Regardless of the film's historical accuracy, however, it clearly increased public awareness of the importance of water quality and the role that forensic scientists play in uncovering environmental crimes. It also opened up discussion for proponents of more stringent water regulation by creating a media forum in which broader issues of water quality were addressed.

Erin Brockovich led to several concrete changes in government policies regarding environmental health. For example, the state of California passed two bills requiring assessment of chromium 6 levels in drinking water in its San Fernando Basin aquifer and setting limits for chromium 6 in drinking water sources. The federal government allocated $3 million for a treatment plant and technology to remove chromium 6 from drinking water.

Despite the critical acclaim and commercial success enjoyed by the film *Erin Brockovich*, the Brockovich-PG&E case has continued to generate controversy. Some scientists have concluded that chromium 6 is not, after all, a carcinogen. In 2001, the Chromate Toxicity Review Committee, a panel made up of university scientists that had been formed at the request of the California Environmental Protection Agency's Office of Environmental Health Hazard Assessment (OEHHA) concluded that there was no basis for concluding that chromium could cause cancer when ingested through water. Although the panel's report posed a serious challenge to future lawsuits concerning water contamination, some critics suggested that the panel's composition was suspect and its report had been skewed to protect the utility industry's interests.

Dante B. Gatmaytan

Further Reading

Banks, Sedina. "The 'Erin Brockovich Effect': How Media Shapes Toxics Policy." *Environs: Environmental Law and Policy Journal* 26 (2003): 219-251. Presents an interesting exploration of the impact of the film *Erin Brockovich* on public policy decisions.

Brockovich, Erin, and Marc Eliot. *Take It from Me: Life's a Struggle but You Can Win*. New York: McGraw-Hill, 2002. Motivational autobiography in which Brockovich recounts the events in her life that led to her involvement in the PG&E case.

Egilman, David. "Corporate Corruption of Science: The Case of Chromium (VI)." *International Journal of Occupational Environmental Health* 12 (2006): 169-176. Scholarly discussion addresses the controversy over the suspected health hazards of chromium 6.

Ellis, Erin Brockovich, and Dan Levine. "*Erin Brockovich*." *Conservation Matters* 8 (June 22, 2001): 12. Views the film *Erin Brockovich* in the broader context of the impacts on the environment of PG&E's practices.

Grant, Samantha. *"Erin Brockovich": The Shooting Script*. New York: Newmarket Press, 2001. Complete script of the Hollywood film based on the Brockovich-PG&E case; edited, with notes, by the original screenwriter, Samantha Grant.

Martens, Daniel L. "Chromium, Cancer, and Causation: Has a Death-Blow Been Dealt Chromium Cases in California?" *Natural Resources and Environment* 16 (2002): 264-266. Focuses on the possible legal impacts of the Brockovich case.

Pellerin, Cheryl, and Susan M. Booker. "Reflections on Hexavalent Chromium: Health Hazards of an Industrial Heavyweight." *Environmental Health Perspectives* 108 (2000): A402-A407. Discusses the potential hazard posed to the environment by chromium 6.

See also: Air and water purity; Chemical terrorism; Decontamination methods; Nuclear detection devices; Nuclear spectroscopy; Toxicological analysis.

Bubonic plague

Definition: Highly contagious human bacterial disease with a very high rate of mortality.

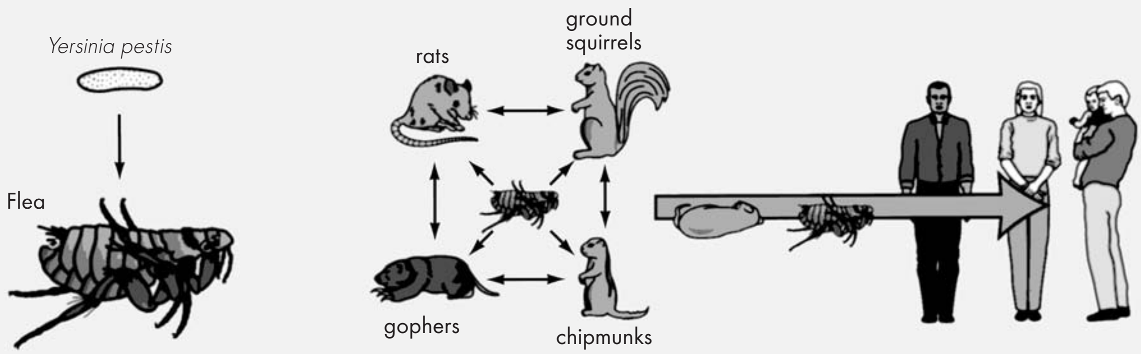
Significance: Natural outbreaks of bubonic plague still occur periodically, with an average of 18 cases in the United States and 1,666 cases worldwide per year. A larger cause for concern, however, is the possibility that weaponized plague bacteria could be used in biological terrorism.

Bubonic plague is caused by a gram-negative, facultative anaerobe bacterial species, *Yersinia pestis*, acting as an intracellular parasite. The disease is transmitted primarily by fleas from infected hosts, including more than two hundred species of rodents as well as domestic cats, dogs, rabbits, and even sheep or camels. Transmission may also occur through contact with infected bodily fluids or tissues as well as through aerosol exposure from a coughing patient. The bubonic plague is also known as the Black Death because it results in buboes, infected and inflamed lymph nodes that turn black as they become necrotic and hemorrhagic.

Three forms of plague are known. The skin form of the disease, bubonic plague, has a mortality rate of 50-90 percent if untreated and up to 15 percent if treated. A second form, pneumonic plague, results when the bacteria invade the lungs. Pneumonic plague is especially virulent, with mortality of 100 percent if not treated within twenty-four hours. Moreover, it causes bronchial pneumonia, which leads to coughing of highly infective aerosols of bacteria. The third form of plague is septicemic plague, in which blood-borne bacteria are widespread throughout the body, invading almost all organs. Septicemic plague is 100 percent fatal if untreated, and some 40 percent of those who contract it die even with treatment. Incubation time for plague before symptoms appear is one to six days.

Symptoms of bubonic plague include fever (as high at 105 degrees Fahrenheit), chills, mus-

Transmission of Plague



The bacterium responsible for the disease, *Yersinia pestis*, circulates among rodents and their fleas in many parts of the world.

Rats, ground squirrels, prairie dogs, chipmunks, and gophers are all examples of rodents.

Humans may become infected if they enter plague-affected areas when fleas, carrying the disease bacterium, transfer from dead rodents to humans.

A variety of small mammals, particularly rodents, may carry the flea that transmits the plague bacterium *Yersinia pestis*.

cular pain, sore throat, headache, severe weakness, extreme malaise, and enlarged, painful lymph nodes especially in the groin, armpits, and neck. In later stages, accelerated heart rate, accelerated breathing, and low blood pressure ensue. The normal course of treatment is antibiotics of the tetracycline or sulfonamide families. A vaccine does exist, but it is no longer available in the United States; it is used to contain local outbreaks in other parts of the world.

Because of the highly contagious nature of *Y. pestis*, this organism poses a grave danger as an agent in a biological terrorism attack. Aerosolized plague organisms as well as antibiotic-resistant strains of plague have been developed in former biological weapons facilities in Russia and the United States. Rapid identification of the agent is essential in any bioterrorism event.

Ralph R. Meyer

Further Reading

Brubaker, Bob. "*Yersinia pestis* and the Bubonic Plague." In *The Prokaryotes*, edited by Martin Dworkin et al. 3d ed. Vol. 6. New York: Springer, 2006.

Orent, Wendy. *Plague: The Mysterious Past and Terrifying Future of the World's Most Dangerous Disease*. New York: Free Press, 2004.

Parker, Philip M., and James N. Parker. *Bubonic Plague: A Medical Dictionary, Bibliography, and Annotated Research Guide to Internet References*. San Diego, Calif.: ICON Health Publications, 2003.

See also: Bacteria; Bacterial biology; Bacterial resistance and response to antibacterial agents; Biological terrorism; Biological warfare diagnosis; Biological weapon identification; Biotoxins; Centers for Disease Control and Prevention; Chemical Biological Incident Response Force, U.S.; Hemorrhagic fevers; Parasitology; Pathogen transmission; Smallpox; Tularemia.

Bugs. *See* Electronic bugs

Bullet-lead analysis

Definition: Examination of the amounts of trace elements in lead bullets to enable comparison of bullets and determination of their sources.

Significance: Analysis of the trace elements present in bullets can be conducted on bullet fragments found at a shooting scene and on any bullets found in the possession of suspects; comparison of the findings can link a suspect to a crime.

Bullets found at crime scenes may be compared with test bullets fired from weapons suspected to have been used in the crimes, but such analysis is not possible when only bullet fragments are recovered or no weapons are found. To address such situations, the technique of bullet-lead analysis was developed during the 1960's. In this process, a fragment of a bullet is dissolved, the solution is vaporized, and the vapor is heated until it glows. By examining the spectrum of light from the glowing vapor, the analyst can determine what trace elements are present in the lead and the amount of each element. Lead typically has traces (1 percent or less) of antimony, arsenic, bismuth, cadmium, copper, silver, and tin. The amounts of these elements vary with where the lead was mined and what kinds of scrap lead have been added. (Most modern bullets are made from recycled lead taken from automobile batteries.)

The use of bullet-lead analysis has been criticized by some. In one case involving the analysis of bullet lead, Michael Behm was convicted in 1997 of murdering a man in South River, New Jersey. The only physical evidence presented in court that linked Behm to the murder was a chemical match between the amounts of trace elements found in bullet fragments from the crime scene and the amounts of those elements found in ammunition recovered from Behm's home. The prosecution led the jury to believe that this meant that the crime scene bullet fragments must have come from the box of ammunition in Behm's possession. This was a serious misuse of bullet-lead analysis because such a match does not necessarily pinpoint a bullet's source. A large batch (or melt) of lead might produce millions of bullets, so hundreds of people in each of dozens of towns might have had bullets matching the crime scene fragments.

Another serious problem with bullet-lead analysis is the question of how the level of experimental error should be calculated. For example, the amount of antimony in a sample might be reported as 0.85 percent ± 0.15 percent, meaning that the amount of antimony is between 0.70 percent and 1.0 percent. If the level of experimental error (in this instance ±0.15 percent) is estimated from too few measurements, confusion can result. Suppose that the antimony content of a different lead sample is reported as 0.51 percent ± 0.20 percent, so that it lies between 0.31 percent and 0.71 percent. Because this range overlaps with the antimony range given for the first lead sample, it appears that the antimony contents in the two lead samples "match" or are "analytically indistinguishable." Had the second measurement been reported as 0.51 percent ± 0.10 percent, no overlap, and thus no match, would have resulted.

A questionable practice sometimes used in the presentation of evidence involving bullet-lead analysis is called chaining: Because bullet A is found to be a chemical match to bullet B, which in turn matches bullet C, the claim is made that bullet C matches bullet A, regardless of whether A and C are chemical matches. Chaining was used in convicting Behm. On March 7, 2005, an appellate judge ruled this interpretation of the bullet-lead analysis results invalid and overturned Behm's conviction. On September 1, 2005, after extensive review, the Federal Bureau of Investigation (FBI) announced that it would discontinue the use of bullet-lead analysis.

Charles W. Rogers

Further Reading

Boyce, Nell. "Do Bullets Tell Tales?" *U.S. News & World Report*, November 24, 2003, 60-61.

Goho, Alexandra. "Forensics on Trial: Chemical Matching of Bullets Comes Under Fire." *Science News*, March 27, 2004, 202.

See also: Atomic absorption spectrophotometry; Ballistic fingerprints; Ballistics; Firearms analysis; Gunshot residue; Gunshot wounds; Integrated Ballistics Identification System; Lead; Nuclear spectroscopy.

Bureau of Alcohol, Tobacco, Firearms and Explosives

Date: Established in 1972 as the Bureau of Alcohol, Tobacco and Firearms, an independent division of the U.S. Department of the Treasury

Identification: Regulatory and law-enforcement unit of the U.S. Department of Justice.

Significance: The lead agency for much of the U.S. government's forensic work involving firearms, explosives, and arson.

The bulk of the work of the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF, also sometimes known as BATFE) involves the regulation of lawful firearms and explosives businesses in the United States as well as some regulation of alcohol (for example, labeling laws) and tobacco. The bureau also enforces federal criminal laws related to these products and, accordingly, conducts forensic investigations involving firearms and explosives as well as illegal sales of alcohol and tobacco.

Firearms

Pursuant to U.S. law, all firearms must have serial numbers, and persons who sell firearms (whether as manufacturers, wholesalers, or retailers) must keep written records of the sales. Starting in the 1990's, many manufacturers and wholesalers of firearms began providing ATF's National Tracing Center with computerized records of all their sales. In conjunction with local law-enforcement agencies, ATF frequently uses serial numbers to trace the histories of recovered crime guns. In some cases, ATF agents conduct fieldwork to attempt to find out what happened to particular guns after their retail sale.

ATF's National Integrated Ballistic Information Network (NIBIN) uses the Integrated Ballistics Identification System (IBIS) to supply 182 federal, state, and local law-enforcement agencies with ditigized images of bullets and cartridge cases recovered from crime scenes. These images can be used in ballistic fingerprinting—for example, to investigate whether the same gun might have been used in crimes in two different states.

Arson and Explosives

Federal law regulates the manufacture, sale, and possession of explosives in the United States and provides penalties for the misuse of explosive materials. Under the theory that some fires are started with accelerants that might legally be considered explosives, ATF has become the leading federal agency involved in arson investigation. In 1978, the bureau created its National Response Team (NRT), which assists local authorities in investigating significant arson fires. The NRT comprises four units, each assigned to a different region of the United States. Each NRT unit includes ATF agents with expertise in arson or bombing investigation, forensic chemists, dogs trained in the detection of explosives or accelerants, and various support personnel.

The main purpose of the NRT is to assist in local investigations of major commercial arson fires, but the NRT also provides help to local law-enforcement agencies that must investigate bombings. The NRT was involved with the investigations of the 1993 World Trade Center bombing, the 1995 Oklahoma City bombing, and the 1996 Atlanta Summer Olympics bombing. The NRT also supports ATF's regulatory role by participating in investigations of illegal explosives manufacturing and by responding to explosions at lawful ammunition and fireworks factories.

ATF's International Response Team (IRT) assists in arson and explosives investigations in foreign countries, with the approval of the U.S. ambassadors to the particular nations. The IRT has participated in the investigation of Islamist terrorist bombings in Argentina as well as in investigations involving improvised explosive devices (IEDs) in other nations.

In 1996, many news media outlets in the United States reported on what some observers described as a massive wave of racist arson attacks on black churches in the South. Although no actual increase in church arson attacks had occurred, in response to the perceived need

ATF's Stated Mission, Vision, and Values

Mission

The Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) is a principal law enforcement agency within the United States Department of Justice dedicated to preventing terrorism, reducing violent crime, and protecting our Nation. The men and women of ATF perform the dual responsibilities of enforcing Federal criminal laws and regulating the firearms and explosives industries. We are committed to working directly, and through partnerships, to investigate and reduce crime involving firearms and explosives, acts of arson, and illegal trafficking of alcohol and tobacco products.

Vision

The Bureau of Alcohol, Tobacco, Firearms and Explosives must protect the public against crime, violence, and other threats to public safety. Our vision will help us chart the course to improve the way we serve and protect the public, provide leadership and expertise, and achieve new levels of effectiveness and teamwork.

Values

We value each other and those we serve. We will:

- Uphold the highest standards of excellence and integrity;
- Provide high quality service and promote strong external partnerships;
- Develop a diverse, innovative, and well-trained work force to achieve our goals; and
- Embrace learning and change in order to meet the challenges of the future.

Agents of the Bureau of Alcohol, Tobacco, Firearms and Explosives search through the ashes for evidence after an arson fire destroyed the Mount Pleasant Missionary Baptist Church in Kossuth, Mississippi. This fire was one of numerous arson attacks on African American churches in the South in 1996. *(AP/Wide World Photos)*

the U.S. Congress and President Bill Clinton created the National Church Arson Task Force (NCATF), a multiagency federal organization in which ATF assisted with church-related arson and bombing investigations.

Research and Training

In its database known as the Arson and Explosives National Repository, ATF compiles information about arson and explosives crimes and suspected crimes. The bureau uses the Advanced Serial Case Management (ASCMe) system to manage the collection and organization of data from arson scenes.

In 1986, ATF and the Federal Bureau of Investigation (FBI) began a joint program to profile at-large criminals who are perpetrating arson or bombings. The Arson and Bombing Investigative Services (ABIS) subunit is part of the FBI's National Center for the Analysis of Violent Crime (NCAVC) in Quantico, Virginia.

The U.S. Bomb Data Center was created by Congress in 1996. Led by ATF, the center compiles data about arson and explosives crimes from various agencies and makes those data available for statistical research by scholars and law-enforcement personnel.

ATF also operates three laboratories (in Atlanta, San Francisco, and suburban Maryland) that work on cases involving alcohol, tobacco, firearms, explosives, and fire debris. The ATF National Laboratory Center in Maryland has a facility where scientists researching arson can re-create the circumstances of particular fires under controlled conditions. Each of the three ATF labs has a Rapid Response Laboratory that can join on-scene investigations.

ATF conducts many training programs for

other law-enforcement agencies, covering topics such as arson investigation, recovery of defaced serial numbers on firearms, and postblast explosives investigation.

David B. Kopel

Further Reading

Kopel, David B., and Paul H. Blackman. *No More Wacos: What's Wrong with Federal Law Enforcement and How to Fix It*. Amherst, N.Y.: Prometheus Books, 1997. Offers a close analysis of the disastrous 1993 raid on the Branch Davidians compound in Waco in the context of broader problems with the Bureau of Alcohol, Tobacco and Firearms.

Moore, James. *Very Special Agents: The Inside Story of America's Most Controversial Law Enforcement Agency—The Bureau of Alcohol, Tobacco, and Firearms*. Champaign: University of Illinois Press, 2001. Presents a fervent and heartfelt defense of the bureau. Includes several informative appendixes.

National Learning Corporation. *Alcohol, Tobacco and Firearms (ATF) Inspector: Test Preparation Study Guide—Questions and Answers*. Syosset, N.Y.: Author, 2005. Volume designed to prepare students to pass a qualifying test to become an ATF inspector. Focuses on the bureau's regulatory side.

U.S. Bureau of Alcohol, Tobacco, Firearms and Explosives. *2008 Essential Guide to the ATF: Complete Coverage of Firearms Publications, Laws, Forms*. Washington, D.C.: Author, 2007. This guide on CD-ROM, published annually, provides all the material available on the ATF Web site as well as many other public documents related to the bureau.

Vizzard, William J. *In the Cross Fire: A Political History of the Bureau of Alcohol, Tobacco, and Firearms*. Boulder, Colo.: Lynne Rienner, 1997. A retired ATF supervisor criticizes the bureau's institutional weaknesses.

See also: Accelerants; Arson; Ballistic fingerprints; Body farms; Bombings; Canine substance detection; Exhumation; Federal Bureau of Investigation; Firearms analysis; Improvised explosive devices; Integrated Ballistics Identification System; National Church Arson Task Force; World Trade Center bombing.

Buried body locating

Definition: Determination of the placement of human remains that are obscured from view—whether by water, soil, or other intervening materials—for the purpose of their recovery.

Significance: Law-enforcement authorities are concerned with the systematic and efficient location of human remains in cases of crimes, accidents, and natural disasters, as location of the remains is the vital first stage in the recovery and identification of the victims, the investigation of the manner of their death, and the return of the remains to surviving relatives.

Human remains may be obscured from view, or buried, as the result of intentional human acts, accidents, or natural events. Bodies can be buried in a variety of settings, depending on the circumstances preceding death and at the time of death. In cases of crimes, accidents, and natural disasters, bodies may be obscured by water, soil, building debris, or other materials. Different burial environments require different methods of body location.

Possible Locations of Bodies

Human remains in bodies of water may be trapped in sunken ships, automobiles, or aircraft, or they may be entangled in or obscured by trees, logs, or brush floating in the water or along the banks of rivers or lakes. In the case of a disaster such as the collapse of a bridge over water, bodies may be further obscured by debris from the fallen structure.

Bodies buried in soil may be found at various depths, depending on the circumstances of the deaths. Perpetrators of homicides might bury victims covertly only a few inches below the surface. Bodies buried by mudslides might be found several feet under the surface, and those of the victims of an airplane crash might be interred deeply (along with associated debris) as a result of the impact of the aircraft. Victims of a building collapse might not be buried in the soil but may be obscured from view under construction debris. Victims of floods or tornados might also be hidden under debris, whether that of buildings or natural materials.

Methods

The method of body location applied is specific to the particular case at hand. When bodies are believed to be in a body of water, physical searches may be conducted by certified divers, although in some circumstances floating sediment or algae can obscure visibility. Small, localized bodies of water, such as ponds, may be dredged or drained to enhance exposure of any human remains. Side-scan sonar, which produces sound pulses that reflect off submerged objects and are recorded, is a remote-sensing technology that has been used with success to identify sunken vessels, crashed airplanes, and even individual drowning victims submerged in water. Computer simulations may also be conducted to predict the locations of drowning victims, given known hydrological data for a body of water.

For bodies buried under soil, a variety of location methods may be used. A walkover line survey, wherein several searchers are aligned and move in unison across the search area, is effec-

Employees of a commercial locating service stand near their ground-penetrating radar equipment while awaiting permission to enter an Indianapolis home to assist in a homicide investigation in early 2005. With the aid of their equipment, the bodies of three recent murder victims were found buried under freshly laid concrete. Although used primarily for locating underground utility conduits at construction sites, ground-penetrating radar is also invaluable to homicide investigations and archaeologists, as this technology often enables the quick location of human remains without damaging structures or other property. *(AP/Wide World Photos)* tive in identifying the disturbed soil or vegetation indicative of a covert (hidden) burial, usually fairly close to the surface. Even though this method works best in open areas, some modified form of walkover survey is a useful first step even in urban mass-disaster settings (such as the aftermath of a tornado). In such a setting, individual remains may be partially covered or intermingled with debris on or near the surface of the soil.

Remote-sensing techniques such as infrared aerial photography and electromagnetic devices such as ground-penetrating radar (GPR), soil resistivity or conductivity meters, and metal detectors are also useful. Infrared aerial photography is most useful for identifying large buried features, such as mass graves. GPR is considered the best ground survey tool for identifying graves, although it works best in well-drained soil. Resistivity or conductivity meters and metal detectors can find buried metallic objects that may be associated with buried bodies. These remote-sensing devices identify anomalies (unusual patterns) in the electromagnetic signals coming from the ground. Forensic investigators can then narrow their focus on these anomalies as potential locations of buried remains. Actual controlled excavation of these anomalies is necessary to confirm their forensic significance.

When bodies are obscured by vegetation debris or by debris from destroyed structures following natural or human-made disasters, such as Hurricane Katrina or the September 11, 2001, terrorist attacks on the World Trade Center in New York City, special measures may be needed to locate them. In localized events, cadaver dogs can help to locate bodies under debris by scent. When large mass disasters occur, local authorities may be overwhelmed and may require outside assistance. In 1993, the U.S. government established ten regional Disaster Mortuary Operational Response Teams (DMORTs) to provide local agencies with added expertise in the location, recovery, and identification of deceased individuals after such disasters. These teams, under the direction of the U.S. Department of Health and Human Services (National Disaster Medical System), are made up of pathologists, forensic anthropologists, forensic odontologists, medical technicians, medical examiners, nurses, medical technologists, counselors, and funeral home directors. Team members are skilled private citizens who, when deployed, have the initial goal of location and recovery of remains in complex, debris-filled settings.

Cliff Boyd

Further Reading

Buck, Sabrina. “Searching for Graves Using Geophysical Technology: Field Tests with Ground Penetrating Radar, Magnetometry, and Electrical Resistivity.” *Journal of Forensic Sciences* 48 (2003): 5-11. Reports on the results of tests of the efficiency of three geophysical remote-sensing techniques in a variety of settings, including cemeteries and in a murder investigation. Discusses the limitations of each method in detail.

Dupras, Tosha L., John J. Schultz, Sandra M. Wheeler, and Lana J. Williams. *Forensic Recovery of Human Remains: Archaeological Approaches*. Boca Raton, Fla.: CRC Press, 2006. Provides detailed descriptions of search-and-recovery methods and the equipment used for such purposes in forensic scene investigations. Includes standardized recording forms and conversion tables in appendixes.

Haglund, William D., and Marcella H. Sorg, eds. *Advances in Forensic Taphonomy: Method, Theory, and Archaeological Perspectives*. Boca Raton, Fla.: CRC Press, 2002. Extensive edited volume presents several case studies of the recovery of human remains in a variety of settings, including remains found in water, in burned structures, and in mass graves.

Killam, Edward W. *The Detection of Human Remains*. 2d ed. Springfield, Ill.: Charles C Thomas, 2004. Presents thorough descriptions of intrusive and nonintrusive forensic search methods, including various forms of remote sensing.

Owsley, Douglas. “Techniques for Locating Burials, with Emphasis on the Probe.” *Journal of Forensic Sciences* 40 (1995): 735-740. Discusses the effectiveness of intrusive methods of locating graves.

See also: Bombings; Cadaver dogs; Crime scene search patterns; Croatian and Bosnian war victim identification; Drowning; Forensic anthropology; Forensic archaeology; Forensic botany; Infrared detection devices; Mass graves; Metal detectors; Mummification.

Burn pattern analysis

Definition: Analysis of the spread of a fire from its site of origin, along with the type of burn damage and extent of destruction, to determine the cause of the fire.

Significance: Burn pattern analysis helps investigators to determine whether fires were started by natural events (such as lightning strikes) or by human activity and, if the latter, whether they were caused accidentally (for example, by cooking fires or welding sparks) or intentionally. Determining the causes of fires is important to both law-enforcement and insurance investigators because arson is the most common cause of major structure fires (houses, schools, warehouses) and accounts for greater monetary losses than any other category of fires.

Every twenty seconds, a fire department somewhere in the United States responds to a fire. According to the National Fire Protection Association, in 2006 more than 1.6 million fires caused 3,245 civilian and 89 firefighter deaths and $11.3 billion in property damage. More than 31,000 structure fires and 20,500 vehicle fires were intentionally set, about half of them by juveniles. Nevertheless, despite the high rate of arson fires, few arsonists are successfully prosecuted.

In the past, much of the information investigators had about how different types of fires behave and the burn patterns they leave behind was gleaned from firefighter observation. In the twenty-first century, however, the desire to improve the rates of arson convictions has combined with advances in technology to create a movement to develop a better and more scientific understanding of how fires behave under specific conditions. Researchers at educational agencies such as the Maryland Fire and Rescue Institute at the University of Maryland use controlled experiments to demonstrate that different types of fires create different burn patterns and to validate what burn pattern analysis reveals about the origin, type of fuel, and other factors that characterize a fire.

Point of Origin and Ignition

Every fire starts somewhere. Burn pattern analysis begins with an attempt to determine the site or origin of the fire. When a fire ignites simultaneously in several locations within a building, for example, this pattern suggests that the fire was intentionally set. A single point of origin does not by itself rule out arson, however. Investigators also consider whether the fire started inside or outside the structure or vehicle, if it started in a location where one might normally expect to find an ignition source (such as in a kitchen or workshop), and what type of fuel was likely to be available. In determining the point of origin, investigators may not only examine the physical remains of the structure or vehicle but may also request a chemical analysis of the remains and interview witnesses for information about the early stages of the fire.

Spread and Intensity

Once a fire has ignited, how it behaves is determined by three factors: availability of fuel, availability of oxygen, and the heat these produce. These factors are in turn influenced by such elements as the type of fuel available, weather conditions, ventilation systems, drafts from open windows and doors, functioning of installed fire suppression equipment within a building, and firefighter intervention. Although most fires follow a characteristic pattern of development, the constellation of conditions surrounding each fire is unique, and a burn pattern analysis must consider all these factors.

Investigators know that certain materials burn in predictable ways and leave particular telltale signs. Burn pattern analysis involves putting all these signs together to explain the behavior of the fire. Examples of signs that fire investigators might look for that can become part of their burn pattern analyses include the following:

- V-shaped charring patterns on walls, which can give clues to the intensity of fires
- Spalling, or flaking, patterns on concrete or stone floors, which may indicate that accelerant liquids were dribbled across the floors and ignited
- Large, shiny char blisters, which are more likely to form when accelerant liquids are present (small, dull blisters are more characteristic of slow-igniting accidental fires)
- Atypical burn rates for specific materials, which may suggest that accelerants were used
- Abnormal or atypical continuity of burn patterns

Because of the many factors that influence the behavior of any given fire, burn pattern analysis evidence is often successfully challenged in court. Only 2 percent of arson cases result in conviction. Since the late 1990's, the federal Building and Fire Research Laboratory (BFRL) has conducted research to gather scientific documentation on specific burn patterns. For example, researchers have started experimental fires under precisely the same conditions but using different types of accelerants; they have also started fires in rooms that are identical except for having different types of flooring. The burn patterns and other data from these experiments are documented and made available to fire investigators. In addition, the BFRL has developed computer simulations of fire scenarios to assist in training fire investigators and to help explain the results of burn pattern analyses to jurors.

Martiscia Davidson

College students in a class on arson investigation observe the burn patterns in several staged fires. *(AP/Wide World Photos)*

Further Reading

Almirall, José R., and Kenneth G. Furton, eds. *Analysis and Interpretation of Fire Scene Evidence*. Boca Raton, Fla.: CRC Press, 2004. Examines the technical aspects of fire scene investigation with emphasis on what burn patterns can tell investigators.

Faith, Nicholas. *Blaze: The Forensics of Fire*. New York: St. Martin's Press, 2000. Describes how fire investigators work and the methods that forensic scientists use in examining evidence from fire scenes.

Icove, David J., and John D. DeHaan. *Forensic Fire Scene Reconstruction*. 2d ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2008. Shows how investigators trace the history of a fire by using physical evidence of human activity and knowledge of burn patterns.

MacDonald, Jake. "After the Inferno: Winnipeg's Arson Squad Can Tell How a Fire Started and Often Who Started It, by Sifting Through the Ashes and Reading Scorch Marks on the Wall." *Saturday Night*, May 20, 2000, 24-32. Explains how fire investigators use burn pattern analysis to determine how a fire started.

Redsicker, David R., and John J. O'Connor. *Practical Fire and Arson Investigation*. 2d ed. Boca Raton, Fla.: CRC Press, 1997. Provides comprehensive coverage of all aspects of fire investigations, with emphasis on fires that cause death.

See also: Accelerants; American Academy of Forensic Sciences; Arson; Bureau of Alcohol, Tobacco, Firearms and Explosives; Crime scene documentation; Electrical injuries and deaths; Fire debris; National Church Arson Task Force; Physical evidence; Structural analysis.

C

Cadaver dogs

Definition: Dogs that are specially trained to find the scents associated with decomposing human remains.

Significance: Although dogs have been used for many years to aid in crime detection, their use in more highly specialized investigative techniques is a relatively recent development. During the last two decades of the twentieth century, law-enforcement agencies and dog trainers increasingly focused on training dogs to search out human remains in addition to the already established use of dogs to track living humans.

Cadaver dogs constitute a subcategory of search-and-rescue dogs, which are used to help law-enforcement officials find missing people. Cadaver dogs differ from other kinds of search-and-rescue dogs in that cadaver dogs search only for human remains; they are not used to find living humans or other kinds of evidence. Training dogs for the purpose of finding human remains is a fairly recent development in law enforcement's use of dogs. In addition to their use by law enforcement at crime scenes, cadaver dogs are used to find bodies following natural and human-caused disasters.

Cadaver dogs receive specialized training in which they are cross-trained for use both in trailing living humans and in detecting the scents of decomposing human remains. These dogs are trained to differentiate among a variety of scents and to recognize the difference between decomposing human flesh and other scents. In addition to identifying the locations of recent human remains, cadaver dogs can detect the presence of bones and blood as well as other residual scents.

Most cadaver dogs are first trained as trailing and air-scenting dogs, which are used in tracking lost and injured people. After their initial training in tracking general scents, they begin their training as cadaver dogs. In this stage, trainers use special chemicals that mimic the smells of decomposing human flesh to familiarize the dogs with the scents associated with human remains. Careful screening is necessary to identify those dogs that are likely to become good cadaver dogs; trainers must attempt to determine the dogs' abilities to track the necessary scents and whether the dogs are attracted to those scents.

The Institute for Canine Forensics and other organizations draw distinctions among different kinds of search-and-rescue dogs. Subcategories of dogs used by law enforcement, in addi-

A cadaver dog and his handler from Rhode Island Urban Search and Rescue search for human bodies near Waveland, Mississippi, in September, 2005, after Hurricane Katrina destroyed homes and property there. *(AP/Wide World Photos)* tion to cadaver dogs, include search dogs, area search dogs, trailing dogs, forensic evidence dogs, water search dogs, and human remains detection dogs. The last of these are similar to cadaver dogs but more specialized, in that human remains detection dogs are trained only to scent decomposing human flesh; they have never been trained to track living humans. The training of human remains detection dogs includes training in the ability to rule out the scent of live human flesh and other animal scents.

The science of canine forensics is a fairly new discipline in law enforcement. As more dogs are used successfully in new capacities, the idea of using dogs for many law-enforcement purposes is gaining popularity. Highly trained dogs such as cadaver dogs are becoming an indispensable part of many law-enforcement agencies.

Kimberley M. Holloway

Further Reading

Bulanda, Susan. *Ready! The Training of the Search and Rescue Dog*. Irvine, Calif.: Doral Publishing, 1994.

Rebmann, Andrew, and Edward David. *Cadaver Dog Handbook: Forensic Training and Tactics for the Recovery of Human Remains*. Boca Raton, Fla.: CRC Press, 2000.

Snovak, Angela Eaton. *Guide to Search and Rescue Dogs*. New York: Barron's Educational Series, 2004.

See also: Animal evidence; Buried body locating; Canine substance detection; Crime scene investigation; Decomposition of bodies; Fire debris; Forensic archaeology; Scent identification.

Canine substance detection

Definition: Work carried out by trained dog and handler teams to discover contraband items and hazardous materials associated with criminal activities or security threats.

Significance: Well-trained dogs, with their natural scent abilities, are able to locate illegal narcotics and explosive and flammable chemicals expeditiously, whereas humans and technological search devices might overlook these materials or discover them only slowly. Canine substance detection has proven useful in the apprehension and prosecution of lawbreakers.

For several centuries, dogs have assisted humans in seeking forensic evidence related to crimes, including tracking missing people and finding human remains. Law-enforcement agencies' use of canines to detect illegal drugs, explosives, and accelerants intensified during the late twentieth century. Although other animals, such as rats, also have keen smelling abilities, law-enforcement personnel prefer dogs because of their appeal to many people, their ability to work in congested areas and shift quickly to additional sites, and their willingness to obey commands.

The scent capabilities of canines significantly exceed those of humans. A dog's sense of smell is enhanced by the presence of approximately 220 olfactory receptors in the nose. Mucus covers these receptors, enabling them to capture molecules released by chemicals when the dog sniffs nearby. Information from these molecules reaches the dog's brain through a nerve, alerting it to the presence of specific substances. These qualities make dogs ideal for law-enforcement use in detecting various illegal and dangerous substances.

Training and Certification

Law-enforcement personnel procure detection dogs from various sources. The Australian Customs Service Detector Dog Breeding Program provides stock for U.S. detection dog breeders, particularly the Transportation Security Administration (TSA) Explosive Detection Dog Program and Auburn University's Canine Detection Training Center (CDTC) at McClellan, Alabama, which supply detection dogs for governments at various levels. As the sole training program of its kind affiliated with a veterinary school, the CDTC benefits from studies conducted by veterinarians and scientists at the Canine and Detection Research Institute. The government and university programs focus on

ATF-Trained Detection Dogs

In a press release dated March 12, 2008, the Bureau of Alcohol, Tobacco, Firearms and Explosives announced the graduation of seven canine teams from its Canine Training Center:

The Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) graduated a new class of canine handlers today at its Canine Training Center in Front Royal, Va. The ceremony was the culmination of an intensive, 10-week training course completed by federal officers from the CIA, Department of Defense, U.S. Marshals Service and the Federal Protective Service, in which ATF canine trainers spent six weeks "imprinting" the dogs, giving them the capability to locate 19,000 explosive odors—including peroxide-based explosives.

These handlers and their ATF-trained canine partners will be deployed throughout the Washington, D.C. metropolitan area and other parts of the country, where they will be used for criminal investigations, protective search and sweep operations, and safeguarding national special events such as the Republican and Democratic National Conventions, G-8 summits, the World Series and the Super Bowl. . . .

The handlers and their canines train extensively together for 10 weeks, learning how to search out explosives in vehicles, schools, train stations, concert venues, warehouses and retail stores. The dogs can also detect firearms and ammunition. Prior to graduation, each canine must pass an odor recognition test with 100 percent accuracy. This certification test is conducted by a forensic chemist using the National Odor Recognition Test developed by ATF.

ATF trains approximately 90 new canine teams each year and places them, without cost, with local, state, federal or foreign law enforcement agencies. Teams are recertified each year and receive continuous support from ATF throughout the approximate eight-year working life of the dogs.

refining detection qualities in Labrador retrievers, Belgian Malinois, and shepherd breeds considered to be behaviorally reliable and physically sturdy.

Detector dog selection and training are rigorous, and only the most competent canines are approved for deployment to law-enforcement agencies. Several government facilities, the CDTC, and private businesses train canines and handlers for substance-detection duties. The Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) Canine Training Center at Front Royal, Virginia, where the U.S. Customs and Border Protection (CBP) also has a canine training site, certifies dogs that complete successfully national odor recognition testing. The U.S. Drug Enforcement Administration (DEA) licenses the use of drugs at government and approved private training facilities. ATF also trains canines to detect explosives, working with forensic chemists to choose appropriate explosives for effective training.

According to their individual intended purposes, the dogs are trained to detect and distinguish the scents of many substances, ranging from chemicals found in heroin, cocaine, marijuana, and methamphetamine to explosive nitroglycerin, trinitrotoluene (TNT), and smokeless powders. In ATF training for arson dogs, the dogs learn to detect specified odors of gasoline, kerosene, and other accelerants.

Detection and Effectiveness

Many law-enforcement officials consider the use of canines to be the most efficient and effective method of detecting narcotic substances, resulting in arrests of suspects. Substance-detection dogs are taken to public and private locations, including schools, businesses, prisons, stadiums, and motor vehicles, where they seek the scents they are directed to detect; they alert their handlers to any substance finds by scratching, barking, or sitting.

At border checkpoints, CBP and U.S. Department of Agriculture detection dogs search for illegal substances, including harmful agricultural products. For example, in 2004, U.S. customs authorities using substance-detection dogs conducted 11,600 narcotics seizures totaling approximately 1.8 million pounds of narcotics as well as 6,500 pounds of illegal plant and animal products.

Substance-detection dogs that locate explosives effectively defuse potentially hazardous situations. The U.S. Department of Homeland Security oversees canine substance detection in its antiterrorism work; this work is conducted by CBP and TSA dogs that are trained to locate dangerous chemicals and bombs. Because such substances are often hidden in sealed containers and in concealed areas, dogs can swiftly find them where humans might not easily detect them. Explosives experts provide information on the chemicals that have previously been used by terrorists, and the dogs are trained to detect those substances.

As part of enhanced security measures in the United States and elsewhere, canines sniff luggage, packages, mail, and cargo for illegal substances, explosives, and bombs at airports, train stations, ports, and crowded areas that could be terrorist targets. Dogs are used to examine industrial sites for potential sabotage. The ability of dogs to detect explosive chemicals has also led to their use in arson investigations to find accelerants at sites of suspicious fires. As new chemical threats emerge, researchers and trainers are constantly refining their training procedures to expand the abilities of substance-detection dogs to detect chemical and narcotic substances.

Despite detector dogs' high accuracy rates, many courts disregard evidence located by dogs through scent detection because this method lacks a sufficient scientific basis. Some judges, however, have ruled that search warrants can be issued based on detection dogs' alerts, as in the finding in *United States v. Trayer* (1990), a

An officer with the Maryland Transportation Authority works with a substance-detecting dog to check luggage for the presence of explosives or other hazardous materials at Baltimore-Washington International Airport. *(AP/Wide World Photos)* case that involved a dog alerting to drugs at the door of a train compartment.

To reinforce legal acceptance of the forensic contributions of detector dogs, researchers are attempting to gain a better scientific understanding of canine scent-detection capabilities. Scientists study handler-canine interactions, canine behavior, and environmental factors to try to find ways to improve dogs' scent-detection training and performance. Law-enforcement agencies consistently evaluate and recertify substance-detection canines and their handlers, removing from service those that do not perform adequately and might discredit canine substance detection as a forensic tool.

Elizabeth D. Schafer

Further Reading

Bidner, Jen. *Dog Heroes: Saving Lives and Protecting America*. Guilford, Conn.: Lyons Press/Globe Pequot Press, 2002. Presents examples of canines performing police and customs work, including ATF detection dogs that search for drugs and bombs.

Bryson, Sandy. *Police Dog Tactics*. New York: McGraw-Hill, 1996. Comprehensive text written by a police dog trainer and handler. Includes sections on drug searches and the detection of explosives and accelerants.

Derr, Mark. "With Dog Detectives, Mistakes Can Happen." *The New York Times*, December 24, 2002, p. F1. Relates some incidents in which detection canines falsely alerted to locating substances and examines the reasons for dogs' scenting errors.

Needles, Colleen, and Kit Carlson. *Working Dogs: Tales from Animal Planet's K-9 to 5 World*. Photographs by Kim Levin. New York: Discovery Books, 2000. Profiles several drug enforcement, arson, police, and customs inspector dogs.

U.S. Congress. House. Committee on Homeland Security. *Sniffing Out Terrorism: The Use of Dogs in Homeland Security*. Washington, D.C.: Government Printing Office, 2007. Transcript of statements made by canine detection trainers, handlers, scientists, and law-enforcement representatives at a congressional hearing held on September 28, 2005.

See also: Airport security; Bombings; Bureau of Alcohol, Tobacco, Firearms and Explosives; Cadaver dogs; Courts and forensic evidence; Drug Enforcement Administration, U.S.; Fire debris; Narcotics; Scent identification; Training and licensing of forensic professionals.

Carbon monoxide poisoning

Definition: Poisoning caused by exposure to toxic levels of carbon monoxide, a colorless, odorless, and tasteless gas derived from incomplete burning of carbon-containing organic materials, such as gasoline, natural gas, oil, propane, coal, and wood.

Significance: Carbon monoxide (CO) poisoning is the most common type of accidental poisoning that occurs in the United States. Undetected, unsuspected, or undiagnosed, carbon monoxide poisoning can result in death. Hospital emergency departments treat thousands of patients with confirmed and probable CO poisoning yearly, and hundreds of fatalities occur as the result of unintentional, non-fire-related CO exposure. It is estimated that the incidence of intentional CO poisoning, such as suicide and homicide, is even higher.

Carbon monoxide is known as the "silent cold-weather killer" and as "the Great Imitator" because the manifestations of its toxicity are nonspecific. If CO is not considered as a cause when CO poisoning occurs, health care personnel can easily misdiagnose the victim. CO is a ubiquitous gas that is present in workplaces, recreational areas, and homes. The most common sources of carbon monoxide include motor vehicle exhaust, smoke from fires, portable kerosene heaters, charcoal grills, propane stoves, and tobacco smoke. Chemical sources include spray paints, solvents, degreasers, and paint removers containing methylene chloride, which is processed in the liver and changed into CO.

The annual incidence of fatal and nonfatal toxic exposure to carbon monoxide is highest during the winter months, when many homes are closed up against cold weather; cases of CO poisoning are fewest during the summer months. More than two hundred CO poisoning fatalities are caused annually in the United States by fuel-burning appliances such as furnaces, gas ranges, water heaters, and kerosene space heaters. CO poisoning occurs at low levels in susceptible individuals, such as young infants, pregnant women, the elderly, and those with anemia or heart and lung diseases.

The symptoms of CO poisoning are vague; in many ways they are similar to those of viral illnesses, and victims may be misdiagnosed. The most common symptoms are headache, dizziness, nausea, and fatigue. More severe symptoms include loss of consciousness, shortness of breath, confusion, and loss of muscle control. Some patients develop delayed symptoms of the nervous system, such as memory loss, personality changes, and movement disorders. All of these symptoms arise because CO binds tightly to hemoglobin, a protein found in red blood cells, and this binding causes a decrease in oxygen supply, especially in the heart and brain. Medical personnel should be suspicious if anyone displaying such symptoms reports circumstances of the illness that could relate to possible CO exposure.

The diagnosis of CO poisoning is made through the measurement of the CO bound to hemoglobin. Treatment consists of providing supplemental oxygen to dissociate the CO-hemoglobin binding. Oxygen may be delivered through a face mask, through hyperbaric oxygen therapy, or through mechanical ventilation.

Preventive measures to avoid CO poisoning include having heating and ventilation systems, water heaters, and other similar devices serviced yearly by qualified technicians. Generators, charcoal grills, camp stoves, and other similar appliances should not be used indoors or near buildings, and gas ovens should not be used to heat homes. In addition to these precautions, many experts recommend the installation of home CO detectors, which should be checked regularly. Finally, medical attention should be obtained immediately if CO poisoning is suspected.

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Further Reading

Occupational Safety and Health Administration. *Carbon Monoxide Poisoning Fact Sheet*. Washington, D.C.: Government Printing Office, 2002.

Penny, David G., ed. *Carbon Monoxide Poisoning*. Boca Raton, Fla.: CRC Press, 2007.

Piantadosi, Claude A. "Perspective: Carbon Monoxide Poisoning." *New England Journal of Medicine* 347, no. 14 (2002): 1054-1055.

See also: Air and water purity; Arson; Centers for Disease Control and Prevention; Chemical agents; Food poisoning; Forensic toxicology; Livor mortis; Nervous system; Poisons and antidotes; Smoke inhalation; Suffocation; Suicide.

Casting

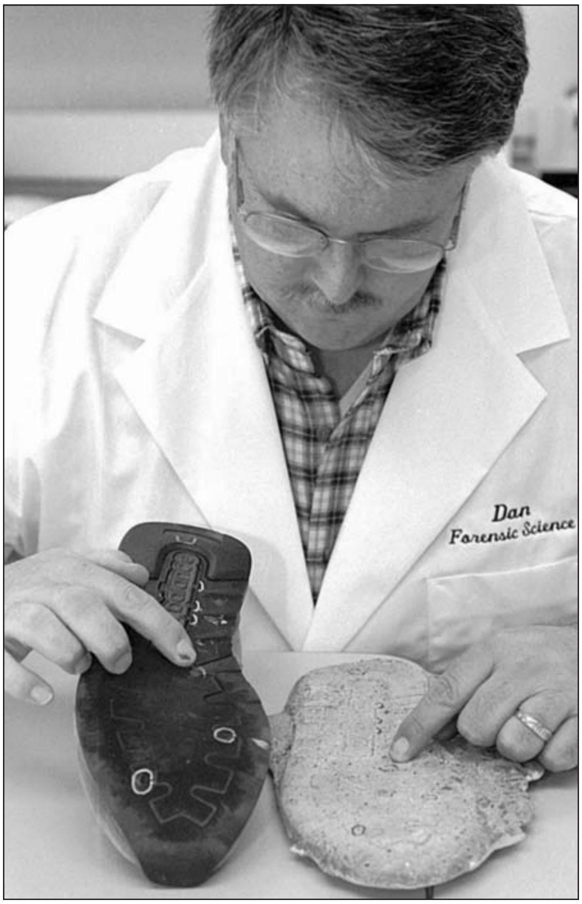
Definition: Production of three-dimensional models of impressions left by footwear, tires, or tools at crime scenes.

Significance: Forensic scientists use casts, permanent physical records of marks left at crime scenes, to compare with the vehicle tires, footwear, or tools found in the possession of possible suspects.

Perpetrators often leave traces of their presence at crime scenes in the form of tire impressions or footprints in dust, soil, mud, or snow. The tools used by perpetrators also leave distinctive impressions, such as the marks left on a door by a crowbar. Casting is a way of making permanent three-dimensional records of these impressions. Because tires, footwear, and tools do not wear evenly, they develop unique use patterns. Using a cast made from an impression found at a crime scene, a forensic scientist can compare the unique wear pattern shown by that impression with the wear patterns on the possessions of any suspects. Casts often show marks with a degree of accuracy that either confirms or eliminates the presence of some persons at the crime scene. In court, casts are used as physical evidence to show a link between the accused and the crime.

Casting in Soil

Castings in mud, dirt, and sand are made with a product known as dental stone. Dental stone creates a crisper, more detailed cast than does plaster of paris or other plasters and is less likely to be damaged during cleaning. Dental stone comes in powder form, and water is added at the crime scene to make a runny, batterlike mixture that is used to fill the impression. Photographs are taken to locate the impression within the scene, and a plastic frame is placed around the impression before the cast is made. In loose soil or sand, the impression may be sprayed with a chemical that hardens the surface before casting.



A forensic latent impressions examiner compares a cast made from a shoe print at a crime scene with the sole of the shoe that may have made the print. *(AP/Wide World Photos)*

To prevent distortion of the impression, the technician fills it with dental stone gently. After the impression is filled, the dental stone is allowed to harden for at least half an hour in warm weather and longer in cold or very humid conditions. Before hardening is complete, the technician inscribes the cast with identifying information. Once the cast has solidified, it is removed from the soil and is allowed to air-dry for several days, after which it is cleaned of clinging soil and examined.

Casting in Snow

Casting in snow creates special problems because of the fragility of the impression. This is especially true when the impression has been made in very dry, nonpacking, or windblown snow, or in snow that has begun to melt. Two techniques can be used to cast in snow. In one, before the dental stone cast is made, several layers of a product called Snow Print Wax are sprayed over the snow to stabilize the impression. The impression is then cast in the same way as an impression in soil. Cold conditions substantially slow the hardening of the cast, and it may be several hours before the cast can be removed from the snow.

Another way of casting in snow involves the use of Snow Print Wax and prill sulfur, a pellet form of sulfur that is a by-product of natural gas refining. The pellets are melted and then cooled so that the sulfur will not melt the snow. The impression is first sprayed with Snow Print Wax and then filled with the melted sulfur. Pouring the sulfur when it is at the correct temperature—not hot enough to melt the snow yet not so cold that it starts to form crystals before it is poured—is a critical step in creating a good prill sulfur cast. After about twenty minutes, the cast is hard enough to remove. Because prill sulfur casts are brittle and easily broken, they are often embedded in a protective layer of dental stone. In 2003, the Royal Canadian Mounted Police tested both methods of casting in snow and found that prill sulfur casting produced sharper, more detailed casts than did Snow Print Wax casting alone.

Casting Tool Marks

Tools that are used to pry, scrape, cut, or drill hard surfaces leave marks that can be cast. For example, a hammer hitting a nail leaves a reproducible and distinctive mark. When tool marks found at a crime scene are on objects too large to move to the laboratory (such as on a safe or a door frame), photographs are taken to locate the marks within the scene and casts are then made with sprayable silicone rubber or a similar silicone resin. This material dries quickly and accurately reproduces the unique indentations and ridges made by tools. Tool marks are more difficult to match than are tire or footwear marks, and the marks made by a tool may change over time if the tool is heavily used.

Martiscia Davidson

Further Reading

Bodziak, William J. *Footwear Impression Evidence: Detection, Recovery, and Examination*. 2d ed. Boca Raton, Fla.: CRC Press, 2000. Comprehensive guide to handling footwear evidence includes information on casting both footwear and barefoot impressions.

Du Pasquier, E., J. Hebrard, P. Margot, and M. Ineichen. "Evaluation and Comparison of Casting Materials in Forensic Sciences: Applications to Tool Marks And Foot/Shoe Impressions." *Forensic Science International* 82, no. 1 (1996): 33-43. Presents a review of various casting materials and their appropriate uses.

Hilderbrand, Dwane S. *Footwear, the Missed Evidence: A Field Guide to the Collection and Preservation of Forensic Footwear Impression Evidence*. 2d ed. Wildomar, Calif.: Staggs, 2005. Provides information about all aspects of preserving, collecting, and interpreting footwear impressions, including detailed information on how to cast impressions under a variety of conditions.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005. Easy-to-read introductory textbook covers all aspects of forensics, including the casting of footwear and tire impressions.

McDonald, Peter. *Tire Imprint Evidence*. Boca Raton, Fla.: CRC Press, 1993. Classic work in the field of tire imprint collection and interpretation.

See also: Autopsies; Bite-mark analysis; Disturbed evidence; Evidence processing; Footprints and shoe prints; Oral autopsy; Prints; Tire tracks; Tool marks.

Celebrity cases

Definition: Forensic investigations of accidents and alleged crimes involving well-known persons.

Significance: Whenever a celebrity is involved in an incident requiring law-enforcement investigation, the event receives widespread coverage in the news media. The in-depth reporting on these cases by some media outlets brings public attention to the uses of forensic science and demonstrates the need for investigators to follow correct procedures in the collection of evidence.

Tragedies among the rich and famous typically garner significant attention from the general public. Among others, the cases described below involving entertainment industry celebrities have drawn public attention to the use of forensic techniques in law-enforcement investigations.

Robert Blake

Best known for his role as the star of the television series *Baretta* (1975-1978), Robert Blake, who had also been a member of the cast of the Our Gang series of comedy shorts in the 1930's and 1940's, gained renewed notoriety in 2001 as the prime suspect in the murder of his wife, Bonny Lee Bakley.

Bakley was shot and killed as she sat in a car outside a Los Angeles restaurant, and Blake was charged with one count of murder, two counts of solicitation of murder, and one count of murder conspiracy. He was accused of trying to hire two Hollywood stuntmen to kill his wife. Blake was tried for and acquitted of the murder charge and of one count of solicitation of murder; the other charges against him were dropped. In 2005, however, Blake was found liable for Bakley's wrongful death by a jury in a civil suit filed by Bakley's four children and was ordered to pay the family thirty million dollars.

Among the forensic evidence introduced during Blake's criminal trial was the finding from an analysis of the amount of gunshot residue (GSR)—particles emitted when a gun is fired—found on Blake's hands after Bakley was shot. An independent scientist testified that she found only five particles of GSR on the actor's hands and that the killer would likely have had ninety-seven to ninety-eight particles; the GSR found on Blake could have been a result of Blake's handling his own gun, which was not the murder weapon. Other experts testified that the source of the GSR on Blake's hands could not be confirmed. Additionally, no latent fingerprints could be found on the murder weapon.

Another area of suspicion for both the prose-

Robert Blake (left), with his attorney Thomas Mesereau, Jr., during a hearing in a Los Angeles Superior Court in February, 2004. Blake was charged in the shooting death of his wife, Bonny Lee Bakley. *(AP/Wide World Photos)* cution and the defense was the fact that Blake had no blood on his clothes immediately after the shooting. A forensics expert who analyzed the blood-spray patterns in the car where Bakley was killed said that the killer would not necessarily have been sprayed by blood because of the angle of the shooting. Other forensic testimony was presented in the case by a psychopharmacologist, who testified that frequent methamphetamine and cocaine use could cause delusions, paranoia, and hallucinations; this testimony was used to discredit the claims of the two stuntmen Blake was alleged to have tried to hire to kill his wife.

Christian Brando

Known for having a bad temper fueled by frequent drug and alcohol abuse, Christian Brando, the son of actor Marlon Brando, had an especially close relationship with his sister, Cheyenne, who also had drug and alcohol problems. In 1990, Christian Brando was accused of murdering his sister's longtime boyfriend, Dag Drollet, whom Cheyenne had accused abusing her. After a night of drinking, Christian, carrying a handgun, confronted Drollet in a bungalow on the Brando estate. Drollet was shot and killed; Brando claimed that the gun had gone off accidentally.

Evidence reports, as well as two autopsies, called into question Brando's story that the two men were struggling for the gun when it went off. Forensic analyses indicated that Drollet had died from a bullet to the back of the head, not in the face, as Brando originally reported. Further, investigators found that the scene of the death did not indicate that a struggle had taken place.

Forensic psychologists who testified for the prosecution characterized Christian Brando as a violence-prone threat to society, whereas defense experts described him as chronically depressed with diminished capacity as the result of long-term drug abuse. Key witnesses were not available to testify at the trial, and the court ruled that Brando's Miranda warning was inadequately administered, rendering his earlier confession inadmissible. Eventually, Brando pleaded guilty to voluntary manslaughter and was sentenced to ten years in prison.

Bob Crane

The 1978 murder of Bob Crane, who is best known as the star of the television series *Hogan's Heroes* (1965-1971), remains a mystery. After Crane was found brutally beaten to death in a Scottsdale, Arizona, apartment, investigators determined that he had been bludgeoned while he slept. The murder weapon was never found, but it was believed to be a camera tripod. The prime suspect was a video expert, John Henry Carpenter, who frequently participated in group sex parties that Crane organized. Criminologists found blood in Carpenter's car that matched Crane's relatively rare blood type, but at the time, the source of the blood could not be confirmed; DNA (deoxyribonucleic acid) typing did not yet exist. The case was closed for lack of evidence. When it was reopened in 1992, it was discovered that improper storage of the evidence made DNA analysis of the blood impossible. Nonetheless, Carpenter was indicted, and forensic photography experts were called to testify as to the authenticity of photos of an unknown material found in Carpenter's car. Despite these attempts, Carpenter was acquitted.

John Holmes

Dubbed the "Sultan of Smut," John Holmes starred in more than two thousand pornographic movies and was the template for one of the characters in the 1997 film *Boogie Nights*. By the 1980's, he had become debilitated by drug use, and his career had collapsed. Holmes came under suspicion of being one of the three masked thugs who committed the brutal 1981 quadruple homicide that became known as the "Wonderland murders," named for the street on which the killings occurred. The murders were later confirmed to be drug-related retaliation killings.

From a forensic standpoint, the Wonderland murders marked a turning point in courtroom evidence. The first law-enforcement investigators at the crime scene were so appalled by the amount of blood they found—the victims had all been beaten to death—that they videotaped the scene, and the prosecutors used the tape at trial. This marked the first time video evidence was admitted in court. Despite significant evidence pointing to Holmes's involvement in the killings, he was acquitted in 1982.

Manson Family

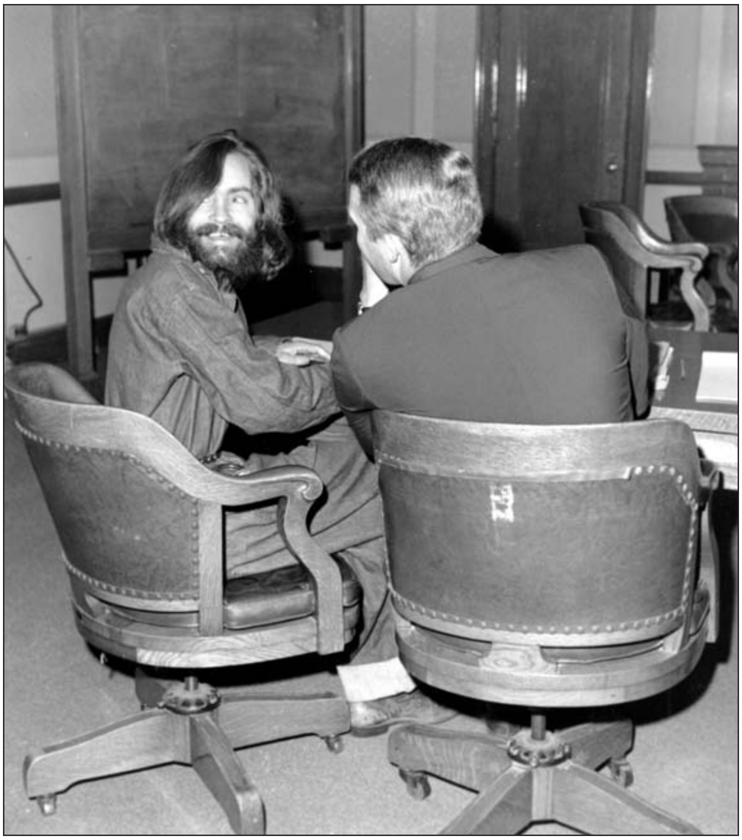
In August, 1969, starlet Sharon Tate was eight months pregnant by her husband, film director Roman Polanski. On a warm Saturday evening, Tate gathered with friends at her home near Beverly Hills. Early the next morning, Tate's housekeeper discovered a gruesome scene: five bodies, including Tate's. Investigators found that the victims had been shot, beaten, strangled, and mutilated. The word "PIG" had been scribbled in blood on a door, and the broken grip of a .22 caliber revolver was discovered at the scene.

The next day, in another part of town, Leno and Rosemary LaBianca were discovered stabbed and strangled. The word "WAR" had been carved into Leno's body, and "DEATH TO PIGS," "RISE," and "HEALTHER SKELTER" (misspelled this way) had been scrawled in blood. A few days earlier, music teacher Gary Hinman had been stabbed to death, and "POLITICAL PIGGY" had been written on his wall in his own blood.

Initially, the Los Angeles Police Department (LAPD) refused to draw connections among the three crimes, claiming that the Tate murders were a result of a drug deal gone bad. Two weeks after the murders, a .22 revolver with a broken grip was found in another Los Angeles suburb, but police failed to connect it to the earlier crimes. The Los Angeles County Sheriff's Department and the LAPD continued to pursue the cases separately for three months. In October, 1969, the two departments began to work together on the cases, and investigations led to a commune run by Charles Manson; Manson and his followers were known as the Manson Family.

A key piece of evidence in the Tate case was a fingerprint found in Tate's home that belonged to one of Manson's followers. In addition, bullets matching those found at the crime scene were discovered in the Manson compound. The .22 revolver in LAPD custody was finally rediscovered and matched to the bullets. In March, 1971, Manson was found guilty of first-degree murder. Several of his followers were later convicted.

In the years since the Manson murders, forensic historians have frequently referred to these cases in terms of "what not to do" for crime scene investigators. For example, the bodies found at the scenes were initially covered with household sheets, which could have contaminated evidence with unrelated fibers. Blood that had been left by the killers on the security gate button at the Tate estate was smeared by police officers who used the button. Police also smeared possible fingerprints on the .22 revolver when they received it, and pieces of the broken gun grip were inadvertently kicked under a chair. In addition,



Charles Manson (left), leader of the so-called Manson Family, confers with his public defender attorney on December 4, 1969, soon after his arrest for eight murders. *(AP/Wide World Photos)* investigators tracked blood throughout the Tate house, and insufficient blood samples were taken from the crime scene and from the victims.

Marilyn Monroe

Officially, Marilyn Monroe died of an accidental overdose of sleeping pills, but some experts have suggested that Monroe was actually murdered, speculating that her death may have been related to her involvement with President John F. Kennedy and his brother, Robert F. Kennedy. Several elements of the August 5, 1962, death have raised questions. For example, Monroe's housekeeper found her unconscious at about 3:30 A.M. and called Monroe's psychiatrist and her physician. Despite confirming the death upon their arrival, the two doctors then waited at least a half hour to call the police. Further, although toxicologists found Nembutal (a barbiturate) in her system (the drug had been prescribed for Monroe as a sleep aid), they also found high levels of chloral hydrate of unknown origin.

The initial autopsy was performed by Dr. Thomas Noguchi of the Los Angeles County Coroner's Office, who would go on to become somewhat famous as the "coroner to the stars." Although later investigation would deem his autopsy to have been thorough, Noguchi wanted to investigate further. Shortly after his initial autopsy, he tried to reexamine the tissue samples, but they were missing. In addition, one of the nation's top forensic pathologists deemed the toxicology report incomplete.

Other evidence suggested that Robert Kennedy had visited Monroe in the evening before her death; it has been asserted that he went there to break off contact between Monroe and the Kennedy brothers. Additionally, it has been alleged by some that actor Peter Lawford, who was the brother-in-law of John and Robert Kennedy, may have removed from Monroe's house any evidence suggesting her involvement with the Kennedys. The Los Angeles District Attorney's Office reopened the case in 1982, but after a lengthy examination of the evidence, investigators again concluded that Monroe's death was a probable suicide.

George Reeves

George Reeves, star of the 1950's television show *Adventures of Superman*, died of a gunshot wound to the head in his California home on June 16, 1959. The death was ruled a suicide; it was believed to have been the result of Reeves's despondency over the cancellation of his television series and his waning career. Much later, unofficial investigations into Reeves's death raised questions about this ruling, citing forensic evidence that appears to contradict a finding of suicide. For example, no fingerprints were found on the gun, no gunpowder burns were present around the entry wound, and no record exists of any test for gunshot residue on Reeves's hands. Forensics experts have noted, however, that the gun was too well oiled to retain fingerprints, that gunpowder stippling frequently does not occur when a gun is held directly against the skin, and that tests for gunshot residue were not commonly performed in the 1950's.

Elizabeth Short

The case of the "Black Dahlia" is still considered one of the most notorious Hollywood murders. Nicknamed perhaps for her penchant for black clothes, Elizabeth Short was an aspiring starlet. On January 15, 1947, her nude body was found in a weed-covered lot by a pedestrian. Her remains had been slashed and stabbed, and the body was neatly cut in half. Further, the young woman had been posed spread-eagle with the two halves set a foot apart, and the letters "BD" were carved into her thigh. Perhaps most disturbing, her face had been slashed to resemble a clownish death grin. The body appeared to be washed clean and there was little blood at the scene, leading investigators to surmise that Short had been killed elsewhere.

Forensic technicians working for the Federal Bureau of Investigation (FBI) used fingerprint analysis to identify the body as Short's. The Los Angeles Coroner's Office reported that Short had died of massive internal hemorrhaging caused by blows to the head, and no traces of sexual activity were found. The clean bisection of her body led some investigators to believe the murder might have been the work of a medical student or butcher. The young woman's shoes and purse were found in a trash receptacle several miles away from the scene where her body was discovered.

Although "confessions" began pouring in to the LAPD and the FBI, and investigators eventually interviewed more than one thousand people, it was all to no avail. Nine days after Short's body was found, the *Los Angeles Examiner* newspaper office received a package containing Short's belongings, including photos, her birth certificate and Social Security card, and an address book containing the names of seventy-five men—none of whom could be connected to the murder. The sender had soaked the package in gasoline, apparently to remove any fingerprints or other identifying materials.

One key suspect, Robert Manley, had been the last to see Short alive, but the police released him after he passed a polygraph test. Later, he was committed to a mental institution; he was questioned again there after being dosed with sodium thiopental—a so-called truth serum—and he still denied the murder. Over a period of years following Short's death, police and various news media outlets received thirteen letters thought to be written by the murderer, but they produced no identifying evidence. The case remains unsolved.

O. J. Simpson

O. J. Simpson's murder trial became one of the most highly publicized trials in American history and brought DNA evidence to the forefront of public awareness. Nicole Brown Simpson, the former wife of sometime actor and retired professional football star O. J. Simpson, was stabbed to death outside her home on the night of June 12, 1994, along with an acquaintance, Ronald Goldman.

After police responded to the crime scene, detectives immediately went to Simpson's home, where they found a bloodstain on the door of his Ford Bronco along with a trail of blood leading up to his house. As they questioned Simpson, the investigators noticed a cut on his left hand. Crime scene investigators had already concluded that the killer also had been cut on his left hand. In addition, analysis of drops of blood found at the crime scene indicated that they had DNA factors that pointed toward Simpson. Investigators also found footprints in Simpson's size at the crime scene and determined that they had been left by an exotic brand of shoe that Simpson owned. They also discovered a bloodstained glove on his property that matched one taken from the crime scene. Finally, investigators found traces of Nicole Brown Simpson's blood in Simpson's car and house, intermingled with Simpson's blood.

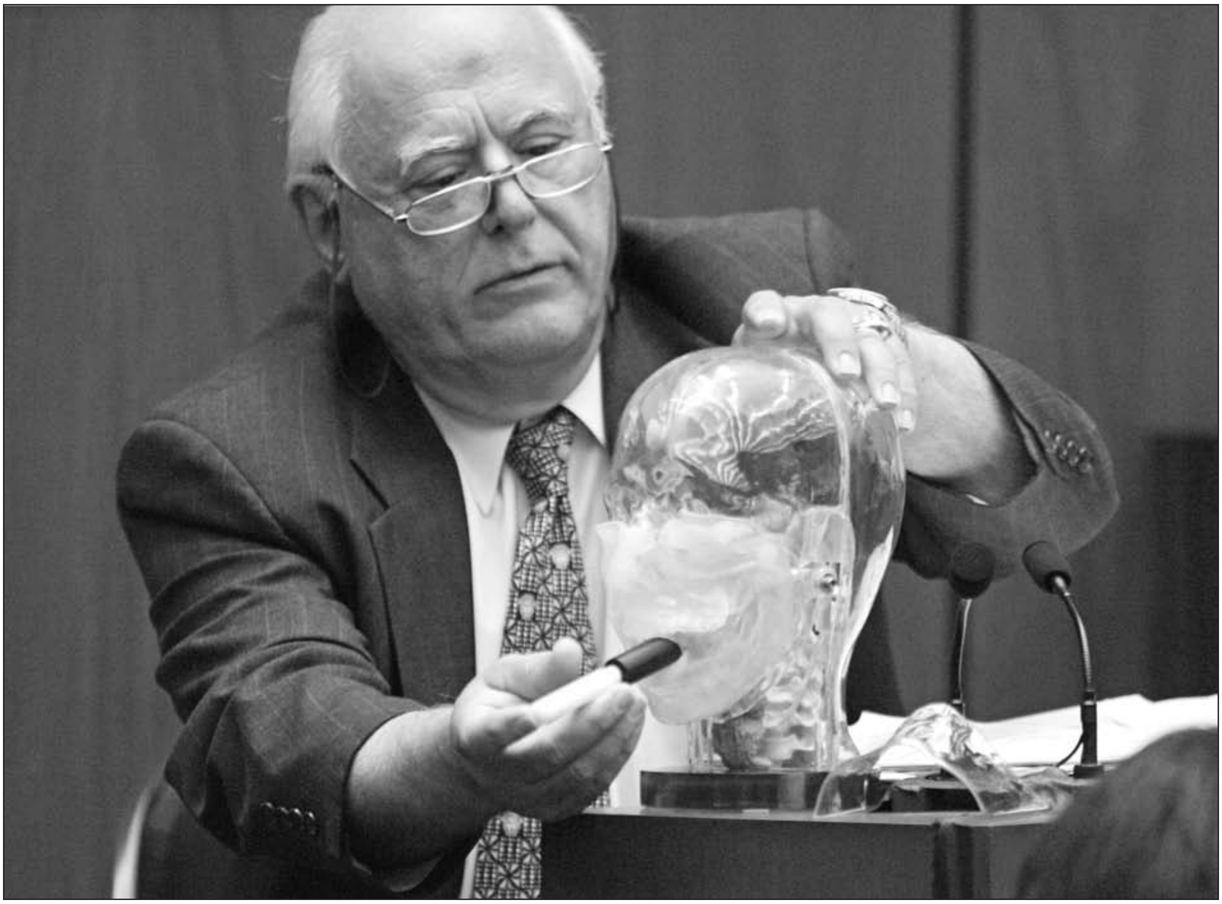
During the trial, Simpson's defense attorneys called forensic witnesses who asserted that the blood samples used as evidence by the prosecution had been mishandled, raising the possibility that they were contaminated or too degraded to produce accurate DNA analysis results. The prosecution produced other criminologists to refute these claims, but Simpson was eventually acquitted on all counts. In 1997, the jury in a civil suit brought by Ronald Goldman's father found Simpson responsible for the deaths of Brown Simpson and Goldman.

Phil Spector

Phil Spector, a well-known music producer who had worked with the Righteous Brothers, the Beatles, and many other famous recording artists, was arrested on February 3, 2005, when police discovered the body of actress Lana Clarkson in the foyer of Spector's home in Alhambra, California. Although Spector initially told police, "I think I killed someone," he later claimed the shooting was an "accidental suicide."

Spector's 2007 murder trial was surrounded by controversy. Famed forensic expert Henry C. Lee was accused by the district attorney of hiding evidence that proved Spector's guilt. In addition, a coroner concluded that bruises on Clarkson's tongue indicated that the gun had been forced into her mouth. The defense got a break when a DNA expert testified that only Clarkson's DNA was found on the murder weapon and that none of Spector's DNA was found under Clarkson's fingernails. In addition, a forensic pathologist testified for the defense that Clarkson had mental problems that could have led to suicide.

During the trial, forensic witnesses for the defense used a sophisticated three-dimensional plexiglass bust of the victim to demonstrate how



Defense witness Dr. Vincent DiMaio, testifying in Phil Spector's murder trial in June, 2007, introduces a rod into the mouth of a plastic model of a human head to demonstrate the damage caused by a self-inflicted intraoral gunshot wound. Spector was charged with killing actor Lana Clarkson, but the defense argued that the latter's death was an "accidental suicide." *(AP/Wide World Photos)*

the bullet went through her head and into her spine. The defense ended its arguments by presenting a computer-animated demonstration of the shooting as Spector asserted it took place. The trial ended in a hung jury, resulting in a mistrial, and the Los Angeles District Attorney's Office began preparing for a new trial.

Cheryl Turner

Cheryl Turner, daughter of movie queen Lana Turner, was fourteen years old when police investigated her role in the 1958 death of her mother's boyfriend, Johnny Stompanato. Lana and Johnny had a tempestuous relationship, and Cheryl had witnessed several incidents in which Stompanato had been violent toward her mother. During one of these episodes, Cheryl apparently intervened and stabbed Stompanato with a knife.

At a grand jury inquest during which Lana Turner gave what was described as a stunning performance, the Los Angeles coroner introduced an autopsy report outlining the extent of Stompanato's injuries. Further testimony indicated some confusion over details such as the lack of fingerprints on the knife, strange fibers in the blood on the knife, and a lack of blood on Lana Turner's clothes. Nonetheless, the jurors deemed the death justifiable homicide, and the prosecutor decided not to file charges. Stompanato's family subsequently brought a wrongful-death suit against Lana Turner; it was eventually settled out of court.

Cheryl Pawlowski

Further Reading

Bugliosi, Vincent. *Outrage: The Five Reasons Why O. J. Simpson Got Away with Murder*. New York: W. W. Norton, 1996. Famous former Los Angeles prosecutor presents a compendium of alleged mistakes by the legal system that resulted in the acquittal of O. J. Simpson.

Bugliosi, Vincent, with Curt Gentry. *Helter Skelter: The True Story of the Manson Murders*. 25th anniversary ed. New York: W. W. Norton, 1994. Best-selling book by the chief prosecutor in the case tells in graphic detail the story of the investigation and prosecution of Charles Manson and his followers.

Gilmore, John. *Severed: The True Story of the Black Dahlia Murder*. Los Angeles: Amok Books, 1994. Luridly detailed account of the investigation into the death of aspiring starlet Elizabeth Short, written by the son of a Los Angeles police officer who helped investigate the case.

Graysmith, Robert. *Auto Focus: The Murder of Bob Crane*. New York: Berkley Books, 2002. Examines Crane's life and discusses how the investigation into his murder was marred by conflicts and the inexperience of the investigators.

Noguchi, Thomas T., with Joseph DiMona. *Coroner*. New York: Simon & Schuster, 1983. Los Angeles coroner Noguchi explores some of the more famous cases in which he was involved, including the deaths of Robert Kennedy, Sharon Tate, and Marilyn Monroe.

See also: *Cold Case*; *CSI: Crime Scene Investigation*; DNA extraction from hair, bodily fluids, and tissues; Fingerprints; *Forensic Files*; Forensic photography; Homicide; Journalism; Misconceptions fostered by media; Prints; Pseudoscience in forensic practice; Simpson murder trial; Sports memorabilia fraud.

Centers for Disease Control and Prevention

Date: Founded in 1946 as the Communicable Disease Center

Identification: Agency of the U.S. Department of Health and Human Services that promotes a higher quality of human life through the prevention and control of disease, injury, and disability in the United States and globally.

Significance: The Centers for Disease Control and Prevention, the highest-level governmental health organization in the United States, employs forensic and public health experts who can efficiently investigate outbreaks of disease, mass-casualty events, and biological, chemical, nuclear, and radiological terrorist attacks domestically and elsewhere. Because of the organization's vast resources and expertise, all public health institutions in the United States as well as institutions in many other countries look to the Centers for Disease Control for training and investigation of mysterious diseases and deaths.

The agency now known as the Centers for Disease Control and Prevention (CDC) was called the Communicable Disease Center when it was organized in Atlanta, Georgia, during World War II. At that time, its major mission was to assist in the prevention and control of malaria in the southeastern United States and in war zones with endemic malaria. The agency was organized by Dr. Joseph W. Mountin, a visionary public health official. Within a few years, the center eradicated malaria in the southeastern United States. The success of this project was confirmed through the disease surveillance programs that the agency established in 1949. With the outbreak of the Korean War in 1950 and the threat of biological warfare, the CDC launched the Epidemic Intelligence Service (EIS) to carry out biological warfare surveillance. This program trained "disease detectives" to be deployed throughout the world to monitor outbreaks of diseases and to investigate suspected biological warfare-induced conditions.

Late Twentieth Century Achievements

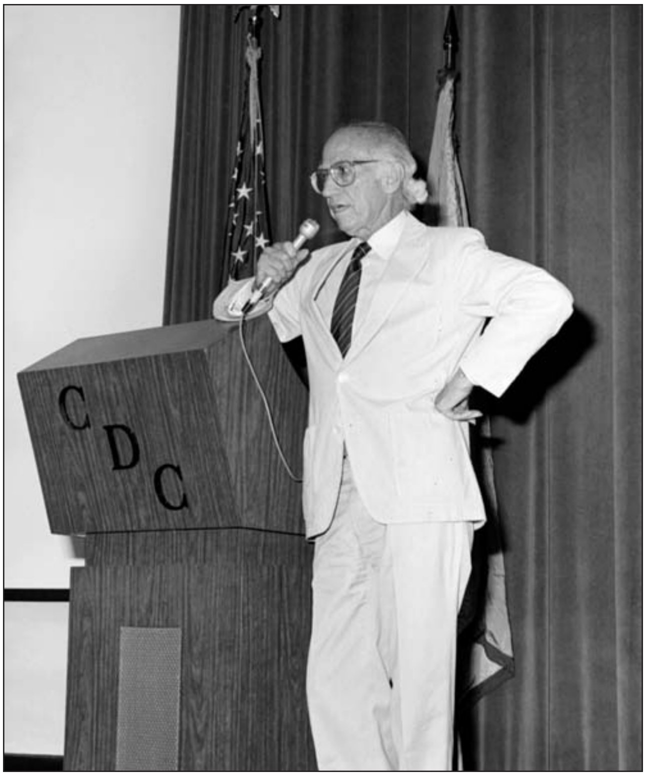
The credibility of the CDC in disease investigation was bolstered after the successful control of poliomyelitis outbreaks among recipients of the new Salk polio vaccine in 1955. This success was followed by the successful tracing of the course of an influenza epidemic that led to the CDC's development of a flu vaccine in 1957. During the early 1960's, the CDC expanded its mission to work involving surveillance of chronic diseases, nutrition, occupational safety, quarantine services, and immunizations against measles, rubella, and smallpox. The agency also joined international efforts to control malaria and expanded its disease control programs globally.

To combat the menace of smallpox, the CDC developed and tested the jet-gun immunization device, which was used successfully in immunizing people in South America and Central and West Africa in 1966. Following increasing involvement in international projects, in 1970 the agency's name was changed to the Center for Disease Control; it was renamed the Centers for Disease Control in 1980.

In collaboration with the World Health Organization, the CDC assisted in the global eradication of smallpox, which was declared accomplished in 1977. The CDC was also involved in the identification of Ebola virus, isolation of hepatitis C, and the first description of the sexual transmission of hepatitis B. In another investigation, the agency successfully described the association between Reye's syndrome and aspirin. The agency also helped to explain the relationship between occupational exposure to vinyl chloride and liver cancer, and, after a thorough investigation, the agency reported the harmful effects of a popular liquid protein diet.

From 1970 through early 1980, the CDC investigated mysterious deaths that occurred in the United States and found their causes in toxic shock syndrome and Legionnaires' disease; the agency both described health hazards and applied appropriate preventive measures to combat them. The CDC also described the first case of acquired immunodeficiency syndrome (AIDS) in 1981 and published information on the disease's associated risk factors and control measures. In collaboration with the National Center for Health Statistics, the CDC identified the dangers to human health of lead, which was subsequently removed from gasoline.

During the 1980's the CDC also investigated the use of estrogen replacement therapy and oral contraceptives and the relationship of such use to risks of breast, cervical, and ovarian cancers. At the request of the U.S. Congress, the agency investigated the effects of service in Vietnam on the health of Vietnam War veterans and their offspring. This led to the development of a serum test for a toxin called dioxin, which



Dr. Jonas Salk speaks to the press during a visit to the Centers for Disease Control in 1988. The credibility of the CDC in disease investigation was bolstered by the successful control of poliomyelitis outbreaks among recipients of the polio vaccine created by Salk in 1955. *(Centers for Disease Control and Prevention)* was identified as a potential cancer-inducing chemical. In the 1990's, the CDC participated in the investigation of an outbreak of hantavirus pulmonary syndrome in the United States. In addition, the agency played major roles in global efforts to eradicate polio and to prevent neural tube defects among unborn babies. In recognition of the CDC's diverse roles in both disease control and prevention, the U.S. Congress changed the agency's official name to the Centers for Disease Control and Prevention in 1992.

Twenty-first Century Missions

The CDC's role in monitoring the use of biological and chemical weapons intensified in the twenty-first century. Following the September 11, 2001, terrorist attacks on Washington, D.C., and New York City and the anthrax bioterror mail attacks that occurred shortly thereafter, the agency embarked on policies that would improve its ability to respond to similar events in the future. In addition, the Emergency Operation Center (EOC) of the CDC collaborated with law-enforcement agencies and state and local health departments in an investigation of the source of the anthrax used in the 2001 attacks and the hunt for victims of the attacks.

When Hurricane Katrina struck the U.S. Gulf coast in August, 2005, the CDC's disaster response team was involved in attempting to help manage the crisis. The agency also provided support to the National Disaster Medical System and the Federal Emergency Management Agency (FEMA). The CDC played similar roles during the Hurricane Rita disaster of September, 2005.

As part of its ongoing work, the CDC maintains constant surveillance for new infectious diseases and signs of biological and chemical terrorist attacks. The agency also coordinates training aimed at enhancing its responses to future attacks through its strategic plan for bioterrorism preparedness and response, which was developed in conjunction with other federal agencies responsible for public health and safety.

CDC Partners and Investigations

The CDC works with many other domestic agencies, as well as agencies of foreign governments, to carry out disease surveillance around the world. It is also involved in the detection and investigation of health problems and the management of disaster events involving mass casualties. Furthermore, the CDC conducts research to determine the best ways to enhance efforts to prevent such problems. In addition, the center fosters the training of public health leaders while assisting in the development of sound public health policies and the implementation of prevention strategies.

Among the CDC's notable external partners is the World Health Organization, with which it works to control and prevent infectious diseases. In addition to collaborating with public health institutions and laboratories in other countries, the CDC maintains its own laboratories in other parts of the world. Through these networks, the CDC plays a crucial role in world health. Because it operates the finest health laboratories in the world, the agency serves as an international center for training and disease investigation. Law-enforcement agencies employ its services in investigations of homicides, terrorist attacks, and unusual deaths.

CDC investigations focus on identifying the causes, current victims, and potential victims of major public health problems, including both natural and human-made disasters. The agency's experts collaborate with officials of local and national law-enforcement agencies in conducting investigations of particular events.

Chronic and Infectious Diseases

Investigations of health problems involve isolating the agents or risk factors responsible. For example, in cases of chronic disease, investigators seek to establish the association between agents and diseases, such as in the CDC's work that connected aspirin consumption by young children with Reye's syndrome. The CDC frequently carries out investigations of suspected relationships between toxic agents and exposure to special occupational and environmental conditions. Forensic toxicologists are often involved in such investigations.

When it began during World War II, the CDC was concerned primarily with the control of malaria. It gradually evolved to become one of the most important institutions in the world in the investigation of infectious diseases. Apart from employing a large number of highly trained public health experts, the agency maintains one of the best laboratories devoted to the study of infectious diseases in the world. CDC investigators examine outbreaks of infectious diseases by isolating the infectious agents responsible, characterizing those agents, identifying possible vectors and reservoirs of the organisms, and mapping transmission patterns.

In some cases involving fatalities, the CDC uses forensic samples to identify or isolate the infective agents. Samples from body fluids and suspected harbingers of infectious agents may also be used in CDC investigations. The CDC has identified, isolated, and characterized a number of infectious agents in this way. The agency's Special Pathogens Branch studies highly infectious viruses that cause human diseases. This group's laboratory studies such dangerous microorganisms as hantaviruses and Ebola, Lassa, and Nipah viruses. All outbreaks of infectious disease in the United States are reported to the CDC, and many foreign governments engage the CDC to investigate disease outbreaks in their countries.

Bioterrorism

The investigation of biological attacks has become an increasingly important part of the CDC's work, as the U.S. government has recognized the potential for such attacks to produce mass casualties. Organisms used in biological attacks may be dispersed through the atmosphere or introduced into domestic food and water supplies.

In late 2001, the CDC was involved in the investigation of attacks in several American cities in which the bacterium that causes anthrax was sent through the U.S. mails. The investigation identified eleven cases of inhalation anthrax and eleven cases of cutaneous anthrax. Organisms were isolated from samples of blood, cerebrospinal fluids, and wound and skin biopsies taken from victims of the attacks. In seeking to identify the sources of the organisms, investigators recovered four letters that had been sprayed with powder containing the anthrax bacterium and were able to trace the paths of the envelopes. Further investigation revealed the presence of the organism in facilities where U.S. mail was sorted. Although the perpetrator of the attacks was not identified, this investigation was helpful in identifying the attack agents and the victims. Because the potential sources of the anthrax were identified, people who were exposed to anthrax were promptly treated, and others were protected from potential infection.

Among the many other infectious agents that bioterrorists may disseminate are smallpox virus, plague bacteria, and the Ebola, Marbug, and Lassa viruses. The CDC classifies such viruses, which can cause high mortality and can be disseminated relatively easily, as Category A agents. The CDC has also recognized the dangers posed by agents causing lower mortality rates that may be used by terrorists. Category B agents include *Coxiella burnetii* (the bacterium that causes Q fever), alphaviruses, ricin (a toxin derived from castor beans), *Clostridium perfringens* (a bacterium involved in food-borne illnesses), and bacteria such as *Salmonella*, *Shigella*, and *Escherichia coli*.

Category C organisms include emerging infectious agents and other pathogens that are readily available and may be engineered for mass dissemination. Members of this group include hantaviruses, Nipah virus, tick-borne hemorrhagic fevers and encephalitis viruses, and multidrug-resistant tuberculosis.

Chemical Agents

The CDC maintains a nationwide surveillance system for the detection of possible terrorist attacks with a wide range of dangerous chemical agents. These include nerve agents such as tabun, sarin, soman, cyclosarin (GF), and VX; blood agents such as hydrogen cyanide; blister agents such as lewisite and mustard gas; volatile toxins such as benzene, chloroform, and trihalomethanes; pulmonary agents such as phosgene, vinyl chloride, and chlorine; poisonous industrial gases such as cyanides and nitriles; and incapacitating agents such as BZ. The CDC provides guidelines for local health authorities to help them manage possible chemical attacks. As poisons are often used as murder weapons, all cases of suspected poisoning in the United States are reported to both local health authorities and the CDC, which has helped solve many cases of murder by poison.

Edward C. Nwanegbo

Further Reading

Fong, I. W., and Ken Alibek, eds. *Bioterrorism and Infectious Agents: A New Dilemma for the Twenty-first Century*. New York: Springer, 2005. Provides information on bioterror agents and emerging infectious diseases that will foster understanding, treatment, and protection against these agents.

Hogan, David E., and Jonathan L. Burstein. *Disaster Medicine*. 2d ed. Philadelphia: Lippincott, Williams & Wilkins, 2007. Presents excellent coverage of human-made and natural disasters in different parts of the world and steps to be taken in managing medical emergency situations. Discusses the allocation of resources during disasters as well as treatment of the individuals affected.

Landesman, Linda Young. *Public Health Management of Disasters: The Practice Guide*. 2d ed. Washington, D.C.: American Public Health Association, 2005. Comprehensive discussion of natural and human-made disasters in the United States takes a practical approach to disaster response and management.

Lashley, Felissa R., and Jerry D. Durham, eds. *Emerging Infectious Diseases: Trends and Issues*. 2d ed. New York: Springer, 2007. Collection of essays provides information on the epidemiologies and clinical manifestations of various infectious diseases and discusses prevention and treatment of those diseases. Includes chapters on bioterror agents and avian influenza.

McQueen, David V., and Pekka Puska, eds. *Global Behavioral Risk Factor Surveillance*. New York: Kluwer Academic/Plenum, 2003. Excellent collection presents information on lifestyle behaviors in different parts of the world that foster development of chronic diseases such as diabetes, cancer, cardiovascular disease, and chronic obstructive airway diseases. An important resource for readers interested in understanding the roles of alcohol, tobacco, unhealthy diet, and inactivity in the development of chronic diseases.

Roy, Michael J. *Physician's Guide to Terrorist Attack*. Totowa, N.J.: Humana Press, 2003. Provides an informative review of the infectious and chemical agents that potentially can be used in terrorist attacks. Includes diagnostic and therapeutic guides to assist physicians in recognizing and managing the problems caused by such agents as well as information on the treatment of blast injuries.

Tucker, Jonathan B., ed. *Toxic Terror: Assessing the Terrorist Use of Chemical and Biological Weapons*. Cambridge, Mass.: MIT Press, 2000. Presents twelve case studies of the use of chemical and biological agents by terrorist groups. Identifies terrorists' patterns of behavior and discusses strategies to combat them.

Veenema, Tener Goodwin, ed. *Disaster Nursing and Emergency Preparedness: For Chemical, Biological, and Radiological Terrorism and Other Hazards*. 2d ed. New York: Springer, 2007. Nursing management guide addresses emergency needs for different categories of terrorist attacks as well as postdisaster care and psychological support for victims and their families.

See also: Autopsies; Bacterial biology; Biological terrorism; Biological warfare diagnosis; Biotoxins; Chemical Biological Incident Response Force, U.S.; Chemical terrorism; Chemical warfare; Food poisoning; Food supply protection; Forensic toxicology; Mustard gas; September 11, 2001, victim identification; U.S. Army Medical Research Institute of Infectious Diseases; Viral biology.

Chain of custody

Definition: Documentation of the location of physical evidence from the time it is collected until the time it is introduced at trial.

Significance: The establishment of chain of custody is important for all physical evidence collected in criminal investigations, but it is particularly crucial when items of evidence might become confused with other evidence or when there is a possibility that someone could have tampered with the evidence.

In criminal investigations, the identification of an object as one found at a certain place involves the establishment of a proper chain of custody, or paper trail. Each piece of physical evidence must be authenticated or identified by a witness or through other means.

Authentication

Authentication involves proof that the evidence is what it purports to be. Rule 901 of the Federal Rules of Evidence sets out methods of authenticating or identifying evidence. According to the rule, authentication or identification may be established by any of the following means: testimony of a witness with knowledge that a matter is what it is claimed to be, a nonexpert opinion as to the genuineness of handwriting based on familiarity, comparison by the trier of fact (jury) or expert witness with specimens that have been authenticated, distinctive characteristics, voice identification, telephone conversations showing that a call was made to a certain number and the identification of the person who answered the phone individually or on behalf of a business, ancient document or data compilation in existence twenty years or more at the time it is offered, evidence describing a process or system used to produce a particular result, or a method provided by act of Congress or by other rules pursuant to statutory authority.

Proper Chain of Custody

The first clause of Rule 901 addresses proper chain of custody. A weapon found next to a victim and then taken by the police and put into a bag that is sealed and marked with identification can later be identified by an officer on the stand at trial as the one found next to the victim. If more than one person had access to the bag, however, the role of each must be accounted for to ensure that the evidence is truly the object it is claimed to be. Similarly, when a powder is put into an evidence bag that is then sealed and checked in to the evidence room, the bag may later be checked out and sent to a laboratory for analysis of the contents. The laboratory technician has the responsibility of keeping track of the substance while testing it. The technician can then take the stand and testify about the identity of the substance.

It should be noted that minor gaps in the chain of custody are permissible and do not destroy the chain of custody. The evidence can be considered by the jury, which will determine its reliability and its probative value, if any, given the missing links in the chain. If, however, the evidence is not what the proponent claims it to be because of tampering in the chain of custody, the judge may prevent the jury from seeing or considering the evidence.

Chain of Custody in Court

It is important that law-enforcement personnel document the seizure, custody, control, trans-

The chain of custody usually begins with evidence being placed in appropriate packaging at the scene of a crime. *(Brand-X Pictures)* fer, analysis, and disposition of physical and electronic evidence. Because evidence can be used in court to convict persons of crimes, it must be handled carefully to avoid later allegations of tampering or misconduct that can compromise cases. Establishing a chain of custody is especially significant when the evidence takes the form of fungible goods—that is, goods that can easily be substituted for other items in the same category. This applies to illegal drugs seized by law enforcement.

An identifiable person must always have custody of the evidence. Therefore, when a police officer or detective takes charge of a piece of evidence, the officer or detective must document the item and give it to an evidence clerk for secure storage. This transaction and every succeeding transaction affecting that evidence, from its collection to its appearance in court, should be completely documented so that the evidence can withstand any challenges to its authenticity. Properly detailed documentation includes the conditions under which the evidence was gathered, the identities of all those who handled the evidence and how long they had it in their possession, the security conditions that existed during handling and storing of the evidence, and the manners in which the evidence was transferred to subsequent custodians.

In the case of the recovery of a bloody weapon at a murder scene, for example, every transfer of the weapon from person to person must be documented, from the time the weapon is picked up at the scene to the time it is presented in court. Law-enforcement personnel must be able to prove that only persons with legitimate reasons to inspect, test, or otherwise examine the weapon have had access to it. In cases involving chemical sampling, proper chain of custody ensures maintenance of the condition of samples by providing documentation of their control, transfer, and analysis.

Marcia J. Weiss

Further Reading

Broun, Kenneth S., ed. *McCormick on Evidence*. 6th ed. St. Paul, Minn.: Thomson/West, 2006. Considered to be the ultimate standard reference on the law of evidence. Contains detailed explanations and case references.

Mauet, Thomas A. *Trial Techniques*. 7th ed. New York: Aspen, 2007. Handbook covering all aspects of the trial process includes extensive examples of patterns of questions that attorneys use in examining expert witnesses.

Rothstein, Paul F., Myrna S. Raeder, and David Crump. *Evidence in a Nutshell*. 5th ed. St. Paul, Minn.: West, 2007. Provides a succinct summary of the law of evidence. Useful for both students and practitioners.

Stopp, Margaret T. *Evidence Law in the Trial Process*. Albany, N.Y.: West/Delmar, 1999. Undergraduate textbook intended primarily for paralegals discusses the principles of the law of evidence. A chapter on lay and expert witnesses includes cases and examples.

See also: Biological warfare diagnosis; Crime scene documentation; Disturbed evidence; Drug and alcohol evidence rules; Drug confirmation tests; Evidence processing; Handwriting analysis; Locard's exchange principle; Quality control of evidence; Rape kit; Toxicological analysis.

Challenger and *Columbia* accident investigations

Dates: *Challenger* accident took place January 28, 1986; *Columbia* accident took place February 1, 2003

The Event: After the accidents that destroyed the *Challenger* and *Columbia* space shuttles, investigators began the difficult tasks of finding and identifying evidence that would allow scientists to understand what had happened and allow the families of the dead crew members to bury their loved ones.

Significance: High-profile, widely publicized, multiple-casualty disasters create particular complexities in the search, collection, and identification portions of the investigation process. The investigations of the *Challenger* and *Columbia* tragedies required the use of many forensic tools.

The National Aeronautics and Space Administration (NASA) began the space shuttle program with *Columbia*, which launched for the first time in April, 1981. *Challenger* was the next shuttle to be launched, after *Columbia* had completed five missions. *Challenger* made its maiden flight in April, 1983.

On January 28, 1986, seventy-three seconds after it lifted off for its tenth mission, the space shuttle *Challenger* disintegrated. Investigators would later determine that the disaster was caused by the failure of an O-ring seal in the craft's right solid rocket booster. This failure caused a flame leak that engulfed the fuel tank and resulted in structural breakdown. With the structure compromised, aerodynamic forces broke the shuttle apart.

On January 16, 2003, as it was lifting off for its twenty-eighth mission, the space shuttle *Columbia* sustained damage when a piece of foam insulation broke off the main propellant tank and struck the shuttle's left wing, damaging the thermal protection system. The crew continued and completed their mission, but the damage was enough to compromise the wing's structure, and the shuttle began to fall apart during reentry into Earth's atmosphere on February 1. Eyewitnesses on the ground reported seeing debris break off the shuttle prior to its disintegration above Texas and Louisiana.

Government-appointed review boards were commissioned to look into the two shuttle disasters, and both found that the accidents were caused by malfunctions of which NASA officials were already aware. Both boards cited NASA administrators' insensitivity to the true potential risks posed by these documented issues as the main contribution to the tragedies.

Forensically speaking, every investigative scene analysis is intended to answer the same basic questions: How does the scene fit into what really happened, and what evidence within the scene supports the conclusions about what happened? Forensic scene searches are concerned with the identification, collection, and preservation of evidence. Scenes of the magnitude of the two shuttle destructions are no different from smaller scenes; they are simply amplified. When everything from the number of people involved to the amount of evidence available is on a grand scale, it becomes essential for investigators to establish a system to keep track of every detail.

Jurisdiction

The first thing that must be established in any type of law-enforcement investigation is which agency has the proper jurisdiction to investigate the case—that is, which agency is going to take charge of the investigation based on its legal authority over the crime or event, the geographic area, or the laws of the area. Sometimes jurisdictions can overlap, such as when both state and federal agencies have interests in particular cases. In these cases, agencies can share authority; this known as concurrent jurisdiction. It is always better, however, for one agency to take the lead in an investigation so that the work is not hampered by any competing goals and agendas the different agencies may have.

The investigators of both the space shuttle accidents had to contend immediately with jurisdictional issues. The agencies and other entities involved in the *Challenger* investigation included NASA, the Federal Bureau of Investigation (FBI), a specially appointed presidential commission chaired by former U.S. secretary of state William P. Rogers (known as the Rogers Commission), and the U.S. Air Force, Navy, and Coast Guard. The *Columbia* investigation included personnel from NASA, the FBI, the National Transportation Safety Board, the Secret Service, the U.S. Marshals Service, the Air Force, the Office of the Armed Forces Medical Examiner (OAFME), many Texas and Louisiana state and local agencies, and, later, the North American Aerospace Defense Command (NORAD). The *Columbia* incident was also reviewed by a presidential commission known as the *Columbia* Accident Investigation Board.

NASA took the lead in the *Challenger* investigation, confiscating tapes and pictures of the incident and making decisions to release little information to the news media. The FBI conducted an investigation to determine whether sabotage was involved, but eventually the Rogers Commission took jurisdiction to direct the investigation. In the *Columbia* incident, the FBI initially guided the search for shuttle parts and human remains on the ground, but NASA and the OAFME soon became the two main agencies involved. All recovered parts of the shuttle were sent to NASA for technical analysis, and the astronauts' remains and uniforms were sent to the OAFME for identification and examination.

Searching the Scenes

When *Challenger* broke apart, it was about 10 miles above the Atlantic Ocean, approximately 18 miles offshore. Pieces of the shuttle continued to fall for an hour, making it dangerous for search crews to enter the area immediately. *Challenger*'s nose section, with the crew cabin inside, was blown free from the rest of craft. NASA later learned from flight-deck intercom recordings and the apparent use of some emergency oxygen packs that at least three of the astronauts were alive during *Challenger*'s fall. The nose section shattered upon hitting the ocean at what is estimated to be about 200 miles per hour. The wreckage scene covered approximately 93,000 square miles of ocean that included depths of up to 1,200 feet.

An hour after the incident, search-and-recovery planes and ships began the search for survivors and wreckage. Although some pieces of the shuttle floated on the surface of the ocean, most of the debris had sunk to the bottom. The bodies

Two days after the space shuttle *Columbia* broke up on reentry on February 1, 2003, contractors for the National Aeronautics and Space Administration record the location and description of a piece of debris that fell from the craft. Hundreds of experts in engineering, aircraft accidents, and forensic science joined in the search for debris over an area nearly 60 miles wide by 250 miles long over East Texas and Louisiana. *(AP/Wide World Photos)* of the crew were not found right away, despite a search effort that included twenty-two ships, six submersibles, and thirty-three aircraft. Over the next few months, pieces amounting to about 50 percent of the shuttle were recovered, including parts of the external tank, both solid rocket boosters, and the orbiter. About 45 percent of the orbiter itself was found, including all three main engines, which were recovered intact, leading investigators to believe the engines were not involved in the incident.

On March 8, 1986, thirty-nine days after the search began, search teams found the crew cabin, which had not been destroyed. The bodies of all seven crew members were found inside, still strapped into their seats. The bodies were transported to the OAFME mortuary at Dover Air Force Base in Delaware for autopsy.

On the morning of February 1, 2003, NASA officials lost contact with the crew of the space shuttle *Columbia* about fifteen minutes prior to its scheduled landing. Video evidence depicts the shuttle breaking apart over Texas, approximately 39 miles above the ground. It has been estimated that the shuttle was traveling at approximately 12,500 miles per hour. The debris covered a rectangular area nearly 60 miles wide by 250 miles long over East Texas and Louisiana, in terrain that ranged from arid ground to bogs.

In contrast with the *Challenger* scene, which, as it was in the ocean, was relatively isolated from the public, the *Columbia* scene was accessible to anyone within the vicinity. Control of the scene became an immediate concern for investigators, and they found such control nearly impossible to achieve. Within the first few hours after the accident, materials alleged to be parts of the shuttle were being offered for sale on the auction Web site eBay. Authorities quickly shut down the auctions, and the posters were charged with tampering with an investigative scene and evidence.

The *Columbia* scene was so large that no single investigative agency could handle the search independently. All local law-enforcement agencies were contacted and asked to help within their areas of responsibility. If searchers came across anything they thought could possibly be related to the *Columbia* or its crew, they were told to collect it, note the appropriate location and time, and send it to NASA officials. NASA held all the recovered mechanical debris at Barksdale Air Force Base in Louisiana, and all organic materials found were sent to the OAFME mortuary at Dover Air Force Base for identification.

Autopsies and Victim Identification

A question often arises concerning autopsies conducted on persons who died as the result of a known disaster: What can such autopsies prove beyond what is already known? In both of the space shuttle tragedies, the deaths of all fourteen crew members were obviously the result of the shuttles' disintegration. Forensic pathology, however, can shed light on other important aspects of cases in addition to cause and manner of death, including incident analysis and victim identification. Remains may be identified through the analysis of DNA (deoxyribonucleic acid), fingerprints, or dental records. It is important to identify remains positively for the sakes of the families of the deceased.

In the case of *Challenger*, all seven crew members were found in their uniforms and strapped into their seats, so presumptive identification was easily accomplished. The news media and the crew members' families, however, also wanted to know when the crew died and whether they had suffered before their deaths. The autopsy findings in this case were inconclusive, largely because the remains had been submerged in the ocean for more than a month, and severe decomposition had set in. NASA officials found evidence that some of the crew may have survived the initial breakup of the craft, but then the crew cabin fell more than 50,000 feet and hit the water at approximately 200 miles per hour—no one could have survived such an impact.

Victim identification was an extremely important element of the investigation of the *Columbia* incident. The remains of the *Columbia* crew were found in parts, scattered with the shuttle debris over a very large search area. Identification of every body part was essential, so that the family of each crew member could be presented with as complete a body as possible for burial.

Findings

The Rogers Commission concluded that the space shuttle *Challenger* did not explode; rather, it was torn apart by aerodynamic stress after the structural failure of an external tank. The condition of the shuttle's three main engines showed no signs that they contributed in any way to the incident. An assessment of the external tank debris suggested that the tank itself was not responsible for the accident; rather, the failure of an O-ring used to seal joints in the solid rocket booster compromised the structure.

The *Columbia* Accident Investigation Board concluded that a puncture in the leading edge of the shuttle's left wing was caused by a piece of insulation foam that peeled off the external tank at launch. The hot gases formed during reentry into Earth's atmosphere expanded inside the wing, causing the shuttle to break apart on its final approach.

Russell S. Strasser

Further Reading

Cabbage, Michael, and William Harwood. *Comm Check . . . : The Final Flight of Shuttle Columbia*. New York: Free Press, 2004. Offers a good summary of the ethics of *Columbia*'s mission and the debate among engineers on the ground concerning whether it was safe for the shuttle to return. Notes that opportunities to learn the extent of the spacecraft's problems were missed and that repeated warning signs were ignored.

Feynman, Richard P. "Richard P. Feynman's Minority Report to the Space Shuttle *Challenger* Inquiry." In *The Pleasure of Finding Things Out: The Best Short Works of Richard P. Feynman*, edited by Jeffrey Robbins. Cambridge, Mass.: Perseus, 1999. One presidential commission member—a Nobel laureate in physics and widely renowned scientist and teacher—presents his explanation of what caused the *Challenger* accident.

Kubey, Robert W., and Thea Peluso. "Emotional Response as a Cause of Interpersonal News Diffusion: The Case of the Space Shuttle Tragedy." *Journal of Broadcasting and Electronic Media* 34, no. 1 (1990): 69-76. Good post-*Challenger* look at how NASA dealt with the media and the visual depictions of the *Challenger* incident. Discusses how these factors may have affected the investigation.

Langewiesche, William. "*Columbia*'s Last Flight." *The Atlantic Monthly*, November, 2003, 58-87. Excellent overview of the investigation that followed the *Columbia* tragedy, with good explanations of the findings of the *Columbia* Accident Investigation Board.

Lighthall, F. F. "Launching the Space Shuttle *Challenger*: Disciplinary Deficiencies in the Analysis of Engineering Data." *IEEE Transactions on Engineering Management* 38 (February, 1991): 63-74. Analyzes the field data acquired before the launch and compares them with the results of the investigation. Somewhat technical, but very informative.

McDanels, S. J. "Space Shuttle *Columbia* Post-accident Analysis and Investigation." *Strain: An International Journal for Experimental Mechanics* 42 (August, 2006): 159-163. Presents a thourough, technical review of the *Columbia* incident and investigation.

Report of the Presidential Commission on the Space Shuttle Challenger Accident. Springfield, Va.: National Aeronautics and Space Administration, 1986. Provides a comprehensive view of what caused the *Challenger* accident and the tragedy's repercussions.

Vaughan, Diane. "Autonomy, Interdependence, and Social Control: NASA and the Space Shuttle *Challenger*." *Administrative Science Quarterly* 35 (June, 1990): 225-257. Provides informative discussion of NASA's failure to identify legitimate risks, which resulted in the *Challenger* tragedy.

See also: Accident investigation and reconstruction; Crime scene search patterns; Evidence processing; Flight data recorders; Mitochondrial DNA analysis and typing; Oral autopsy; ValuJet Flight 592 crash investigation.

Check alteration and washing

Definition: Process of changing checks intended for others, by simple alteration or exposure to chemical substances, to collect funds from bank accounts fraudulently.

Significance: The fraudulent cashing of stolen checks costs individuals and businesses in the United States hundreds of millions of dollars each year. Unfortunately, many altered checks are not detected until funds have already been transferred and the criminals are long gone. Security features are constantly evolving to combat this problem.

Check alteration is a very common problem in the United States, causing losses to victims of many millions of dollars each year. A common scenario is as follows: Someone writes a check to pay a bill and places the envelope containing the check in a residential mailbox, raising the box's red flag so that the letter carrier will pick up the outgoing mail. Unfortunately, the red flag also alerts a criminal that outgoing mail is in the box, and when no one is around the criminal rifles through the mail and takes anything that looks like it might contain a check. After collecting checks from a number of different mailboxes in the neighborhood, the criminal alters them, either by washing and rewriting them or by using simpler methods, so that he or she can cash them using a false identity. By the time the victims discover the withdrawal of funds from their accounts, the criminal has moved on to another identity or another town.

How Checks Are Changed

In the most basic type of check alteration, the perpetrator simply makes small changes to a check using a pen or other writing instrument similar enough to the one that was used to write the check to avoid detection. Examples of this include an individual changing a check for five dollars to a check for five thousand dollars by adding extra zeros and the word "thousand." Another example involves checks made out to the IRS (Internal Revenue Service). A criminal can take these checks and by adding two pen strokes change "IRS" to read "MRS." The criminal can then add a last name, making the check payable to "MRS. SMITH" or something similar, and then uses false identification to cash the check.

More complex check alteration involves actually removing the writing on the "payable to" line of the check, along with the amount. When this is done through the submersion of the check in a bath of fluid to dissolve the ink, it is known as check washing. Practiced criminals, and even some amateurs, can use a variety of household products to remove the inks of many commonly used pens from handwritten checks.

Common substances such as acetone (found in many products, including nail polish remover), bleach, and isopropyl alcohol can be used to wash checks. Different chemicals are often effective at removing different types of ink, and seasoned check washers can recognize many inks and choose just the right solutions to accomplish their goal. Check washers protect the signatures on the checks during the washing process, either by covering them with tape or by holding them out of the wash solution, so that after the chemicals have done their work, they have blank, signed checks that they can rewrite for any amount. Check washers often have many false identities supported by false driver's licenses, identification cards, and other documentation to help them cash checks without raising suspicion. After the checks are cashed, the victims often remain ignorant of the fraud for days or weeks, and by the time they report the crimes, the criminals have usually moved on.

Detection and Prevention

The most basic types of check alteration, those involving the simple addition or modification of writing on the payee line or in the amount of the check, can often be detected through close visual inspection or examination of the check with a magnifying glass or microscope. Very rarely is it possible for a criminal to find exactly the same type of pen used to write the check originally or to match the handwriting of the original check writer perfectly. Unfortunately, bank tellers, store clerks, and others in the first line of defense against check fraud rarely have the training, or the time, to do significant examination of each check that is presented for cashing. Because of this, most of even the most basic types of check alteration can slip through undetected; they are not caught until it is too late, when the victims whose accounts were charged receive their bank statements.

It can be difficult to detect check washing, but careful examination of a check can often reveal clues. In some cases, especially when the check washer is an amateur, some traces of the original ink markings may be visible. One problem with detecting check washing is that when the process does not work well, the criminal usually will simply not attempt to pass that particular check. This is good for the person whose check was stolen; instead of losing hundreds or even thousands of dollars, the individual is simply inconvenienced by the apparent disappearance of a check that never made it to where it was intended to go. Checks that seem to have been lost in the mail may have been stolen by individuals who planned to wash them; thus persons who realize that checks they have written are missing should be extremely vigilant.

Increasingly, security measures are being built into checks, especially high-security checks, that make it more difficult for criminals to copy or wash the checks and also make it easier for professionals to detect check alteration. Features of checks that can deter attempts to pass photocopied versions include watermarks, thermal verification seals, and the use of colored fibers woven into the paper. These features do not necessarily protect against washing, however. The best protection against check washing that is offered by check manufacturers involves the treatment of checks with chemicals that cause the paper to change color if it is submerged in any of the solutions commonly used by check washers.

Some simpler means of protecting against check alteration and washing are also available. One of these is the use of gel pens, instead of ballpoints or other pens, to write and sign checks. Gel inks are much more difficult to wash successfully because these inks enter the paper fibers of checks and become trapped. Another way to prevent check washing is to prevent the stealing of mail containing checks. People can help to protect themselves from check fraud by mailing bill payments only at post offices or by handing such mail directly to letter carriers. If they must place mail containing checks in home or business mailboxes for pickup, they should be careful to put the mail out as close to the pickup time as possible.

Helen Davidson

Further Reading

Abagnale, Frank W. *The Art of the Steal: How to Protect Yourself and Your Business from Fraud—America's Number One Crime*. New York: Broadway Books, 2001. Explains the various ways in which most common types of fraud, including check alteration, are committed and offers advice regarding how individuals can avoid becoming fraud victims.

Abagnale, Frank W., with Stan Redding. *Catch Me If You Can*. New York: Grosset & Dunlap, 1980. True story of a master of check alteration and washing, who passed more than $2.5 million in fraudulent checks in only five years.

Koppenhaver, Katherine M. *Forensic Document Examination: Principles and Practice*. Totowa, N.J.: Humana Press, 2007. Overview of document examination includes a chapter dedicated to check fraud and information on the presentation of evidence of document alteration in the legal process.

Wells, Joseph T. *Principles of Fraud Examination*. Hoboken, N.J.: John Wiley & Sons, 2005. Covers many different aspects of fraud, including check tampering, and discusses red flags that may indicate fraud. Provides many real-world examples.

_______, ed. *Fraud Casebook: Lessons from the Bad Side of Business*. Hoboken, N.J.: John Wiley & Sons, 2007. Collection of more than sixty real cases written by the fraud experts who investigated them. Includes information about the practices and investigative techniques used.

See also: Document examination; Fax machine, copier, and printer analysis; Forensic accounting; Handwriting analysis; Hughes will hoax;

Identity theft; Microscopes; Paper; Questioned document analysis; Secret Service, U.S.; Sports memorabilia fraud; Typewriter analysis; Writing instrument analysis.

Chemical agents

Definition: Chemical compounds with toxic properties that can be used to cause harm to humans, plants, and animals.

Significance: Chemical agents are classified as weapons of mass destruction and have the capability of inflicting massive amounts of damage and death. Given that some domestic terrorist groups have attempted to deploy chemical agents within the United States, it is important that forensic investigators have a thorough understanding of these compounds, their effects on the human body, and effective ways to combat chemical attacks.

Since their first use as weapons during World War I, chemical agents have been deployed numerous times. Large stockpiles of these agents are maintained in different parts of the world, largely because of nations' needs to develop chemical programs for research purposes.

The U.S. Department of Homeland Security lists six main categories of chemical agents: biotoxins, blister agents, blood agents, choking agents, nerve agents, and incapacitating agents. Biotoxins are agents that come from plants or animals; these include compounds such as ricin and nicotine. Blister agents, also known as vesicants, are among the agents most commonly associated with the term "chemical weapons"; these cause blistering to the skin, eyes, and respiratory system on contact. Mustard gas, perhaps the most widely known blister agent, was first employed by Germany in 1917, during World War I. Blood agents, which include cyanide and carbon monoxide, enter the body through the bloodstream.

Choking agents, when inhaled, damage the membrane of the respiratory tract and cause asphyxiation from pulmonary edema. Chlorine and phosgene are both choking agents. Nerve agents are some of the most recently used chemical weapons (during the Iran-Iraq War, 1980-1988); these compounds are designed to disrupt the nervous system and keep it from functioning properly. The nerve agent sarin was employed in the Tokyo subway attack perpetrated by the religious cult Aum Shinrikyo in 1995. Nerve agents can kill within minutes of exposure to a lethal dosage. Incapacitating agents, in contrast with other chemical agents, are not generally lethal; they produce mental or physiological effects that inhibit normal functioning. Law-enforcement agencies sometimes use such highly irritating agents for purposes of crowd control; tear gas is the most widely known example.

Numerous chemical detection devices are in common use by law-enforcement and emergency medical personnel who respond to scenes where chemical contamination may be suspected. One type consists of a glass tube that contains reagents (substances designed to foster a reaction with another substance) that will react chemically with a suspected agent in a predetermined volume of air. By measuring the stain produced, the user can determine which agent was detected. Among the least effective methods of detecting chemical agents is the use of pH test strips. When chemicals come into contact with such strips, they indicate the alkalinity or acidity of the chemicals through a change of color. A gas chromatograph-mass spectrometer (GC-MS) is a device made of two separate tools that are most effective in combination. A GC-MS separates the various elements that make up compounds and measures their quantity to identify the compounds. Many of the devices that first responders use to detect chemical agents are most reliable when they are employed in conjunction with other tools of forensic science.

Michael W. Cheek

Further Reading

Bevelacqua, Armando, and Richard Stilp. *Terrorism Handbook for Operational Responders*. 2d ed. Albany, N.Y.: Delmar, 2004.

Croddy, Eric A., with Clarisa Perez-Armendariz and John Hart. *Chemical and Biological*

Warfare: A Comprehensive Survey for the Concerned Citizen. New York: Copernicus Books, 2002.

Hoenig, Steven L. *Handbook of Chemical Warfare and Terrorism*. Westport, Conn.: Greenwood Press, 2002.

See also: Blood agents; Centers for Disease Control and Prevention; Chemical Biological Incident Response Force, U.S.; Chemical terrorism; Chemical warfare; Chemical Weapons Convention of 1993; Decontamination methods; Mustard gas; Nerve agents; Sarin; Soman; Tabun.

Chemical Biological Incident Response Force, U.S.

Date: Activated on April 4, 1996

Identification: Branch of the U.S. Marine Corps designed to respond rapidly to terrorist-initiated chemical and biological threats against the United States.

Significance: Developed in response to growing threats of terrorist attacks during the mid-1990's, the U.S. Chemical Biological Incident Response Force is designed to work with other federal, local, and state emergency response agencies. The force's services include chemical and biological agent detection, emergency medical care, casualty search and rescue, and personnel decontamination.

A self-sustaining unit under the command of the U.S. Marine Corps, the Chemical Biological Incident Response Force, or CBIRF, is part of the Fourth Marine Expeditionary Brigade. It is headquartered at Indian Head, Maryland, twenty-seven miles from Washington, D.C. Its personnel represent a variety of military occupational specialties. The CBIRF owns and maintains commercially available radiological, biological, and chemical defense equipment; general support equipment; and medical equipment used in support of its quick-response mandate to terrorist incidents occurring throughout the world.

Although the CBIRF is not directly involved in counterterrorist operations, its personnel are trained to deal with the consequences of chemical and biological attacks. Other government agencies have expertise and responsibilities that overlap those of the CBIRF. What makes the CBIRF exceptional is that it is a completely self-contained unit capable of handling all its mandated responsibilities on its own.

Background

Creation of the CBIRF was a response to such terrorist events as the bombing of Oklahoma City's federal office building and the Aum Shinrikyo cult's nerve gas attack on a Tokyo subway station—both of which occurred in 1995. In the aftermath of those events, U.S. president Bill Clinton issued a directive on counterterrorism policy calling for specific efforts to deter deadly terrorist attacks in both the United States and allied nations. The most tangible outcome of that presidential directive was the establishment of the CBIRF within the U.S. Marine Corps in April, 1996.

Shortly after its creation, the CBIRF was deployed to assist in a series of high-profile events. One of the first of these was the Summer Olympic Games in Atlanta, Georgia, during 1996. Less than ten minutes after a pipe bomb exploded in the Olympic Village, a CBIRF unit on standby only one mile away went into action. Since that time, CBIRF units have been deployed to serve at presidential inauguration ceremonies, subsequent presidential state of the union addresses in Congress, papal visits to the United States, and the 1999 summit meeting of the North Atlantic Treaty Organization (NATO).

Since the terrorist attacks on the United States of September 11, 2001, CBIRF units have been active in collecting biological samples and screening congressional mail and office equipment. In December of 2001, the CBIRF sent a one-hundred-member initial-response team into the Dirksen Senate Office Building in Washington, D.C., to detect and remove anthrax. CBIRF units have also supported overseas exercises in such countries as Bahrain, France, Iceland, Italy, Jordan, the Philippines, and Japan.

The Five CBIRF Elements

The CBIRF is organized to operate through five areas of responsibility called "elements": reconnaissance, decontamination, medical, security, and service support. After the nuclear, biological, and chemical (NBC) reconnaissance element defines the locations of incident sites, the decontamination element decontaminates personnel and equipment exposed to chemical or biological agents. Meanwhile, the medical element provides triage support to casualties, the security element provides security for the contaminated site, and the service support element provides shelter, food, and water.

Members of the reconnaissance elements are always the first to enter affected areas. They are trained and equipped to detect, classify, and identify all known chemical and biological agents. This element has two reconnaissance vehicles equipped to detect vapor and liquid contamination. The unit's twenty Marines, ten corpsmen, and one medical officer also provide emergency casualty evacuation teams capable of stabilizing and extracting casualties from the affected area.

Decontamination elements made up of twenty-seven Marines and sailors are responsible for the decontamination of personnel and casualties, and they stabilize casualties waiting for further treatment. Decontamination elements establish themselves at the edges of contaminated areas, near the medical elements' triage stations. There, personnel and casualties, both ambulatory and nonambulatory, are processed through a series of stations derived from NBC decontamination standards.

As contaminated individuals enter the areas, their personal effects and equipment are collected, and clothing items are removed. The individuals themselves are then sprayed and sponged with a 0.5 percent bleach solution and led through showers that rinse off the decontaminating liquid. The personal effects and equipment of the contaminated individuals are also processed through the cycle.

Individuals are then monitored with handheld chemical agent monitors (CAMs) to determine whether traces of contamination are still present. Those found still to be contaminated are again sent through the full decontamination cycle. After all casualties are decontaminated, element members change their bandages and dressings as needed and transport the individu-

CBIRF Teams in Action

At any given moment, CBIRF units are ready for rapid deployment in large diesel vans. These vans are specially equipped with onboard analytical systems designed to provide early detection and identification of chemical and biological agents used in terrorist attacks. When the units must be deployed rapidly to remote locations, the vans are loaded into C-130 aircraft.

During suspected terrorist attacks, the personnel of the CBIRF recon and rapid intervention group are typically first on the scene. There, they provide security, area isolation, and assistance to local medical authorities and service support. They assess the types of chemical agents present and determine the levels of protective clothing required for greatest safety:

- **Level C clothing:** full suits and gas masks
- **Level B clothing:** biological suits with air tanks
- **Level A clothing:** sealed, domelike environments

After donning the requisite clothing, casualty search teams enter the scene to locate and assess victims. They are soon followed by extract teams, which remove the casualties to decontamination tents, where up to thirty victims may receive attention. In assembly-line fashion, victims are placed on rollers that facilitate their movement from station to station within the tents as they progress through levels of assessment and treatment.

Meanwhile, Marines in full decontamination suits work to remove all clothing material for proper disposal. Victims are then sponged with decon solutions, rinsed with water, and sent to the final stations, where medical corpsmen tag them for appropriate medical attention.

New York City firefighters participate in a training exercise conducted by Marines of the U.S. Chemical Biological Incident Response Force in late 2003. Playing victims in a simulated biochemical incident, the trainees are lying on stretchers designed for rapid evacuation. *(AP/Wide World Photos)*

als to waiting medical personnel. Although the decontamination element's personnel includes Marines with a variety of occupational specialties, more than half of the Marines are NBC defense specialists who have undergone nine-week training courses at Fort McClellan, Alabama.

Equipment

When the CBIRF was first organized, it used "off-the-shelf" equipment, such as chemical-protective overgarments and gas masks. Other items included NBC reconnaissance vehicles capable of detecting both vapor and liquid contamination, chemical agent monitors, vapor and liquid agent detection kits, remote chemical agent sensing alarms, and decontamination kits. As the CBIRF has developed, it has played an increasing role in testing innovative concepts in equipment, techniques, and procedures used in its mandated tasks.

During the fall of 2004, CBIRF personnel began conducting exercises with a naval hovercraft on the Potomac and Anacostia rivers. Thanks to its air-cushion technology, the hovercraft is able to land on more than 70 percent of the world's coastlines. This is a huge increase over the approximately 15 percent of coastlines accessible by conventional landing craft. Capable of carrying payloads of up to seventy-five tons, the hovercraft significantly increases the CBIRF's ability to move quickly and efficiently into future emergency situations.

Richard S. Spira

Further Reading

Bolz, Frank, Jr., Kenneth J. Dudonis, and David P. Schulz. *The Counterterrorism Handbook: Tactics, Procedures, and Techniques*. 3d ed. Boca Raton, Fla.: CRC Press, 2005. Practical handbook describes the procedures that should be followed during and after terrorist attacks. Includes many of the procedures used by the CBIRF.

Boss, Martha J., and Dennis W. Day, eds. *Biological Risk Engineering Handbook: Infection Control and Decontamination*. Boca Raton, Fla.: CRC Press, 2003. Provides extensive coverage of the kinds of biological contaminants with which the CBIRF deals.

Cirincione, Joseph, Jon B. Wolfsthal, and Miriam Rajkumar. *Deadly Arsenals: Nuclear, Biological, and Chemical Threats*. Rev. ed. Washington, D.C.: Carnegie Endowment for International Peace, 2005. Presents an authoritative overview of the range of biological, chemical, and nuclear threats that the United States faces from terrorist attacks.

Environmental Protection Agency. *Compilation of Available Data on Building Decontamination Alternatives*. Washington, D.C.: Author, 2005. Provides information on the various technologies employed to decontaminate buildings affected by chemical and biological attacks.

Sauter, Mark A., and James Jay Carafano. *Homeland Security: A Complete Guide to Understanding, Preventing, and Surviving Terrorism*. New York: McGraw-Hill, 2005. Comprehensive textbook discusses the nature, methods, and dangers of terrorism and offers practical advice on dealing with terrorist threats at both national and individual levels.

Tucker, Jonathan B., ed. *Toxic Terror: Assessing the Terrorist Use of Chemical and Biological Weapons*. Cambridge, Mass.: MIT Press, 2000. Presents twelve case studies of the use of chemical and biological agents by terrorist groups. Identifies terrorists' patterns of behavior and discusses strategies to combat them.

See also: Anthrax; Anthrax letter attacks; Biodetectors; Biological terrorism; Biological warfare diagnosis; Biological weapon identification; Centers for Disease Control and Prevention; Chemical agents; Chemical terrorism; Environmental Measurements Laboratory; Quantitative and qualitative analysis of chemicals.

Chemical microscopy. *See* Polarized light microscopy

Chemical terrorism

Definition: Use of dangerous toxic chemicals that cause mass casualties and economic damage to achieve the objectives of terrorist groups.

Significance: The dangers posed to public health by attacks with lethal toxic chemicals are potentially catastrophic. When such attacks occur or are threatened, forensic toxicologists, public health officials, and law-enforcement agencies work together closely to identify the toxins involved, treat victims, decontaminate affected areas, bring perpetrators to justice, and provide protection to the public against future attacks.

Chemical agents capable of causing life-threatening injuries and death present serious threats to human communities. Many agents can be easily produced and disseminated in the atmosphere or public water and food supplies. When they make contact with human skin, mucous membranes, eyes, and respiratory and digestive systems, they can have harmful and even lethal effects. The dangers posed by chemical weapons are made greater by the ready availability of information on how to produce them in printed publications and on the Internet. Would-be terrorists with little or no chemistry training can produce dangerous chemicals easily and cheaply.

Chemical Toxins in History

Although potential uses of chemicals as poison weapons have been known for several centuries, they were not used as important weapons until World War I (1914-1918). In that European conflict, Germany, which then had the world's largest chemical industry, introduced poison gases into combat against Allied ground troops. The numbers of casualties from gas attacks were small in comparison with the overall casualty rates that troops suffered in that war. Nevertheless, the disruptions caused by fear of gas attacks and the need for troops to adopt protective equipment and procedures made poison gas an effective weapon. New lethal chemicals were produced during World War II but were not used as extensively in that conflict as in the earlier war, partly because of conventions against their use that the combatants honored.

After World War II, research and development on chemical weapons accelerated. By the late twentieth century, chemical weapons remained integral parts of many countries' secret military programs. Proliferation of these weapons gave many nations reason for concern that some of them might fall into the hands of terrorist organizations and be used in attacks that would overwhelm public health care delivery systems and cause high fatality rates and general chaos. By the early twenty-first century, no terrorist group had yet successfully mounted a large-scale chemical attack, but numerous small-scale attacks had occurred, and evidence that some groups have planned larger attacks has been found.

During the 1970's, a radical political group known as the Weather Underground Organization, or Weathermen, threatened to use chemical toxins during its series of terrorist attacks on institutions of the U.S. government. In 1984,

Classification of Chemical Toxins

The Centers for Disease Control and Prevention defines the following basic categories of chemical toxins.

- **Biotoxins:** Poisons derived from plants and animals, such as ricin, a poisonous protein extracted from castor beans.
- **Blister agents:** Also known as vesicants, chemicals that cause severe blisters on contact with eyes, the respiratory tract, and skin. An important member of this group is mustard gas.
- **Blood agents:** Chemical agents that cause pathological changes when absorbed into the bloodstream. Important members of this group include arsine and cyanide.
- **Caustics:** Chemicals that cause severe burns or corrosion on contact with the skin, eyes, and mucous membranes. Hydrogen fluoride is an important example.
- **Choking and pulmonary agents:** Chemicals that attack the respiratory tract, causing severe irritation and swelling of the tract and the lungs. Examples include ammonia, chlorine, methyl isocyanate, phosgene, and phosphine.
- **Incapacitating agents:** Chemicals that alter the consciousness of victims, such as BZ and opioids, which include natural and synthetic derivatives of opium.
- **Long-acting anticoagulants:** Toxins that prevent blood clotting, such as warfarin, which was originally developed as a medication for heart patients.
- **Metallic poisons:** Naturally occurring substances such as the chemical compound arsenic and the element mercury.
- **Nerve agents:** Powerful toxins that inhibit nerve functions, such as sarin and VX.
- **Toxic alcohols:** Poisonous alcohols that attack the heart, the kidneys, and the nervous system. An important member of this group is ethylene glycol, which is chemically similar to the ethyl alcohol consumed in liquor, wine, and beer products. Ethyl alcohol itself can also be toxic when consumed in large quantities.

an animal liberation group claimed it had laced candy bars manufactured by Mars, Incorporated, with rat poison. That claim moved the company to recall millions of chocolate bars and sustain a hefty economic loss. In 1985, federal agents found large quantities of potassium cyanide when they raided the Arkansas headquarters of an extremist organization called The Covenant, the Sword and the Arm of the Lord. That organization's apparent intention was to poison the water supply of several large cities. In 1989, Israeli forces found a stockpile of toxic chemicals in a Tel Aviv hideout of the Palestinian Liberation Organization. Three years later, a German neo-Nazi group attempted to pump hydrogen cyanide gas into a synagogue.

Two widely publicized atrocities involving chemical toxins occurred in Iraq and Japan. During the 1990's, the Iraqi government used chemical weapons against its own Kurdish citizens. In Japan, members of the Aum Shinrikyo religious cult attacked civilians in the Tokyo subway system with the nerve gas sarin in 1995. When police afterward raided the headquarters of the cult, which was later renamed Aleph, they found significant quantities of dangerous biological agents.

Combating Chemical Terrorism

The success of chemical terrorist attacks depends on the types of agent used, the ports of introduction of those agents, the methods of disseminating the agents, and the weather conditions. Nerve gas agents such as sarin and VX are strongly toxic and associated with high fatality rates. When such agents are disseminated in the open air, high humidity, high air temperatures, and strong winds can affect their potency and diminish their effectiveness. By contrast, when such agents are disseminated within enclosed buildings, fatality rates are likely to be high. Similarly, the dissemination of such agents with rockets or explosive ammunition in any almost environment can cause massive casualties. Poisoning an entire city's water supply is unlikely to be a practical method of chemical attack because of the massive amounts of toxic chemicals needed to make them effective in a large water system. Chemicals such as cyanide are most dangerous when they are used to target patrons of individual eating places or they are introduced into commercially sold beverages or foods.

Collaboration among the forensic experts and security agents of law-enforcement agencies, such as the Federal Bureau of Investigation (FBI) in the United States, and public health agencies is especially important in investigations of suspected chemical agent attacks. The first task of any investigation is to determine exactly what has happened and whether, in fact, chemical or biological agents have been used. The investigators then work to identify the toxic agents and their source.

Forensic scientists are assisted by security agents in collecting samples from crime scenes. The identification of any chemical agents that are collected assists health care professionals to provide treatment for survivors of the attacks. Public health officials also use forensic investigators' findings to plan and execute environmental decontamination of such crime scenes. Public health officials also work to identify everyone who has been exposed to the toxic agents, provide needed treatment, and monitor their health in case complications later emerge.

Terrorist Incidents in Japan

Immediately after a chemical attack in the Japanese city of Matsumoto in 1994, local police were alerted to a strange illness that claimed the lives of 7 victims and hospitalized 274 others. An initial investigation of the area that had been attacked found dead animals and abnormal changes in vegetation of the area. Autopsies found similarly unusual pathologies in the organs of human victims. Finally, a forensic analysis of the water in a pond within the area found traces of sarin nerve gas, conclusive proof of a deliberate chemical attack.

Japan suffered another, similar attack in March, 1995, during the midst of rush-hour commuter traffic in a Tokyo subway station. This attack exposed more than five thousand people to the dangerous sarin gas. The survivors of this attack who were checked by medical teams demonstrated symptoms similar to those of victims in the previous year's incident. Likewise, forensic pathological examinations of the dead revealed pathologies similar to those of the previous year's victims. Evidence collected from the subway attack confirmed the presence of sarin.

These events demonstrated the importance of close collaboration between security agencies and forensic experts in the investigation of suspected chemical terrorist attacks. The role of security agents is crucial in secluding the area affected by an attack, both to preserve evidence and to prevent more people from becoming exposed to any noxious agents. Security agents also serve important functions during rescue efforts, particularly in the management of mass-casualty disasters such as the Tokyo subway chemical terrorist attack.

Edward C. Nwanegbo

Further Reading

Charles, Daniel. *Master Mind: The Rise and Fall of Fritz Haber, the Nobel Laureate Who Launched the Age of Chemical Warfare*. New York: HarperCollins, 2005. Biography of the scientist who led the German chemical weapons effort during World War I places Haber's work in the context of his times. Includes bibliography and index.

Coleman, Kim. *A History of Chemical Warfare*. New York: Palgrave Macmillan, 2005. Describes the development and use of chemical weapons from 700 B.C.E. to the beginning of the twenty-first century, with extensive discussion of World War I. Also assesses current attempts to control the use and proliferation of such weapons and analyzes their potential use by terrorist groups.

Keyes, Daniel C., ed. *Medical Response to Terrorism: Preparedness and Clinical Practice*. Philadelphia: Lippincott Williams & Wilkins, 2005. Provides a review of clinical treatments for exposure to biological and chemical agents. Also discusses health care organizations' readiness for responding to terrorist attacks.

Roy, Michael J. *Physician's Guide to Terrorist Attack*. Totowa, N.J.: Humana Press, 2003. Provides an informative review of the infectious and chemical agents that potentially can be used in terrorist attacks.

Tucker, Jonathan B., ed. *Toxic Terror: Assessing the Terrorist Use of Chemical and Biological Weapons*. Cambridge, Mass.: MIT Press, 2000. Presents twelve case studies of the use of chemical and biological agents by terrorist groups. Identifies terrorists' patterns of behavior and discusses strategies to combat them.

Veenema, Tener Goodwin, ed. *Disaster Nursing and Emergency Preparedness: For Chemical, Biological, and Radiological Terrorism and Other Hazards*. 2d ed. New York: Springer, 2007. Nursing management guide addresses emergency needs for different categories of terrorist attacks as well as postdisaster care and psychological support for victims and their families.

Von Lubitz, Dag K. J. E. *Bioterrorism: Field Guide to Disease Identification and Initial Patient Management*. Boca Raton, Fla.: CRC Press, 2004. Volume aimed at medical professionals focuses on rapid recognition of the symptoms of exposure to biological or chemical weapons and on first steps in treatment for such exposure.

See also: Biological terrorism; Biosensors; Biotoxins; Botulinum toxin; Centers for Disease Control and Prevention; Chemical agents; Chemical Biological Incident Response Force, U.S.; Chemical warfare; Chemical Weapons Convention of 1993; Decontamination methods; Forensic toxicology; Mustard gas.

Chemical warfare

Definition: Use of toxic chemical substances to increase military and civilian casualties or to make habitat conditions unsuitable for military use by opponents during war.

Significance: Following the widespread use of chemical weapons during World War I, a number of countries tested and maintained stocks of such weapons as supplements to their stockpiles of more traditional military weapons. This work produced new chemical warfare agents as well as increasingly sophisticated ways to deliver and disseminate them, which led in turn to the development of better means of early detection of these agents and prevention of their spread. Forensic science is concerned with detecting and tracing specific chemicals used in the manufacture of chemical weapons, locating facilities that manufacture and store chemical weapons, and identifying nations with military programs that include chemical weapons in their arsenals.

Rudimentary forms of chemical warfare have been employed for millennia. Poisons of different kinds have been used to destroy livestock and armies' food supplies, with varying degrees of success, through the centuries. New World versions of chemical warfare measures include the arming of arrows, darts, and spears with batrachotoxins extracted from the poison dart frog in the tropics of Latin America. Modern chemical warfare was introduced during the early years of World War I, when French chemists loaded tear gas into small, hand-thrown bombs to be used by French troops to drive German soldiers out of their trenches. In response, German chemists manufactured chlorine gas, which was released from canisters downwind of the Russian army on the eastern front, marking the first time that lethal chemical weapons were used on a massive scale by any army. France responded with phosgene gas loaded in artillery shells, and before the end of the war all the major combatants were using chemical weapons. Gas masks became standard issue for soldiers of all sides on all fronts.

Since World War I, many countries have experimented with and stockpiled chemical weapons, and some have promoted chemical warfare, either openly or secretly. Modern chemical warfare involves the production of several types of chemical weapons, which may be classified according to their form (fluids, vapors, gases, or powders) or their persistence (that is, the length of time they maintain their toxic properties after dissemination). Chemical weapons can be further categorized based on how they affect human beings. Some recognized classes include lachrymatory (tear-causing) agents, such as chlorine gas and tear gas; nerve gases, such as sarin, which disrupt the nervous system; cyanides, which poison the digestive system; and agents containing acids that damage the skin or respiratory system.

When chemical substances are the cause of military and civilian casualties in war, specially trained forensic scientists are often called upon to collect and test evidence to determine the substances involved. Such scientists are trained in the detection of the chemicals used in weapons and in locating the sites where such weapons are manufactured. Their first objective is to collect chemical samples from corpses and from the scenes where the chemicals were deployed so that they can conduct tests to determine precisely what chemicals are present. Most substances used in chemical weapons have origin signatures or contain toxins that must be manufactured using specific types of equipment and techniques. By pinpointing the chemicals used, investigators may be able track the weapons from the chemicals' points of origin to the sites where the weapons were manufactured and to any storage locations. The evidence collected in this manner may aid in the investigation of war crimes and may be presented in national and international courts of law when accused perpetrators face trial.

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Further Reading

Harris, Robert, and Jeremy Paxman. *A Higher Form of Killing: The Secret History of Chemical and Biological Warfare*. New York: Random House, 2002.

Marrs, Timothy C., Robert L. Maynard, and Frederick R. Sidell, eds. *Chemical Warfare Agents: Toxicology and Treatment*. 2d ed. Hoboken, N.J.: John Wiley & Sons, 2007.

Romano, James A., Jr., Brian J. Lukey, and Harry Salem. *Chemical Warfare Agents: Chemistry, Pharmacology, Toxicology, and Therapeutics*. 2d ed. Boca Raton, Fla.: CRC Press, 2008.

Somani, Satu M., and James A. Romano, Jr., eds. *Chemical Warfare Agents: Toxicity at Low Levels*. Boca Raton, Fla.: CRC Press, 2001.

Sun, Yin, and Kwok Y. Ong. *Detection Technologies for Chemical Warfare Agents and Toxic Vapors*. Boca Raton, Fla.: CRC Press, 2004.

Tucker, Jonathan B. *War of Nerves: Chemical Warfare from World War I to al-Qaeda*. New York: Pantheon Books, 2006.

See also: Blood agents; Chemical agents; Chemical Biological Incident Response Force, U.S.; Chemical terrorism; Chemical Weapons Convention of 1993; Decontamination methods; Mustard gas; Nerve agents; Poisons and antidotes; Sarin; Soman; Tabun.

Chemical Weapons Convention of 1993

Dates: Opened for signature January 13, 1993; entered into force April 29, 1997

The Convention: International agreement designed to outlaw the production, stockpiling, and use of chemical weapons.

Significance: In addition to contributing to international security, the Chemical Weapons Convention mandated that signatory nations declare all chemical agents they had developed for possible military use and all production facilities for such agents. This information was made publicly available, assisting forensic scientists in their efforts to investigate crimes involving these or similar compounds.

Although crude types of poisonous and other chemical weapons have been known since the Spartans burned sulfur and pitch to create toxic fumes during the Peloponnesian War, it was not until the industrial age that massive quantities of chemical weapons could be produced. The use of substances such as mustard gas and chlorine gas in World War I caused massive deaths and brought chemical weapons to the attention of the world. The 1925 Geneva Protocol sought to limit the use of such weapons, but it did not outlaw the possession of chemical substances that might become weapons. Given that the violation of international law is most likely to happen during wars, at which time the enforcement of the law is least likely, chemical weapons continued to be used at various times throughout the twentieth century, although on a lesser scale than in World War I and often more hidden from public view.

Terms of the Agreement

During the early 1980's, negotiators representing various national governments began seeking to reach an agreement to go beyond the Geneva Protocol and outlaw the possession of chemical weapons. Finally, in 1992, a formal agreement was reached, and the Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on Their Destruction, also known simply as the Chemical Weapons Convention, was signed in January of the following year. As the name indicates, the convention broadened international law to prohibit not just the use but also the possession of virtually all chemical substances used as weapons.

The agreement mandated that all countries that signed the new law had to declare all their chemical weapons and production facilities publicly. The convention also included a long-term schedule for the destruction of stocks of weapons. An independent entity, the Organization for the Prohibition of Chemical Weapons, was created to oversee the provisions of the treaty. Of the 71,300 metric tons of chemical weapons declared by the more than 180 nations that have signed the treaty, more than 23,000 tons were destroyed during the first decade after the treaty entered into force. All the sixty-five production facilities declared were either destroyed or converted to peaceful purposes.

The international law has thus been upheld, which should have decreased the possibility that illegal groups can obtain chemical weapons, but this has not necessarily been the result. After the technology to create a chemical weapon has been developed, others can copy what had previously been done only in government laboratories.

Sarin Attack and Its Aftermath

Although rare, attempts to use chemical substances as weapons on a large scale have been made by individuals and nongovernmental groups. One of the most widely publicized attempts to use a chemical weapon as a tool of terrorism took place in 1995, when members of the Japanese religious cult Aum Shinrikyo released sarin gas, a nerve agent, in the Tokyo subway system. Owing to the relatively small amount of the gas released in the subway cars and an inefficient system of circulating the gas, the death toll was very low in this case, with only twelve people killed. Some fifty-five hundred others were injured by the gas, however. It was later found that the sect had legally purchased tons of materials capable of being used in the production of chemical weapons. The laws in Japan concerning such materials have since changed, as this incident brought vividly into focus the scope of the potential dangers posed by chemical weapons.

Article I of the Chemical Weapons Convention

General Obligations

1. Each State Party to this Convention undertakes never under any circumstances:
   a. To develop, produce, otherwise acquire, stockpile or retain chemical weapons, or transfer, directly or indirectly, chemical weapons to anyone;
   b. To use chemical weapons;
   c. To engage in any military preparations to use chemical weapons;
   d. To assist, encourage or induce, in any way, anyone to engage in any activity prohibited to a State Party under this Convention.
2. Each State Party undertakes to destroy chemical weapons it owns or possesses, or that are located in any place under its jurisdiction or control, in accordance with the provisions of this Convention.
3. Each State Party undertakes to destroy all chemical weapons it abandoned on the territory of another State Party, in accordance with the provisions of this Convention.
4. Each State Party undertakes to destroy any chemical weapons production facilities it owns or possesses, or that are located in any place under its jurisdiction or control, in accordance with the provisions of this Convention.
5. Each State Party undertakes not to use riot control agents as a method of warfare.

The fact that one group had used a chemical agent to push its agenda of destruction made law-enforcement agencies much more vigilant around the world. When the Chemical Weapons Convention had been ratified by enough countries to go into force in 1997, law-enforcement officials gained significant knowledge regarding chemical weapons. As nations declared their weapons stockpiles and production facilities, it became clearer what types of chemical agents might be available and from what sources. After the secrecy surrounding chemical weapons was removed, law-enforcment agencies could make better plans for responding to the threats that did exist. This also facilitated investigation into the possible use of these agents, as law-enforcement personnel could be better prepared to watch for activities that might indicate that criminal groups were trying to create such weapons.

One other aspect of the treaty that affected law-enforcement practices in some countries is the provision limiting the types of chemical agents that can be used for crowd control and other domestic concerns. Unlike some other international treaties, the Chemical Weapons Convention includes provisions that are binding on domestic law-enforcement agencies in signatory nations. Police are not allowed to use chemicals that are on the convention's list of prohibited agents and "have irritation or disabling physical effects which disappear within a short time following termination of exposure."

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Further Reading

Cirincione, Joseph, Jon B. Wolfsthal, and Miriam Rajkumar. *Deadly Arsenals: Nuclear, Biological, and Chemical Threats*. 2d ed. Washington, D.C.: Carnegie Endowment for International Peace, 2005. Provides an overview of the range of chemical weapon threats facing the United States.

Drell, Sidney D., Abraham D. Sofaer, and George D. Wilson, eds. *The New Terror: Fac-*

ing the Threat of Biological and Chemical Weapons. Palo Alto, Calif.: Hoover Institution Press, 1999. Collection of essays with commentary covers a wide range of issues, including the constitutional constraints on U.S. law-enforcement agencies combating chemical weapons and methods for minimizing the damage caused by such weapons.

Kirby, Reid D., and U.S. Army Chemical School. *Potential Military Chemical/Biological Agents and Compounds*. Wentzeville, Mo.: Eximdyne, 2005. U.S. military field manual identifies various chemical agents and their properties. Includes additional information on industrial chemicals.

Sun, Yin, and Kwok Y. Ong. *Detection Technologies for Chemical Warfare Agents and Toxic Vapors*. Boca Raton, Fla.: CRC Press, 2004. Covers the means for detecting both military and industrial chemicals that might be used by terrorists and discusses steps that should be taken to prepare for such attacks or for accidents.

Tucker, Jonathan B., ed. *Toxic Terror: Assessing the Terrorist Use of Chemical and Biological Weapons*. Cambridge, Mass.: MIT Press, 2000. Presents twelve case studies of the use of chemical and biological agents by terrorist groups, identifying terrorists' patterns of behavior and strategies to combat them.

See also: Blood agents; Chemical agents; Chemical terrorism; Chemical warfare; Mustard gas; Nerve agents; Quantitative and qualitative analysis of chemicals; Sarin; Soman; Tabun.

Chicago nightclub stampede

Date: February 17, 2003

The Event: Twelve women and nine men, ages twenty-one to forty-three, were killed and more than fifty other persons were injured when they were trampled or crushed as a panicked crowd attempted to flee Chicago's E2 nightclub through a single exit after pepper spray was used inside the club to break up a fight.

Significance: Situations in which surging crowds of people cause injuries and deaths are of great concern to law-enforcement officials and public safety authorities. When such events occur, coroners and medical examiners must perform autopsies to determine the specific causes of any deaths.

The E2 nightclub occupied the second floor of a building above the Epitome restaurant on South Michigan Avenue in Chicago, Illinois. E2 was frequented by celebrity figures and was considered by many in the local African American community to be the place to be seen. On the night of Monday, February 17, 2003, a party promoted by Envy Entertainment was in progress in the nightclub. The promoter had hired ten security guards to maintain order and assist patrons. When one of the security guards used pepper spray to attempt to stop a fight among some patrons, some people in the crowd began choking on the chemicals and then some began to shout, "Poison gas!" It was later reported also that someone said, "I bet it's Bin Laden."

The panicked crowd scrambled to get to the club's only open staircase leading outside. In the stampede, some smaller people were pushed and trampled by others as they tried to get to the door. The crowd got stuck on the restricted stairway, but people continued to pile on top of those already trapped. Some were literally squeezed to death or asphyxiated by crushing; many sustained broken bones. By the time police and fire officers arrived, even though security guards had been trying to remove fallen victims from below, the crush was so tight that significant exertion was required to begin to disentangle individuals from the pile of patrons.

Following the incident, the Cook County medical examiner's office performed routine after-death activities. The office certified the causes of death and held bodies at the morgue, where, even after several days, families and

Two attorneys watch an expert witness take measurements in the stairwell leading from the E2 nightclub in Chicago. Early the previous morning, February 17, 2003, twenty-one people died in a panic-driven stampede down the narrow stairwell after pepper spray was used in an attempt to break up a fight inside the nightclub. *(AP/Wide World Photos)*

friends came looking for loved ones. Much of the investigation into the incident itself was assigned to the Chicago Fire Department. A deputy medical examiner eventually testified at a hearing that "all E2 victims were crushed."

The deaths triggered a series of investigations and disputes involving licensing of the club and permits issued by the city of Chicago. Prominent African Americans spoke out in support of the club owners, and the owners of the club and their attorneys maneuvered to avoid criminal charges by attempting to discredit Chicago city officials. Significant civil damages were eventually paid.

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Further Reading

Horan, Deborah, and Sean Hamill. "It Was People on Top of People." *Chicago Tribune*, February 18, 2003.

Sadovi, Carlos. "All E2 Victims Were Crushed." *Chicago Tribune*, January 26, 2007.

"Stampede at Chicago Nightclub Leaves Twenty-one Dead." *USA Today*, February 19, 2003.

See also: Asphyxiation; Autopsies; Choking; Fire debris; Forensic pathology; Smoke inhalation; Suffocation.

Child abduction and kidnapping

Definition: Unlawful seizing and detaining of children, through force or enticement, with the intent of keeping the children permanently or with the intent of harming the children or concealing them from their legal parents or guardians until ransoms are paid.

Significance: State and federal law-enforcement agencies working to solve child abduction and kidnapping cases often draw upon the tools of forensic science to locate missing children and to identify children when they are recovered or when their bodies are found.

Distinctions between "child abduction" and "child kidnapping" are not always clear-cut, as the terms are not always used consistently in the news media, the sociological literature, and statutory law. Generally, however, "child abduction" is the more inclusive term and is almost always the term applied to the unlawful seizing or detaining of children by their own close relatives. Abductions by family members are also the most common form of child abduction. The word "kidnapping" tends to be applied more to abductions by nonrelatives, particularly people who are strangers to their youthful victims. That term is generally applied to cases in which perpetrators abduct children with the intention of demanding ransoms for their return, physically abusing or harming the children, or keeping them permanently separated from their legal guardians for other reasons.

In the popular public perception, many if not most abductions of children are perpetrated by strangers or by little-known acquaintances of the victims. However, most nonrelative abductions are actually perpetrated by people with whom the victims' families are well acquainted. Nevertheless, fear of kidnapping by strangers is behind public campaigns to alert families to what is called "stranger danger" and efforts to have children carry identification cards, to collect fingerprints and DNA (deoxyribonucleic acid) samples of children for possible future need, and to have current photos available. Public awareness of the danger of child abduction has been kept alive by such practices as advertising missing children on milk cartons and the broadcasting of AMBER Alerts. Taking their name from "America's Missing: Broadcast Emergency Response," AMBER Alerts are designed to disseminate information on missing children as widely and quickly as possible. In many regions, the alerts interrupt television programs and are broadcast on electronic traffic signs over freeways. These and other practices help to dramatize the dangers of child abduction and foster the perception that most abductions are perpetrated by dangerous criminals.

Abduction and the Law

The abduction of children is everywhere regarded as a horrendous crime against society and has prompted legislation and law-enforcement efforts to prevent its occurrence. Highly publicized kidnapping cases typically prompt fresh legislation and new antikidnapping campaigns. One of the most famous child kidnapping cases in American history was the 1932 abduction and murder of the infant son of Charles A. Lindbergh, a famous aviator who was regarded as a national hero. The widespread public revulsion against that crime prompted the U.S. Congress to pass legislation, the Federal Kidnapping Act, popularly known as the Lindbergh Law. This law was significant because it authorized the investigation of kidnapping cases by the Federal Bureau of Investigation (FBI), which draws on the largest databases and most advanced forensic tools available to law enforcement.

In 1980, Congress enacted the Federal Parental Kidnapping Prevention Act to address the lack of uniformity in state laws regarding kidnapping. Disparities in the laws among different states encouraged some noncustodial parents forcibly to take their children to states with less stringent requirements or to refuse to return their children to the custodial parents' states so they could retain custody themselves. The new federal law gave the home states of abducted children priority in the resolution of custody disputes.

Several federal agencies provide assistance to local law-enforcement agencies that are investigating abducted children. In addition to the FBI, these agencies include the National Center for Missing and Exploited Children and the Forensic Services Division of the U.S. Secret Service. The services the agencies provide include on-site investigators, access to handwriting and fingerprint databases, and laboratory analyses of evidence and written reports. In addition, they make available consultations with forensic experts in such fields as computer forensics, forensic photography, graphic arts, video production, imaging, voice analysis, and computer modeling, and they provide experts to testify in court proceedings.

Prevalence

Among the various violent crimes perpetrated against children and juveniles in the United States, abduction is comparatively rare. In a study published in 2000, David Finkelhor and Richard K. Ormrod found that child abduction was responsible for less than 2 percent of all violent crimes against juveniles that were reported to law enforcement. Although large numbers of children are annually abducted, most abductees are returned to their families within short periods of time. However, parents and other family members are themselves responsible for most child abductions. In the year 1999, for example, roughly 78 percent of the approximately 262,100 children abducted throughout the United States were taken by relatives. Slightly fewer than 1,000 of the abductions were perpetrated by parents who were citizens of other countries.

Kidnapping and abductions by nonrelatives, both family acquaintances and strangers, accounted for about 22 percent of child abductions in 1999. In contrast to popular belief, the most frequent victims of nonfamily kidnapping—about 80 percent—are not young children but youths age twelve and older. Children from fifteen to seventeen years old make up nearly 60 percent of acquaintance and stranger kidnapping.

Family and Acquaintance Abductions

"Parental abduction" is generally defined as taking and not returning a child in violation of the custodial rights of the child's parent or guardian by another member of the family or someone acting on behalf of a family member. Indeed, any form of concealment of a child to prevent return, contact, or visitation is consid-

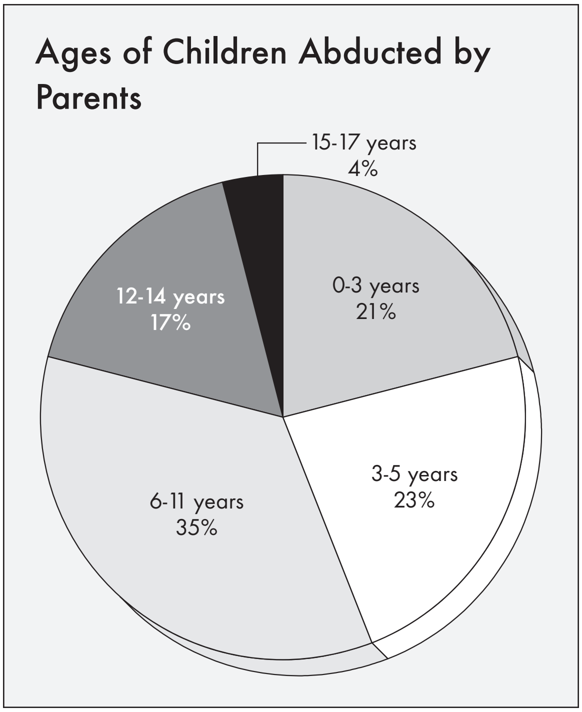
Megan's and Jessica's Laws

In 1994, a seven-year-old girl named Megan Kanka was kidnapped, raped, and brutally killed by a man who lived across the street from her family home in New Jersey. Unbeknownst to her parents up until that time, her murderer and his two housemates were all convicted sexual predators. After Megan's death, her parents created the Megan Nicole Kanka Foundation to put pressure on New Jersey's government to enact legislation requiring public notification of the residences of known sex offenders. The state legislature responded quickly, making New Jersey the first state to pass such legislation. Most other states soon followed New Jersey's lead. Details of legislation requiring community notification regarding persons convicted of sex crimes against children vary widely among the states, but all such legislation has become popularly known as "Megan's Law." The federal government also enacted similar legislation. The Jacob Wetterling Crimes Against Children and Sexually Violent Offender Registration Act of 1994 requires convicted sex offenders to notify local law enforcement of any changes in their addresses or employment.

Another horrific case of kidnapping occurred in Florida in 1995, when a nine-year-old named Jessica Lunsford was kidnapped, raped, and murdered by a forty-seven-year-old man. Public outrage against this crime led Florida's legislature to pass a law setting mandatory minimum prison sentences on adults convicted of sex crimes against children under thirteen years of age. Florida's law and those of the many other states that passed similar legislation are popularly known as "Jessica's Law."

ered be unlawful abduction. Likewise, transporting a child out of a state or country with the intent to deprive the caretaker of custodial rights or contact is also unlawful abduct in order for the act to be considered abduction. In cases involving children who are fifteen years of age or older and considered mentally competent, unlawful abduction occurs only when the perpetrators use physical force or threats of bodily harm to the children who are hidden or are taken from the state. Most parental abductions involve children six years or younger, with two-year-olds being the most frequently abducted. Such abductions typically occur at the children's homes.

Gender appears to have little bearing on parental child abduction. Statistics show that girls and boys are equally at risk of being abducted by their parents. Moreover, both mothers and fathers abduct children. However, although some studies find that noncustodial mothers and fathers are equally likely to abduct their children, others find that noncustodial fathers are more likely than mothers to be perpetrators.



Source: Office of Justice Programs, Office of Juvenile Justice and Delinquency Prevention, 2002. Figures are based on 203,900 incidents of child abduction in the United States in 1999.

Statistics for other types of abduction do show patterns that are more clearly gender-related. For example, almost three-quarters of acquaintance abductions of teenagers involve female victims. In general, teenage girls are more likely to be abducted by acquaintances than by strangers. Almost one-third of perpetrators are teenage boys. Moreover, boyfriends and former boyfriends account for nearly one-fifth of teenage girl abductions.

Stranger Abductions

Although the media often publicize stranger kidnapping, Finkelhor and Ormrod's study of juvenile kidnapping found that stranger and nonfamily child kidnapping is rare. A comparatively small percentage of juvenile abductions conform to the stereotypical model of kidnapping—that is, the taking of children and holding them for extended periods of time, whether to attempt to extort ransom or to subject the children to sexual assault and murder. The majority of perpetrators of that kind of abduction are strangers to their victims. Most stranger kidnappings occur in outdoor settings. Nearly 60 percent of the crimes occur in such outdoor public places as parks, streets, and parking lots. Kidnappings rarely occur on school grounds.

Some gender and age patterns can be seen in stranger abductions. For example, girls are twice as likely as boys to be victims of nonfamily kidnapping. Teenagers account for more than half the victims, elementary school-age children account for just over one-third of the victims, and preschoolers are rarely targeted. About 95 percent of perpetrators of stranger kidnapping are male. About 20 percent of the abductions are connected with other violent crimes, such as sexual assault, which is most commonly inflicted on girls. When kidnapping is connected with robberies, boys are more likely to be victims, and firearms are often involved in the kidnapping.

Among infants between six and twelve months old, boys and girls are equally at risk of being abducted by strangers, and most perpetrators kidnap infants of the same race. Infants who are kidnapped tend to be in good health, and their risk of being physically injured during their abductions is low. However, the risk of harm to the parents—especially mothers—during kidnapping is high when infants are taken from their homes. Mothers are occasionally killed by kidnappers; in some instances, unborn babies are taken from their mothers' wombs.

Forensic Techniques Used in Investigations

As with investigations into any specialized field of crime, child abduction and kidnapping investigations draw on specialized forensic tools and procedures. One of the most important aspects of many child kidnapping investigations is identifying recovered children who have not been seen by their families for many years. The method most frequently used to identify kidnap victims is simple visual recognition by their parents. However, that method may not work in cases involving children who have been away from their parents so long that their physical appearance and voices have changed and their memories have faded. Such cases generally call for advanced forensic techniques. For example, photographic manipulation and age regression techniques may be used. These techniques entail manipulating old photographs artificially to age the faces of children so they will appear to match the current ages of the kidnapped children.

Some of the methods used to identify abducted infants after they are returned employ evidence that may have been collected when the children were born. For example, matching footprints to prints recorded on birth documents is the second-most-frequently used method of identification. Other evidence that is used includes blood tests, photographs, birthmarks, hospital wristbands, and DNA samples.

In kidnapping cases, it is vital that the initial investigators collect as much evidence as possible from the crime scenes, especially when children are abducted by nonfamily members and there is a possibility of their being held for ransom or becoming targets of sexual or violent crimes. Blood samples, hair samples, fibers, and other forensic evidence must be collected as soon as possible and properly stored. Such evidence often proves crucial in tracking victims' movements and identifying young victims after they are recovered.

Characteristics of Strangers Who Kidnap Children

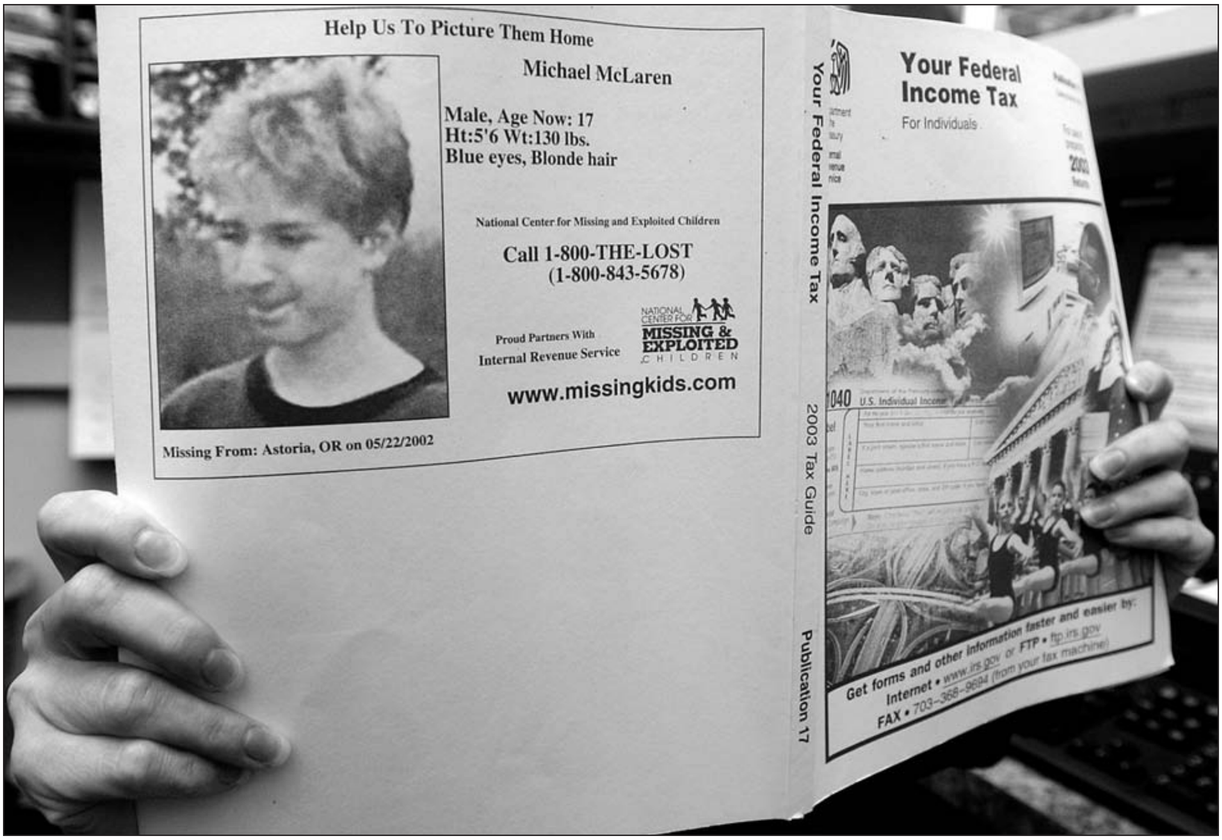
- Most are male.
- Most are white.
- Most are under thirty years of age.
- Most are single.
- About half are employed.
- Employed male kidnappers typically work in unskilled and blue-collar occupations.
- About two-thirds of male kidnappers have prior arrest records, mostly for violent crimes, especially sexual assault against children.
- Female kidnappers are less violent than their male counterparts and rarely murder their victims.
- Female kidnappers are often motivated by revenge, the desire to have a child, or other emotional reasons.

Analysis of latent fingerprints is frequently an important tool in investigations of child abductions and missing children. Fingerprints often reveal the specific locations where children have been or the vehicles in which they have been transported. Latent prints also can be used to identify the child. A special problem in using fingerprint evidence in child abduction cases is that the latent prints of children may not last as long as those of adults, possibly because children's fingers secrete less oily residue.

DNA samples taken at birth from an infant or provided by the guardians of the missing child can be very helpful in identifying a missing child. Also, DNA can place a child at a scene or in an area or in a vehicle, and this information can help authorities to track the child's movements.

Identifying Dead Kidnap Victims

In the unfortunate cases in which kidnapping victims die, a primary task of forensic investigators is to identify the remains of whatever bodies have been recovered. The basic techniques used to identify children's remains are the same as those used to identify remains of adults. However, the remains of juveniles do



In 2004, the Internal Revenue Service joined in the effort to raise public awareness of child abductions in the United States by printing pictures of missing children on income tax preparation materials. *(AP/Wide World Photos)*

present some special problems. For example, juvenile skulls are not as fully developed as skulls of adult human beings. The shapes of skulls change considerably as individuals grow older, making it more difficult to identify the remains of children who have been missing for long periods. Changes in skull shape are particularly great during the first few years of children's lives. The length of an infant skull is about one-quarter the full height of the body. Adult skulls are only about one-eighth of full body height. As children grow older, their skulls and bodies gradually assume adult proportions. Meanwhile, the proportions of their facial features to their heads change. For example, the nasal and dental areas become larger relative to the rest of their faces. Other physical changes occur in the pigmentation and elasticity of their skin and the distribution of fatty tissue in their faces. The forensic reconstruction of juvenile faces must take into account these and other differences between juvenile and adult faces.

Some changes in skulls of children may actually assist in estimating the children's ages. For example, there is a consistent and predictable sequence for the formation, eruption, and loss of a child's first teeth—or baby teeth—and their replacement with permanent teeth. Thus, the age of a preadolescent child can be estimated by examining how many of its teeth have emerged, the extent of calcification of the first molars, and the calcification of the dentition in its entirety.

Judy L. Porter

Further Reading

Bartol, Curt R., and Anne M. Bartol. *Introduction to Forensic Psychology*. Thousand Oaks, Calif.: Sage, 2004. Comprehensive work provides an easily understood guide to forensic psychology.

Beyer, Kristen R., and James O. Beasley. "Nonfamily Child Abductors Who Murder Their Victims: Offender Demographics from Interviews with Incarcerated Offenders." *Journal of Interpersonal Violence* 18 (October, 2003): 1167-1188. Presents the results of an analysis of data gleaned from personal interviews with offenders who have kidnapped and murdered children.

Blasdell, Raleigh. "The Longevity of the Latent Fingerprints of Children Versus Adults." *Policing: An International Journal of Police Strategies and Management* 24, no. 3 (2001): 363-370. Presents evidence from a study that found that children's latent fingerprints do not last as long as those of adults and discusses the implications of this finding for forensic science and law enforcement.

Burgess, Ann Wolbert, and Kenneth V. Lanning. *An Analysis of Infant Abductions*. Washington, D.C.: National Center for Missing and Exploited Children, 2003. Discusses in depth the national data on infant abductions.

Finkelhor, David, and Richard K. Ormrod. *Kidnaping of Juveniles: Patterns from NIBRS*. OJJDP Bulletin NCJ 181161. Washington, D.C.: U.S. Department of Justice, 2000. Brief work presents an analysis of the patterns found in the data concerning child abductions collected by the National Incident-Based Reporting System.

Hammer, Heather, David Finkelhor, and Andrea J. Sedlak. *Children Abducted by Family Members: National Estimates and Characteristics*. Washington, D.C.: U.S. Department of Justice, 2002. Brief work reports on data collected on family abductions by the National Incidence Studies of Missing, Abducted, Runaway, and Thrownaway Children.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005. Provides an overview of forensic science procedures, including those involved in the investigation of cases of kidnapping. Informative for both practitioners and students.

Steadman, Dawnie Wolfe. *Hard Evidence: Case Studies in Forensic Anthropology*. Upper Saddle River, N.J.: Prentice Hall, 2003. Presents constructive case studies that demonstrate the scientific foundations of forensic anthropology as well the broad scope of its modern applications.

Wilkinson, Caroline. *Forensic Facial Reconstruction*. New York: Cambridge University Press, 2004. Provides detailed description of the procedures involved in reconstructing faces and addresses the problems related to the determination of age, sex, and race using only the skull. Notes the particular problems of reconstructing the faces of children.

See also: Argentine disappeared children; Child abuse; DNA fingerprinting; Federal Bureau of Investigation Laboratory; Fingerprints; Forensic anthropology; Hostage negotiations; Lindbergh baby kidnapping; Megan's Law; Ritual killing.

Child abuse

Definition: Mistreatment of children that encompasses sexual molestation, infliction of physical injuries, emotional and psychological maltreatment, neglect, forced isolation, and threats of inflicting harm and other forms of intimidation.

Significance: Child abuse, long one of the most underreported and underinvestigated forms of violent crime, is among the most difficult crimes to uncover and prosecute. In the past, investigations were typically relegated to child protective workers who were untrained in crime scene investigation and evidence collection and processing. With increasing frequency, however, child abuse investigations are being conducted by trained law-enforcement officers and by technicians who draw heavily on the tools of forensic science.

Child abuse is a serious crime whose victims' psychological and physical scars often last for years. Child abuse cases are typically difficult to investigate and prosecute, but the tools of modern forensic science are making important contributions in identifying and convicting offenders. Teamwork plays a special role in these investigations, which typically involve not only law-enforcement professionals but also social workers, mental health providers, physicians, and others.

Forms of Abuse

Both sociological and legal definitions of child abuse and molestation have varied over time. "Child abuse" and "child molestation" can be subsumed under the more inclusive phrase "child maltreatment," which encompasses neglect, child endangerment, emotional and psychological abuse, physical abuse, and sexual abuse. Perhaps the most common form of child maltreatment is neglect—the failure to provide minor children with the most basic needs of food, shelter, clothing, education, and medical care.

Legal definitions of child abuse and subtypes of abuse are codified in state statutes and vary among jurisdictions. In contrast to sociological definitions, which may be vague and open to different interpretations, legal definitions and individual statutes spell out exactly what behaviors are illegal. For example, when adults who are legally responsible for the care of children expose those children to dangerous conditions, the adults are guilty of child endangerment. Examples of endangerment range from leaving young children unattended in parked cars while running errands to leaving minors completely alone in their homes for extended periods.

Physical abuse takes many forms that are easy to define—hitting, slapping, punching, kicking, beating, striking with objects, stabbing, cutting, burning, and choking. Somewhat less obviously abusive but equally serious is the violent shaking of infants or toddlers, which often manifests itself in shaken baby syndrome. Severe instances of physical abuse can lead to death.

Physical abuse may be one of the most underreported crimes against children. Part of the reason is that very young children lack the ability to communicate the abuse. Also, some abused children may regard what their parents do to them as normal behavior. They may even think that they deserve to be hit because of their own misbehavior. Forms of emotional and psychological abuse are less easy to define legally. They include verbally abusing or deriding children and threatening or terrorizing them.

Laws against the sexual abuse of children generally provide precise definitions of illegal behavior. Such abuse encompasses any or all forms of sexual contact between minors and adults, from improper touching and fondling to forced vaginal, oral, or anal intercourse. Consensual sexual contact between two minors can be considered sexual abuse when a significant age difference exists between them. In some jurisdictions, a difference of only three or four years in the ages of sexual partners may be regarded as significant. Sexual abuse also includes involving minors in the making of pornography.

Criminal Investigations

The gathering and preservation of evidence in child abuse investigations can be a daunting job. Police investigators must find out what has happened, how it happened, and other information in order to make arrests and bring offenders to justice. The forensic sciences provide important tools for collecting evidence in these crimes.

The first step in collecting evidence of abuse in cases that are reported is to determine when the crimes occurred and how much time has elapsed since the crimes took place. When child abuse is reported immediately after incidents occur, police can usually collect more physical evidence than in cases in which longer periods of time have elapsed.

The clothing worn by victims during times when they have been abused often provides valuable physical evidence. Hairs and traces of tears, dirt, blood, and semen found on clothing can be used as direct evidence of crimes. Investigators also comb the crime scenes, which often contain such physical evidence as bloodstains, hair samples, semen stains, and fragments of damaged clothing. All items that are collected must be carefully packaged, labeled, analyzed, and protected for use in court.

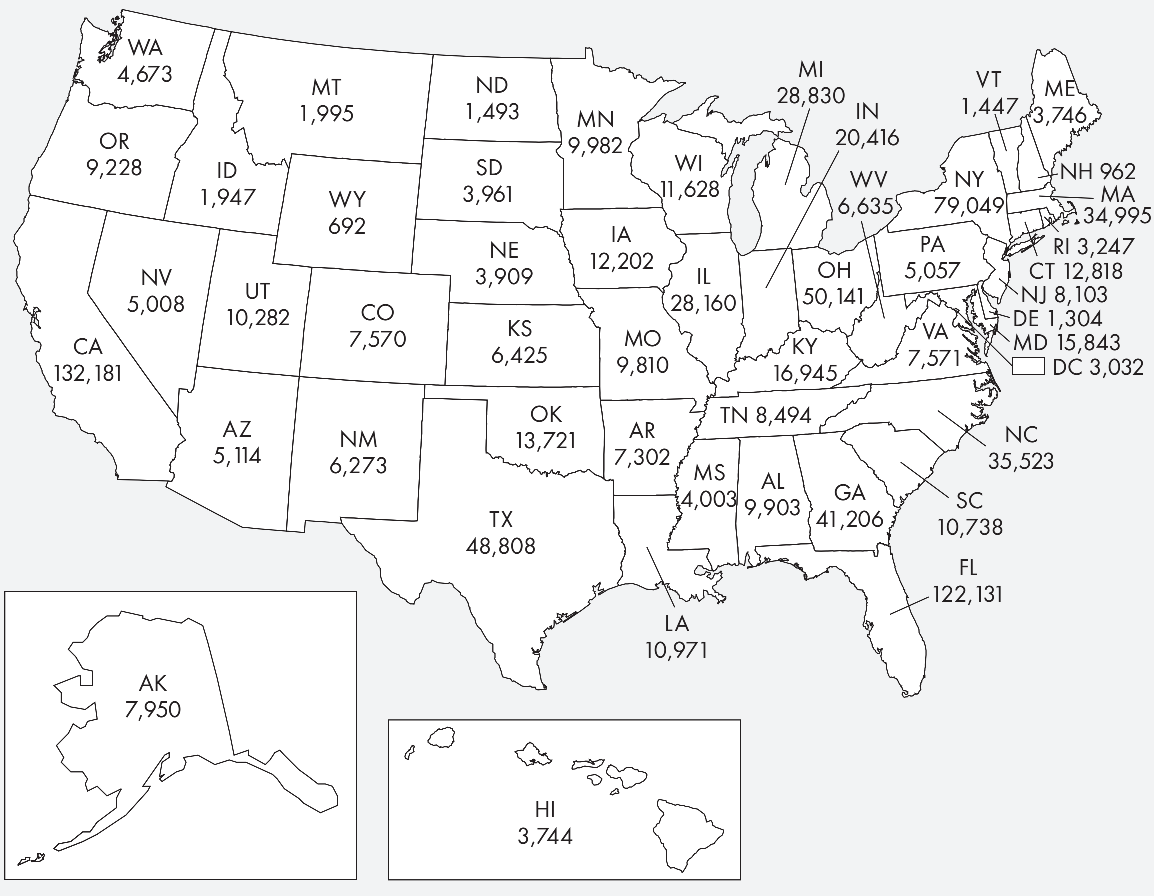
Medical Evidence of Abuse

Most injury evidence can be documented through medical procedures. Ideally, victims of child abuse should receive physical examinations by qualified physicians as quickly as possible. Indeed, in most cases of physical abuse of children, physicians discover evidence that maltreatment has occurred in the injuries themselves. For example, spiral arm fractures provide almost conclusive evidence of abuse, as such fractures are caused by arm twisting and can occur in almost no other way.

Another almost conclusive sign of child abuse that may be detected by physicians is traumatic alopecia—the forceful pulling of hair or breaking of hair shafts by friction, traction, or other forms of physical trauma. Traumatic alopecia occurs when abusers deliberately pull the hair of their child victims. Hair pulling can cause hemorrhaging under the scalp, which has a rich supply of blood vessels. Accumulations of blood under the scalp are often important clues in differentiating between abusive and nonabusive hair loss.

Medical evaluations can discover evidence of shaken baby syndrome, which is responsible for at least half the deaths of victims of child abuse. Vigorous shaking of an infant or toddler causes a number of medical conditions that physicians can read as signs of the syndrome. These include closed-head injuries that are evidenced by altered levels of consciousness, coma, convulsions, or death; central nervous system injuries

Cases of Child Abuse by State



Source: U.S. Department of Health and Human Services, 2004. Figures represent substantiated cases of child maltreatment in 2002. Total number of cases for the entire United States in 2002 was 897,168.

that are evidenced by central nervous system hemorrhaging, lacerations, contusions, and concussions; and retinal hemorrhages.

Central nervous system injuries can be identified through magnetic resonance imaging (MRI) and computed tomography (CT) scans. Both of these techniques are used to discover a variety of injuries that reveal abuse, such as intracranial and intra-abdominal abnormalities. Ultrasound, a technique that creates two-dimensional images and is used for examining internal body structures, can be used to detect physical abnormalities. It is especially useful for detecting intracranial hemorrhaging in children under the age of two.

Techniques for determining the age of skeletal injuries are also valuable in abuse investigations because they can help differentiate between accidental and intentionally inflicted injuries. For example, radiology studies that determine the ages of bone injuries make it possible to identify patterns of physical abuse over long periods of time.

Among all types of cases involving physical injuries, human bites are the most common and easily recognized form of physical maltreatment. The ability to recognize injuries as human bite marks is thus particularly important, and forensic dentistry (also known as forensic odontology) contributes a great deal to the investigation of such injuries. By analyzing bite marks, forensic dentists can often help to identify the individuals who made them.

DNA Evidence

Although many proven forensic science techniques are helpful in the investigation of child abuse, perhaps nothing has helped solve more crimes in this area than DNA (deoxyribonucleic acid) testing. DNA carries coded genetic information that determines individual traits. Analyses of DNA samples can be used to identify the persons from whom the samples come. DNA testing was first used in criminal investigations during the early 1980's and almost immediately became one of the most valuable tools available to forensic science.

Many parts of human DNA are the same in different persons; however, the parts found in nonfunctioning sequences vary greatly. The variable parts can be matched to single individuals. In criminal child abuse cases, investigators often collect samples of fluids, hairs, and tissues left behind on victims by their abusers. These samples are then compared with samples taken from suspected perpetrators. When samples are found to match, the possibilities of misidentification are remote. DNA testing requires only small amounts of sample material. Bloodstains the size of a dime and semen samples the size of a quarter are usually sufficient. Results of analyses are usually obtained within four to six weeks. DNA evidence has been used successfully in the prosecution of many perpetrators of child abuse.

Jerry W. Hollingsworth and the Editors

Further Reading

Barkan, Steven E. *Criminology: A Sociological Understanding*. 3d ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2006. Examines criminal justice issues from a sociological perspective. Includes discussion of child abuse.

Buzawa, Eve S., and Carl G. Buzawa. *Domestic Violence: The Criminal Justice Response*. 3d ed. Thousand Oaks, Calif.: Sage, 2003. Presents information on how law-enforcement agencies and the courts approach cases of child and spousal abuse.

Fontes, Lisa Aronson, ed. *Sexual Abuse in Nine North American Cultures: Treatment and Prevention*. Thousand Oaks, Calif.: Sage, 1995. Collection of essays discusses the characteristics of child sexual abuse in various cultural communities in North America.

Monteleone, James A. *A Parent's and Teacher's Handbook on Identifying and Preventing Child Abuse*. St. Louis: G. W. Medical Publishing, 1998. Provides valuable information on the signs and symptoms of child abuse for lay readers.

_______, ed. *Child Abuse: Quick Reference for Healthcare Professionals, Social Services, and Law Enforcement*. St. Louis: G. W. Medical Publishing, 1998. Illustrated guide is designed to help those who might come into contact with abused children in their professional capacities.

Walker, Lenore E. A., and David L. Shapiro. *In-*

troduction to Forensic Psychology: Clinical and Social Psychological Perspectives. New York: Kluwer Academic/Plenum, 2003. Presents an overview of the applications of psychology to the law. Includes case examples.

See also: Bite-mark analysis; Blunt force trauma; Child abduction and kidnapping; DNA extraction from hair, bodily fluids, and tissues; False memories; Parental alienation syndrome; Rape; Rape kit; Semen and sperm; Shaken baby syndrome; Strangulation.

Choking

Definition: Medical emergency that occurs when partial or complete obstruction of the airway interferes with breathing, depriving the body of the oxygen necessary to maintain life.

Significance: Appropriate actions may be taken to prevent death in choking victims if others present recognize the signs of choking. Choking deaths may be mistaken for other types of deaths, such as suffocation, strangulation, or asphyxia, which may be intentional or accidental.

Choking is almost always accidental and preventable. The signs of active choking vary depending on the age of the person and the type of choking (partial or complete) involved. In adults, choking on food is most commonly found in situations of alcohol intoxication. Children often choke as the result of putting small objects, such as coins or small toys, into their mouths and then unintentionally inhaling them into the trachea (airway). Children also sometimes choke because they have put large amounts of food into their mouths and have not chewed the food properly before swallowing; the objects enter the airway rather than the esophagus.

A choking victim who is able to cough or speak is receiving adequate oxygenation to sustain life; the only action needed in such a situation is observation. The person should be allowed to cough in an attempt to dislodge the object. A partial airway blockage, however, may progress to a complete blockage. When the airway is completely blocked, the victim is not taking in adequate oxygen and is unable to speak or cough. A blue discoloration of the mouth and fingernails may become apparent.

A person who is choking may panic because of the lack of oxygen and fear of death. An adult may avoid seeking help in public owing to embarrassment, whereas a child may run from help out of fear. If the blockage is not quickly resolved, the individual will lose consciousness because of the lack of oxygen to the brain. At that point, the muscles in the airway will relax, but the object will remain in the airway unless the victim receives assistance from another person. If choking continues, the victim's heart will eventually stop beating and death will occur.

Medical and police personnel need to be aware of the signs of choking that may be present at the scene of a death. By thoroughly examining the scene and interviewing witnesses, emergency responders and police officers may aid the medical examiner in determination of the cause and manner of death. Bruising of the neck should not be seen in a choking victim. A person who has died from choking may have scratch marks at the neck from grabbing at the throat; if any skin is found under the fingernails, it will be the victim's own. The eyes of a choking victim may be bloodshot from vigorous coughing or from straining to relieve the blockage. As death occurs, the muscles relax. The bladder also relaxes, and urine may be present at the scene.

Amy Webb Bull

Further Reading

American Red Cross. *American Red Cross First Aid: Responding to Emergencies*. 5th ed. Yardley, Pa.: StayWell, 2006.

Lynch, Virginia A. *Forensic Nursing*. St. Louis: C. V. Mosby, 2006.

See also: Air and water purity; Asphyxiation; Autoerotic and erotic asphyxiation; Chemical agents; Epilepsy; Hanging; Petechial hemorrhage; Smoke inhalation; Strangulation; Suffocation.

Chromatography

Definition: Laboratory techniques used to separate chemical mixtures into their individual components and to quantify and identify the isolated components.

Significance: Chromatography techniques are useful for a variety of purposes in the forensic sciences, including determining causes of death, linking individuals to specific crime scenes, and analyzing the residues from explosives to identify possible suspects.

Chromatography was invented in 1903 by the Russian botanist Mikhail Semyonovich Tsvet, who used it to separate plant pigments, the various colored components of plants. It has been suggested that Tsvet arrived at the name "chromatography" for this process by combining the Greek words *chroma* and *graphein*, literally meaning "color writing." The uses of chromatography are not limited to colored substances, however.

The various forms of chromatography all share certain characteristics. For example, the sample to be analyzed is dissolved in a mobile phase, typically a liquid or a gas, which then comes into contact with a stationary phase, typically a solid or a liquid. As the mobile phase flows over the stationary phase, the various components of the sample are attracted to each phase to different extents, based on their physical characteristics. Those components that are attracted more to the stationary phase will move less quickly than those that are attracted more to the mobile phase, so the components separate from each other.

Chromatographic techniques may be categorized based on the nature of the mobile phase. In liquid chromatography, the mobile phase is a liquid. In gas chromatography, the mobile phase is a gas. Additionally, many of these techniques use columns containing the stationary phase; the mobile phase flows through the column after the sample has been dissolved in the mobile phase and applied to the column. When the components of the chemical mixture have been separated, they may be identified through the use of a detector attached to the chromatographic system. The detector, which may include one of several instruments used in chemical analysis, records various physical properties of the components. When a column is used, the detector is attached to the end of the column where the components are released.

Chromatography is used in the forensic sciences whenever it is necessary to separate the chemical components of a sample to determine the identity or the quantity of one or more of those components. The uses of chromatography include detecting the presence of explosives in airport baggage, analyzing explosives residues to identify the sources as well as possible suspects, and determining cause of death in autopsies through the screening of biological samples (such as blood, hair, and skin) for drugs or poisons. Chromatography is also used to identify the chemical makeup of seized illicit drugs and to determine blood alcohol levels in persons accused of driving under the influence of alcohol. Using chromatography techniques, analysts can determine the composition and quantity of the dyes in textile fibers left at a crime scene and thus help identify the potential source of the fibers, examine the ink on legal documents to determine whether any information has been fraudulently inserted, compare small amounts of soil to link suspects to a crime scene, determine the likely factory source of automobile paint left at the scene of a hit-and-run accident, detect the presence of accelerants at the scene of an arson investigation, and screen foods to determine whether they have been contaminated with dangerous chemicals.

Jason J. Schwartz

Further Reading

Bogusz, M. J., ed. *Handbook of Analytical Separations*. Vol. 6 in *Forensic Science*, edited by Roger M. Smith. 2d ed. New York: Elsevier, 2007.

Miller, James M. *Chromatography: Concepts and Contrasts*. 2d ed. Hoboken, N.J.: John Wiley & Sons, 2005.

See also: Analytical instrumentation; Column chromatography; Forensic toxicology; Gas chromatography; High-performance liquid chroma-

tography; Homogeneous enzyme immunoassay; Mass spectrometry; Quantitative and qualitative analysis of chemicals; Separation tests; Spectroscopy; Thin-layer chromatography; Toxicological analysis.

Class versus individual evidence

Definitions: Class evidence is evidence that can be linked to a type (or class) of items; individual evidence is evidence that can be linked to a specific individual or item.

Significance: Because the majority of evidence at crime scenes is class evidence and not individual evidence, it would be difficult to link objects at crime scenes to specific suspects were it not for the fact that many objects pick up individual characteristics.

Class evidence makes up the vast majority of all evidence in forensic cases. For example, a glass fragment can be analyzed to determine its refractive index and chemical makeup. The resultant laboratory report can tell investigators that the fragment's properties are consistent with a certain type of glass, such as that from windowpanes or car headlights. What the analysis usually cannot reveal is from which particular window or which particular car headlight the fragment comes.

By contrast, individual evidence can be linked to specific objects, such as fingerprints, no two of which have ever been found to be exactly alike. For this reason, any fingerprint that is found must have been made by one, and only one, person. Other examples of individual evidence include human lip prints, ear prints, and sole prints. Researchers have also found through X-ray analyses of skulls that sinus prints—the unique patterns of bone and space in sinus cavities—are also individual. Forensic anthropologists can use this information to identify bodies of long-dead people. Surprisingly, DNA (deoxyribonucleic acid) evidence is not individual, as identical twins have identical DNA.

Many objects that would otherwise fall under the heading of class evidence pick up individual characteristics. For example, the soles of all shoes of a specific model and size come out of their factories looking exactly the same. After they have undergone some substantial wear, however, they develop distinctive wear patterns. The ways in which different users distribute their weight, the feet that they favor, and many other factors, including chemical and biological materials on which they step, contribute to making the soles of their shoes take on individual characteristics.

The individuation of characteristics can be seen in many different types of evidence. For example, tools can develop distinctive wear patterns and leave distinctive marks when they are used. Vehicle tires develop distinctive wear patterns over time, just as shoes do. Firearms can leave distinctive marks on the bullets they discharge. Glass may fracture in ways that make it possible for investigators to reassemble the broken pieces, much like a jigsaw puzzle. In forensic investigations, considerable time is devoted to looking at how class evidence becomes individualized.

Ayn Embar-Seddon and Allan D. Pass

Further Reading

Beavan, Colin. *Fingerprints: The Origins of Crime Detection and the Murder Case That Launched Forensic Science*. New York: Hyperion, 2001.

Platt, Richard. *Crime Scene: The Ultimate Guide to Forensic Science*. New York: Dorling Kindersley, 2003.

See also: Ballistic fingerprints; Chain of custody; Courts and forensic evidence; Crime scene reconstruction and staging; Cross-contamination of evidence; Direct versus circumstantial evidence; Disturbed evidence; DNA fingerprinting; Ear prints; Evidence processing; Federal Rules of Evidence; Fingerprints; Footprints and shoe prints; Physical evidence; Prints; Sinus prints; Trace and transfer evidence; Voiceprints.

Closed-circuit television surveillance

Definition: Monitoring of activities in public or private spaces conducted through the use of video cameras that transmit to limited sets of monitors.

Significance: As a tool of crime deterrence and detection, closed-circuit television technology is used extensively to monitor movement in public areas, despite the serious questions this form of surveillance raises regarding civil liberties. With improvements in video technology and growing fears of terrorism around the world, increasing numbers of law-enforcement agencies are employing closed-circuit television surveillance.

Combating crime committed in public locations has long been an important law-enforcement priority, and closed-circuit television (CCTV) has become an integral part of the technologies used in this effort. CCTV surveillance of public movements is especially pervasive in England, where hundreds of thousands of video cameras are already mounted and the numbers continue to grow, requiring an enormous expenditure of public funds. Other European countries that are heavily involved in CCTV monitoring include Ireland, France, Belgium, Finland, and Scotland. The use of CCTV surveillance in England has attracted widespread attention in high-publicity cases, such as the 2005 London subway bombings, when several of the suspects were caught after they appeared on CCTV cameras.

Methods and Results

Logistically, the monitoring of the images captured by CCTV cameras is conducted remotely. In England, monitoring is conducted from central stations, which are frequently found in police headquarters. The personnel who monitor CCTV feeds may be police or civilians. Across departments, variations are found in terms of the staff time allotted to live monitoring or post hoc monitoring of surveillance tapes and in terms of the periods of time for which the tapes are kept.

The empirical results of the implementation of CCTV surveillance have been mixed, ranging from reports of crime reduction as large as 90 percent to reports of crime increases up to 20 percent. Any interpretation of crime expansion must be made in terms of two basic goals of CCTV use: crime deterrence and crime detection/clearance. An increase in crime might actually be viewed as a success if the presence of CCTV enhanced crime detection.

In terms of property crime, the studies that have found the most positive results have reported long-term reductions in burglary, car theft, and general theft in CCTV areas, with concomitant increases in non-CCTV zones. CCTV may have a displacement effect, whereby the total volume of crime remains fairly constant but much of it is shifted to areas that lack video monitoring. Other studies have found that reported crime reductions in areas with CCTV surveillance could not be isolated from reductions that might have come about because of the large amount of publicity given to the CCTV program itself. Some property crime studies have reported no substantial crime reductions as the result of CCTV surveillance, but it is possible that the monitoring had an impact by holding down projected crime increases.

In studies of elderly populations, CCTV tapes were found to provide records useful for identifying suspects (a task in which elderly persons are typically weak). In another group of studies, CCTV reduced the volume of some crimes, particularly those the commission of which took long enough to be recorded by cameras, such as auto theft. However, the frequency of relatively "quick" crimes, such as burglary and shoplifting, increased. Studies have also found a "fading effect" associated with the implementation of CCTV surveillance—that is, crime rates decline initially but then begin to rise again, after the novelty of the monitoring wears off and its deterrent impact on would-be offenders recedes. Researchers have also found it difficult at times to separate the effects of CCTV monitoring from other simultaneous changes in the areas being studied, such as better lighting or overall security.

Little research has addressed the effects of CCTV implementation on crime trends for violent offenses such as robbery and assault. Because violent offenses are generally more impulsive than property offenses, violent crime is less amenable to preventive measures, but CCTV surveillance could allow police to intervene faster when violent offenses take place.

Public Responses

Researchers have also looked at the effects of CCTV surveillance on fear of crime. In some studies, the majority of the people who were surveyed thought that the use of CCTV would reduce crime in their jurisdictions, but actual fear levels did not decline. Results of such studies have varied depending on the populations involved and the exact crimes and camera locations. In a survey of elderly persons residing in sheltered housing, for example, reduced levels of fear of burglary were found, as the respondents widely believed that the cameras made stranger entry into their homes more difficult.

Studies have found that fears of crime are reduced more by CCTV cameras located in parking lots than by the presence of cameras in shopping centers or on the streets. A sex effect has also been noted regarding fear of crime, with some studies indicating that women are particularly fearful at night in bus and train stations even with CCTV monitoring. Subjects in one study felt that CCTV surveillance was superior to other police crime detection strategies, but they also said that they preferred retaining police foot patrols in order to feel safer, because this facilitated quicker law-enforcement response if needed in any given situation.

CCTV surveillance is appealing in terms of its potential to deter and detect crime. It may also have beneficial effects in terms of reviving businesses located in high-crime areas and increasing the numbers of guilty pleas made by defendants who know their crimes were caught on tape. The use of CCTV surveillance raises several concerns regarding civil rights, however. Some critics have asserted that members of minority groups are disproportionately targeted for observation and that the police or others may use the monitoring videotapes for purposes that exceed the original scope of the surveillance. Members of the public may not always know when they are being monitored, and the actions seen on the tapes (which include images of varying clarity and lack auditory information) may sometimes be misinterpreted. Nevertheless, the use of CCTV surveillance is growing steadily, and the refinement of video technology is expected to become increasingly important in helping law-enforcement authorities meet their crime deterrence and investigatory goals.

Eric Metchik

Further Reading

Gill, Martin, ed. *CCTV*. Leicester, England: Perpetuity Press, 2003. Wide-ranging collection of articles by leading European academics discusses various social and legal aspects of CCTV surveillance.

A closed-circuit television surveillance system operator for the Baltimore Police Department monitors activity on a street where a possible drug deal was taking place in late 2006. *(AP/Wide World Photos)*

Gill, Martin, Anthea Rose, Kate Collins, and Martin Hemming. "Redeployable CCTV and Drug-Related Crime: A Case of Implementation Failure." *Drugs: Education, Prevention, and Policy* 13, no. 5 (2006): 451-460. Presents an analysis of the practical and logistical issues involved in the use of portable CCTV systems to fight drug crimes in three English police precincts.

Goold, Benjamin. "Open to All? Regulating Open Street CCTV and the Case for 'Symmetrical Surveillance.'" *Criminal Justice Ethics* 25, no. 1 (2006): 3-17. Provides a legally oriented analysis of the increasing use of CCTV surveillance of public spaces in the United States.

Newburn, Tim, and Stephanie Hayman. *Policing, Surveillance, and Social Control. CCTV and Police Monitoring of Suspects*. Portland, Oreg.: Willan, 2002. Comprehensive work reviews the English empirical research on the impact of CCTV surveillance.

Norris, Clive, and Michael McCahill. "CCTV: Beyond Penal Modernism?" *British Journal of Criminology* 46 (2006): 97-118. Integrates discussion of the theoretical literature and empirical research findings, emphasizing the experience of four different applications of CCTV technology in the United Kingdom.

See also: Airport security; Electronic bugs; Facial recognition technology; Forensic photography; Night vision devices; Racial profiling; Satellite surveillance technology.

Club drugs

Definition: Variety of illicit hallucinogenic substances that share the general traits of being used in social situations and exciting or sedating users.

Significance: The use of so-called club drugs is known to be widespread in the United States, even though these unregulated substances may put users in dangerous situations and have been linked to risky sexual behavior and sudden death. Law-enforcement agencies expend significant resources in efforts to reduce the illegal manufacture, sale, and use of such drugs.

The group of substances that can be categorized as club drugs includes those that have historically been known as psychedelic drugs (that is, substances that alter perception and thinking) as well as so-called designer drugs, which are typically made by people who seek to profit from manufacturing drugs or are interested in finding substances that patrons of nightclubs or dance clubs can use legally to enhance their enjoyment. The creators of designer drugs often modify unregulated or illegal chemical substances to make them technically legal and thus suitable for such purposes. After problems emerge in connection with these substances, however, the legal system moves in to identify and classify them and assign legal consequences for their inappropriate use.

Types of Club Drugs and Their Effects

Club drugs comprise a large number of different substances, and new drugs emerge every day as various ingredients are designed or redesigned. One of the most popular club drugs is methylenedioxymethamphetamine, or MDMA, which is also known as ecstasy, X, or Adam. MDMA is different from so-called herbal ecstasy (other names include cloud nine, herbal bliss, and herbal X), which is also used as a club drug. MDMA is a derivative of methamphetamine, whereas herbal ecstasy is made from ephedrine or pseudoephedrine and caffeine. Other club drugs include ketamine hydrochloride (known as ketamine or special K), gamma-hydroxybutyrate (GHB, also known as Georgia home boy or liquid X), and rohypnol (known as roach, roche, or roofies). One long-established substance often used as a club drug is lysergic acid diethylamide (LSD), which is also known as acid or blotter.

The effects of these drugs vary from substance to substance. Club drugs generally have no medical uses, although researchers have examined the usefulness of some of them in the treatment of problems such as trauma and antisocial personality disorder. As a group, these substances are known for eliciting positive feel-

Street Names for Club Drugs

GHB (gamma-hydroxybutyrate)
- G
- Georgia home boy
- grievous bodily harm
- liquid ecstasy

Ketamine
- bump
- cat Valium
- green
- honey oil
- jet
- K
- purple
- Special K
- special la coke
- super acid
- super C
- vitamin K

LSD (lysergic acid diethylamide)
- acid
- blotter
- blotter acid
- boomers
- dots
- microdot
- pane
- paper acid
- sugar
- sugar cubes
- trip
- window glass
- windowpane
- yellow sunshine
- Zen

Methamphetamine
- chalk
- crank
- crystal
- fire
- glass
- ice
- meth
- speed

Methylenedioxy-methamphetamine (MDMA)
- Adam
- Clarity
- ecstasy
- Lover's Speed
- X
- XTC

Rohypnol
- forget-me pill
- roche
- roofies
- rophies

ings, such as happiness, euphoria, and a general sense of well-being. Users may also experience feelings of emotional clarity, a decreased sense of personal boundaries, and feelings of empathy with and increased closeness to others. They may also experience pleasant psychedelic effects in the form of other changes in their way of perceiving themselves, others, and their surroundings.

Negative effects of club drugs include physical symptoms such as chills, high blood pressure, rapid heartbeat, respiratory distress, sweating, tremors, and impaired motor control. In some cases, convulsions may occur. The drugs can also have negative psychological effects: Users may experience impaired judgment, memory loss, and unpleasant hallucinations. Club drugs can trigger irrational (sometimes violent) behavior, panic, and paranoia. In addition, as a result of using these substances, some individuals may suffer blackouts and drug flashbacks. In users who are compromised by physical or mental health problems, reactions to club drugs may be magnified.

Risks of Use

These substances can be very dangerous when mixed with alcohol, energy drinks, herbal remedies, prescription medications, or other drugs, even over-the-counter drugs. The synergistic effects—that is, effects from drug interactions—may be multiplicative rather than simply additive, so that any of the drugs consumed together with other substances becomes much more pronounced in its effects. Because club drugs are not manufactured by regulated pharmaceuticals laboratories, their quality varies widely. Some may contain contaminants, and some may simply look like the drugs they are purported to be and thus may deliver unknown drug effects.

How and where these substances are used can mitigate or increase the risks involved. In a medical or laboratory setting, or in a private home under observation, relatively few risks may be present. In contrast, in situations involving crowds, heightened emotions, and the company of strangers, the risks of club drugs may be pronounced. At raves, for instance, users of club drugs may not realize they are becoming seriously dehydrated from continual dancing and other physical activity; this is one reason users often end up in emergency rooms.

The proximity of strangers may add to the risks involved in the use of club drugs in part because users may be easy targets for physical or sexual assault or property crimes. In addition, driving under the influence of these substances may result in accidents, criminal charges, or both.

Beyond the short-term risks associated with use, club drugs may also expose users to risks related to substance abuse and dependence. Habitual use of club drugs may result in problems with functioning at work, home, or school, and may bring users into frequent contact with law-enforcement authorities. Some users may find that they repeatedly use club drugs in dangerous situations or that they are in constant conflict with their significant others over their substance use.

Substance-dependence problems related to the use of club drugs may include issues of tolerance, withdrawal, the use of greater quantities or more frequent use than intended, and persistent desire to quit or unsuccessful efforts to quit. Those who become dependent on these substances are likely to spend increasing amounts of time in obtaining and using the drugs and recovering from their effects, giving up other activities to do so. Both the drug abuse and the abandonment of other activities may cause or exacerbate other psychological or physical problems. For some users, club drugs may interact with other states of mind or conditions, such as anxiety or depression, and trigger more lasting problems with anxiety or mood.

Legal Issues

The legal issues related to club drugs may be seen as a microcosm of the legal issues related to substance use in general, from the drugs' creation to how they are used and their impacts. Manufacturing and distribution issues are relevant in that these drugs are unregulated substances that form the basis for an unregulated economy. Issues of drug identification and classification are also relevant in that the drugs often are designed around the law, challenging the process of identification as well as the issue of enforcement of laws concerning their use and sale. Harmful use related to impaired personal judgment and behavior is also important in terms of the accidents and related crimes it may cause, such as driving under the influence, assault, and property damage. Of additional interest to law-enforcement authorities is the potential for the use of these drugs by individuals wishing to harm others, as in the use of rohypnol and similar substances in sexual crimes.

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Further Reading

Holland, Julie. *Ecstasy: The Complete Guide—A Comprehensive Look at the Risks and Benefits of MDMA*. Rochester, Vt.: Inner Traditions International, 2001. Presents data and arguments pertaining to the typical risks that may be expected from ecstasy and other club drugs. Includes discussion of research perspectives on the potential benefits of these drugs.

Jansen, Karl. *Ketamine: Dreams and Realities*. Ben Lomond, Calif.: Multidisciplinary Association for Psychedelic Studies, 2004. Provides a historical perspective on the uses of ketamine and addresses the risks and benefits related to the drug.

Julien, Robert M. *A Primer of Drug Action: A Comprehensive Guide to the Actions, Uses, and Side Effects of Psychoactive Drugs*. 10th ed. New York: Worth, 2005. Reliable text provides full coverage of the topic, including information about how these drugs affect people from youth to old age.

Stafford, Peter. *Psychedelics*. Oakland, Calif.: Ronin, 2003. Provides broad descriptions of drugs that affect perception, focusing on what these substances may look like and how they may affect users. Also discusses the drugs' individual and societal impacts.

Weil, Andrew, and Winifred Rosen. *From Chocolate to Morphine: Everything You Need to Know About Mind-Altering Drugs*. Rev. ed.

Boston: Houghton Mifflin, 2004. Presents a down-to-earth discussion of drugs that affect the mind. Easy to read.

See also: Amphetamines; Antianxiety agents; *Diagnostic and Statistical Manual of Mental Disorders*; Drug abuse and dependence; Drug confirmation tests; Drug paraphernalia; Hallucinogens; Illicit substances; Inhalant abuse; Psychotropic drugs; Stimulants.

CODIS

Date: Established in 1990

Identification: Database maintained by the Federal Bureau of Investigation that stores DNA profiles for comparison purposes, used by federal, state, and local crime laboratories.

Significance: CODIS allows forensic laboratories to compare DNA profiles related to crimes (forensic profiles) to those obtained from other crimes or from individuals previously convicted of felonies. Through such comparisons, links may be found between crime scenes and repeat offenders may be identified.

The Combined DNA Index System, better known as CODIS, was established as the result of a suggestion from the Technical Working Group on DNA Analysis Methods; the intent was to create a national database of DNA (deoxyribonucleic acid) profiles collected from convicted criminals. When CODIS was initiated in 1990 as a pilot project of the Federal Bureau of Investigation (FBI), it included fourteen state and local laboratories.

The DNA Identification Act of 1994 allowed the formation of a national DNA database and clarified which types of DNA evidence could be stored in it. DNA profiles from persons convicted of crimes, evidentiary items obtained from crime scenes, and unidentified human remains were to be included, as well as profiles voluntarily submitted by relatives of missing persons. In 1998, the national database became operational, and by 2003 it was accepted by all fifty states. Qualified city, county, regional, state, and federal crime laboratories, as well as labs in several in other countries, now contribute to this powerful crime-solving tool.

Structure of the Database

CODIS is operational at three tiers: the National DNA Index System (NDIS), the State DNA Index System (SDIS), and the Local DNA Index System (LDIS) levels. A DNA profile originates locally and then migrates to the state and national levels. This approach allows each state access to a database that is concurrent with its individual legislation, including what crimes will result in submission of a DNA profile (for example, sexual assault, any violent crime, all felonies).

CODIS consists of two main databases: the forensic index and the convicted offender index. The forensic index contains data on DNA profiles obtained from victims or crime scenes, whereas the convicted offender index includes the profiles of those convicted of offenses. Using the two indexing systems, it is possible to link crimes together for the purpose of identifying a repeat perpetrator or to link a crime to a person

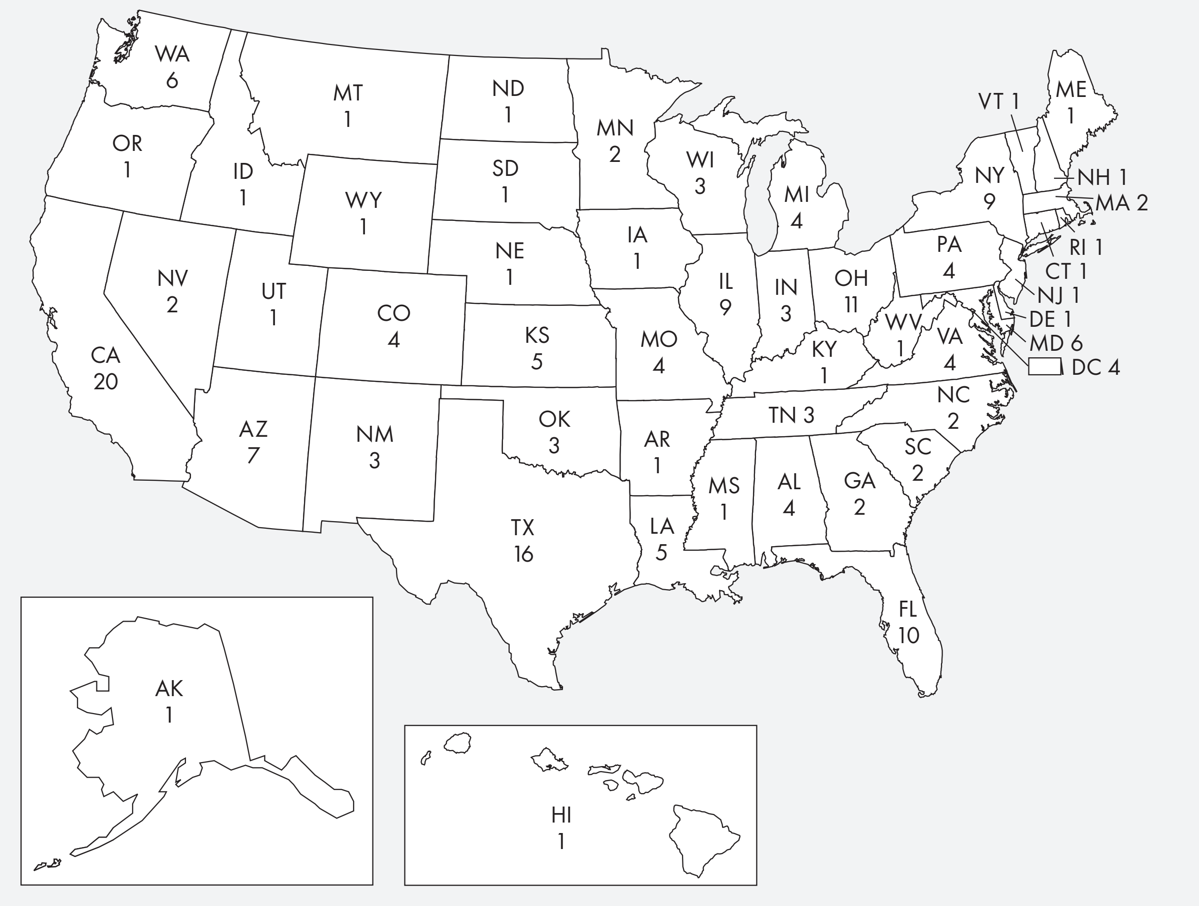
Indexes Within CODIS

- **Convicted offender index:** Contains profiles of individuals who have been convicted of crimes
- **Forensic index:** Contains DNA profiles developed from crime scene evidence, such as semen stains or blood
- **Arrestees index:** Contains profiles of arrested persons (from those states in which laws permit the collection of arrestee samples)
- **Missing persons index:** Contains DNA reference profiles from missing persons
- **Unidentified human remains index:** Contains DNA profiles developed from unidentified human remains
- **Biological relatives of missing persons index:** Contains DNA profiles voluntarily contributed by relatives of missing persons

who is or was in prison. Other databases existing in CODIS include the arrestees index, the missing persons index, the unidentified human remains index, and the biological relatives of missing persons index. Whether an individual state participates in these at the national level depends on state policy or law. In order for a state to be eligible to participate in CODIS, the appropriate state authority must sign a memorandum indicating that the state's laboratory (or laboratories) adheres to FBI quality assurance standards; the laboratory must also pass a series of inspections and subsequent reviews.

A DNA profile found in CODIS contains only the following: an identification code for the submitting agency, an identification number for the specimen, the DNA profile itself, and the name of the person who submitted the information. Only the submitting laboratory can place a name on a DNA profile. The limited data ensure that the DNA profiles are not exploited and that the identities of those whose profiles are submitted to the database are protected. It is also important to note that the profiles do not contain any information about medical conditions. CODIS is accessible only to those working within the field of law enforcement. Participating laboratories submit their information through a secure intranet called CJIS WAN, which is located in Clarksburg, West Virginia.

CODIS Labs in the United States



Source: Federal Bureau of Investigation, 2008.

An FBI unit chief holds a chart outlining the Combined DNA Index System during a 1998 news conference, when the system's national database became operational. *(AP/Wide World Photos)*

Putting a DNA Sample Through CODIS

DNA samples can be taken from convicted persons in several different ways. Blood or buccal swabs (swabs of the inside of the cheek) are generally collected, although in theory almost any tissue could be used. Forensic samples come from a huge variety of sources, the most common being semen from sexual assault cases, but blood, hair, saliva, bone, or virtually any other tissue or body fluid can be tested. New developments have allowed for touch samples—samples extracted from items that have come into direct contact with the persons of interest (such as held objects)—to be used also as potential sources of profiles.

DNA profile information is submitted to CODIS in the form of short tandem repeats (STRs). Thirteen core STR loci were chosen for use with CODIS; the profiles of convicted offenders must contain all thirteen of these loci to be uploaded to CODIS, whereas forensic profiles, which often originate from less-than-ideal sources, are required to have at least ten loci.

At the local level, analysts have some leeway when searching the database. For instance, a laboratory may require that a complete match be made at a locus for that locus to be considered, whereas another laboratory, recognizing that degraded DNA from a crime scene can result in the loss of part of a profile, might find a partial profile probative. Likewise, the minimum number of loci needed to be considered informative can vary from case to case.

After a potential match has been found by CODIS, the laboratories responsible for the corresponding profiles must contact each other to authenticate the results. The samples are often then retested to ensure the validity of the match. Upon confirmation that the two profiles are consistent with each other, the laboratories exchange any additional information they need.

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Further Reading

Balding, D. J., and P. J. Donnelly. "Evaluating DNA Profile Evidence When the Suspect Is Identified Through a Database Search." *Journal of Forensic Sciences* 41 (1996): 603-607. Leads the reader through the process of entering a DNA profile into a database and discusses the population genetics associated with such a profile.

Butler, John M. *Forensic DNA Typing: Biology, Technology, and Genetics of STR Markers*. 2d ed. Burlington, Mass.: Elsevier Academic Press, 2005. Provides a detailed overview of short tandem repeats and their applicability to forensic science.

Houck, Max M., and Jay A. Siegel. *Fundamentals of Forensic Science*. Burlington, Mass.: Elsevier Academic Press, 2006. Good general textbook includes discussion of DNA analysis.

National Research Council. *The Evaluation of Forensic DNA Evidence*. Washington, D.C.: National Academy Press, 1996. Spells out the guidelines on methods of DNA analysis that are accepted in the courtroom.

Walton, Richard H. *Cold Case Homicides: Practical Investigative Techniques*. Boca Raton, Fla.: CRC Press, 2006. Examination of cold cases includes a section on applying CODIS to the investigation of old, unsolved crimes.

See also: DNA analysis; DNA database controversies; DNA fingerprinting; DNA profiling; DNA typing; Ethics of DNA analysis; Federal Bureau of Investigation DNA Analysis Units; Federal Bureau of Investigation Laboratory; Integrated Automated Fingerprint Identification System; National Crime Information Center; National DNA Index System; Rape; Restriction fragment length polymorphisms; Short tandem repeat analysis.

Coffin birth

Definition: Spontaneous delivery of a fetus from the uterus of a dead woman.

Significance: When a fetus is found outside the dead body of the mother, it may be necessary for forensic scientists to determine whether the mother died while the fetus was still in the uterus, the fetus later expelled by the buildup of decomposing gases in the mother's body, or whether the fetus was delivered before the mother's death and died separately. The distinction may be important when charges are brought against a suspect for the murder of a pregnant woman.

Although it has always been rare, the phenomenon of coffin birth, or postmortem birth, has occurred throughout history. Paleopathologists have discovered evidence of coffin birth (or *Sarggeburt* in German, the language in which it was first described) in archaeological digs in ancient graveyards. With modern embalming techniques, it has become even more unusual, although it still may occur in cases of accidental death, murder, or incorrect embalming practices.

Coffin birth is truly the birth of a fetus, not a case of the fetus being expelled through the body through the abdomen, such as with a wound mimicking a birth by cesarean section. The buildup of gases in the decomposing body of a pregnant woman may put pressure on the uterus to the point of expelling an unborn fetus through the birth canal. Scientists believe that this buildup could take weeks or months to happen, and the possibility of a coffin birth occurring depends on many outside factors, such as the air temperature and whether the woman's body is in water or buried in the ground.

Coffin birth is so rare that it does not often appear in the medical literature. The topic came into the news spotlight in 2003, however, in the case of Laci Peterson. Peterson was about seven and one-half months pregnant when she disappeared in December, 2002, leading to speculation that her husband, Scott Peterson, had murdered her. Later, when her body and the body of

Missing-person broadside posted near the police command center in Modesto, California, while the pregnant Laci Peterson was still being sought in early 2003. *(AP/Wide World Photos)*

her late-term fetus were found separately on the shores of the San Francisco Bay, coffin birth was raised as the possible reason that the fetus was no longer in her uterus. Coffin birth was only one possibility of many, but it was thought a strong possibility, partly because Laci Peterson had no external wounds consistent with the fetus's exiting her body other than through the birth canal. Despite the confusion over whether she was still pregnant when she was killed or whether the baby was born before her death, charges were filed against Scott Peterson for the murder of both his wife and son. He was convicted in March, 2005, and sentenced to death for the murders.

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Further Reading

Fleeman, Michael. *Laci: Inside the Laci Peterson Murder*. New York: St. Martin's Press, 2003.

Lyle, D. P. *Forensics and Fiction: Clever, Intriguing, and Downright Odd Questions from Crime Writers*. New York: St. Martin's Press, 2007.

See also: Autopsies; Decomposition of bodies; Forensic archaeology; Paternity evidence.

Cognitive interview techniques

Definition: Interviewing protocols based on the science of cognitive psychology.

Significance: Because eyewitness evidence is critical to solving many crimes, it is important that law-enforcement personnel employ interviewing techniques that elicit extensive and accurate information from witnesses. The use of cognitive interview techniques can maximize the effectiveness of witness interviews.

Evidence collected from cooperative witnesses is critical for solving many crimes and for determining what happened at accident scenes. Nevertheless, many police and accident investigators receive only minimal or no training in techniques to use when interviewing cooperative witnesses. Often the only training they get comes from on-the-job experience or from watching more senior investigators conduct interviews—whether well or poorly. Police and other investigative interviewers therefore often make avoidable errors and collect less information than is potentially available. Even worse, through poor questioning techniques, interviewers may entice witnesses to recall or describe critical events incorrectly.

The most common interviewing mistakes include asking suggestive or leading questions, asking too many short-answer questions and too few open-ended questions, interrupting witnesses during their answers, and asking questions that are unrelated to the witness's thoughts and mental images. To remedy this problem, two research psychologists, Ronald P. Fisher and R. Edward Geiselman, began work during the 1980's to develop an improved interviewing technique, the cognitive interview (CI), to increase the amount of accurate information collected from cooperative witnesses. CI techniques incorporate the theoretical principles of cognitive and social psychology and borrow elements and techniques from other investigative domains, including journalism, medicine, and social work. Part of the training in CI techniques involves the modeling of the differences between effective and ineffective police interviewers.

Principles of the Cognitive Interview

Cognitive interview techniques were developed to improve three psychological processes: the social dynamics between the witness and the interviewer, the thought processes of both the witness and the interviewer, and the communication between the witness and the interviewer. Interviewers can create more favorable social dynamics for interviews by developing personal rapport with respondents. This is especially true when they are interviewing victims and suspects. Interviewers should also instruct witnesses to take an active role within the interview and not merely answer questions with brief responses. Interviewers can accomplish this by instructing witnesses to generate detailed narrative descriptions without waiting for more questions, by asking mainly open-ended questions, and by not interrupting witnesses during their narrative responses.

Witnesses sometimes cannot recall critical details even though they have the information stored in their memories. Interviewers can help witnesses search through their memories more efficiently by instructing them to re-create the context of the original event (asking, for example, What were you thinking about at the time?), to search through their memories repeatedly, and to use all of their senses. Interviewers

Cognitive Interview Versus Hypnosis

The use of cognitive interview techniques with crime witnesses has been criticized as similar to the use of hypnosis, which can raise legal issues. CI techniques and hypnosis do have some elements in common; for instance, in both, interviewers need to develop rapport with witnesses, witnesses are instructed to close their eyes, and witnesses are asked to re-create in their minds the contexts of the original events. Scientific research shows, however, that the cognitive interview and hypnosis function differently: The cognitive interview enhances recall more reliably than does hypnosis; the accuracy of the information collected during cognitive interviews is relatively high, whereas hypnosis may promote fabrication; the cognitive interview does not influence witness confidence, whereas hypnosis elevates confidence; and the cognitive interview reduces witness suggestibility to leading and suggestive questions, whereas hypnosis increases suggestibility. The legal problems associated with hypnosis thus do not plague the cognitive interview.

also make cognitive errors, as they have to do many mental tasks at the same time, including listening to and notating the witness's answers, formulating hypotheses about the critical event, and asking questions. Interviewers can improve their own thought processes by encouraging witnesses to generate information without waiting for questions and by developing more efficient methods to record witnesses' answers.

Interviewers often fail to communicate to witnesses their investigative needs for detailed and extensive information. As a result, witnesses do not report all of their available knowledge. Interviewers should inform witnesses explicitly that they need to provide detailed and informative answers. In addition, interviewers should understand that witnesses may have much information that is stored nonverbally (for example, a mental picture of the crime scene) and should facilitate witnesses' communicating such information by encouraging nonverbal responses (such as making a sketch).

The sequence of the cognitive interview is based on two principles. First, the interviewer should try to develop a general understanding of the witness's cognitive map of the event—that is, how the witness mentally represents the event—and then ask questions that are compatible with the witness's cognitive map. Second, questioning should generally proceed in a funnel-like fashion, from more global, open-ended questions to more specific, closed-ended questions.

The cognitive interview is not a set of specific questions that are posed in the same fashion to all witnesses. Rather, CI techniques comprise a collection of many tools that should be used flexibly, depending on the specific factors of the case, such as the amount of time that has passed since the event and the witness's state of anxiety and verbal skills.

Scientific Testing of the Cognitive Interview

CI techniques have been tested repeatedly in laboratory and field studies. In a typical laboratory study, volunteer witnesses—often college students—see a videotape of a simulated crime or accident or a live, innocuous event. Shortly thereafter, each witness is interviewed by someone trained to use CI techniques or by someone using a more conventional technique (as in, for example, a typical police interview). Researchers have introduced many variations in the basic laboratory study by testing different types of witnesses (children, elderly, learning disabled, autistic), types of events (crimes, vehicular and industrial accidents, medical procedures), and time intervals (immediately after the event, hours later, weeks later, and up to thirty-five years later). Two field studies have also been conducted with victims and witnesses of real crimes.

Approximately one hundred such validation studies have been conducted in the United States, England, Germany, Spain, Australia, and elsewhere. Generally, CI techniques have been found to elicit between 25 percent and 75 percent more correct statements than the conventional technique and at comparable or slightly higher accuracy rates. Only one kind of witness task has not shown the cognitive interview to be superior to conventional interview techniques: identifying a perpetrator from a lineup.

Practical and Legal Concerns

CI techniques are taught and used in some police departments and investigative agencies, but such techniques are not employed universally. Within the United States, CI techniques are more likely to be taught at major investigative agencies (such as the Federal Bureau of Investigation and the National Transportation Safety Board) than at smaller police departments. Internationally, CI techniques are taught and used extensively in England, Australia, Canada, Sweden, and Israel, but less so in other countries. More time is required to conduct a cognitive interview than a conventional police interview, so CI techniques are most likely to be used in relation to major crimes and accident investigations and by follow-up detectives (rather than first responders).

Although CI techniques were developed for interviews with cooperative witnesses, some component techniques are also valuable for interviewing suspects (such as establishing rapport and reporting events in different orders). The cognitive interview has been credited with generating extensive witness information to solve several high-profile cases, ranging from kidnapping to terrorist bombings and accidents at sea.

CI techniques have been challenged unsuccessfully in a few court cases. In England, an appeals court overturned an earlier decision on the basis of information obtained with CI techniques. Although the court did not explicitly mention the cognitive interview in its ruling, the ultimate decision was consistent with the information elicited by the interview. In a California case, the prosecutor used evidence that had been elicited by a police officer trained in CI techniques. The defense attorney claimed that the cognitive interview was similar to hypnosis and that it promoted inaccurate eyewitness testimony. The judge, however, ruled against the defense's argument and allowed the CI-elicited testimony to stand. A Nebraska court evaluated CI techniques for their reliability according to the *Daubert* standard (a standard set by the U.S. Supreme Court concerning expert witness testimony) and found that these techniques met the standards of scientific testing, peer review and publication, known (and acceptably low) error rates, and general acceptance.

Ronald P. Fisher and Margaret C. Reardon

Further Reading

Fisher, Ronald P., and R. Edward Geiselman. *Memory-Enhancing Techniques in Investigative Interviewing: The Cognitive Interview*. Springfield, Ill.: Charles C Thomas, 1992. Written for investigative interviewers; describes in detail how to conduct the CI. Also includes chapters on training and learning the CI technique as well as sample interviews to illustrate good and poor interviewing techniques.

Fisher, Ronald P., R. Edward Geiselman, and Michael Amador. "Field Test of the Cognitive Interview: Enhancing the Recollection of Actual Victims and Witnesses of Crime." *Journal of Applied Psychology* 74 (1989): 722-727. Describes a scientific field study comparing the effectiveness of CI-trained police interviewers with other untrained (but experienced) interviewers. Aimed at forensic researchers.

Kebbell, Mark R., and Graham F. Wagstaff. "Hypnotic Interviewing: The Best Way to Interview Eyewitnesses?" *Behavioral Sciences and the Law* 16 (1998): 115-129. Compares the effectiveness of hypnosis and the CI as methods for eliciting information from witnesses.

Köhnken, Günter, Rebecca Milne, Amina Memon, and Ray Bull. "The Cognitive Interview: Meta-Analysis." *Psychology, Crime, and Law* 5 (1999): 3-27. Applies the statistical technique of meta-analysis to examine the data on the effectiveness of the CI gathered in more than fifty laboratory and field studies.

See also: Accident investigation and reconstruction; Composite drawing; *Daubert v. Merrell Dow Pharmaceuticals*; Eyewitness testimony; Forensic psychology; Interrogation; National Institute of Justice; *People v. Lee*; Police psychology.

Cold Case

Date: First aired on September 28, 2003

Identification: Television series that focuses on Philadelphia detectives who solve cold cases in part through the examination of forensic evidence.

Significance: By immersing viewers in the scientific context of each case it depicts, *Cold Case* demonstrates the relevance and application of forensic science within the criminal justice system.

Cold Case focuses on a fictional special investigative team located in Philadelphia, with particular emphasis on the lead investigator, Detective Lilly Rush (played by Kathryn Morris). Rush and her coworkers investigate cold cases—that is, cases that have gone unsolved, often for long periods, and on which active investigation has ceased because the leads or evidence trails have gone cold—that are brought to their attention for various reasons. Sometimes new evidence is found that relates to an old case

Cold Case police detectives (from left) John Stillman (John Finn), Lilly Rush (Kathryn Morris), and Scotty Valens (Danny Pino) in a scene from the television program. *(Cliff Lipson/CBS/Landov)*

or a witness presents new information; sometimes a body is discovered that has a connection to an unsolved case.

The show's format revisits each unsolved case through the utilization of flashbacks that feature music specific to the year of the case. Cases on the show have ranged from a murder that took place in 1919 to current cases that have no leads. Although the resolutions of some cases rely on witness recall, the majority of the cases are solved through the introduction of new forensic evidence or the reanalysis of evidence that was tainted or misused when it was examined previously. The types of forensic evidence that have figured into the program's plots have included fingerprint analysis, DNA (deoxyribonucleic acid) analysis, ballistics, and blood evidence. *Cold Case* often showcases new forensic technologies that are used to solve criminal cases.

Examples of *Cold Case* episodes in which forensic evidence played an important role include one in which blood evidence on a policeman's nightstick linked the officer to the murder of a college baseball player. In another episode, a skull with a bullet in it was found beneath the remains of an old nightclub, and subsequent ballistics analysis and examination of arson evidence showed that a murder at the scene had been covered up by arson; this information also led to the discovery of twenty-three new murder cases. An episode about the drowning of a military academy's swim coach featured the use of DNA evidence and handwriting analysis, which indicated that children at the academy whom the coach had molested were responsible for his death. DNA evidence was important in an episode in which the detectives found that an innocent man had been convicted of the murder of a fifteen-year-old girl; DNA evidence also identified the correct killer. Skeletal analysis and DNA evidence were featured in an episode that involved the misidentification of some human remains left outside a prison, and in an episode in which the detectives investigated a drive-by shooting, ballistics evidence and fingerprint analysis were important elements.

Alana Van Gundy-Yoder

Further Reading

Ramsland, Katherine. *The Science of "Cold Case Files."* New York: Berkley Books, 2004.

Walton, Richard H. *Cold Case Homicides: Practical Investigative Techniques*. Boca Raton, Fla.: CRC Press, 2006.

See also: Blood spatter analysis; Bullet-lead analysis; Celebrity cases; *CSI: Crime Scene Investigation*; DNA analysis; DNA fingerprinting; Fingerprints; *Forensic Files*; Handwriting analysis; Literature and forensic science; Misconceptions fostered by media.

Columbus remains identification

Date: Began in 2002

The Event: The cities of Seville, Spain, and Santo Domingo, Dominican Republic, have long debated which of them is the resting place of the authentic remains of Christopher Columbus. Modern DNA analysis techniques have been put to use in the examination of the remains in Seville, but efforts to settle the issue conclusively have not been successful because the Dominican Republic has refused to allow the remains in its possession to be tested.

Significance: The use of DNA analysis to test the remains held in Seville that were reputed to be those of Columbus brought international attention to the use of such techniques for the positive identification of individuals. For the countries involved in the debate over Columbus's burial site, national and regional pride are at stake, but tourism and other financial benefits are also major factors.

Christopher Columbus was born in 1451 and died on May 20, 1506, at age fifty-five. He died, from a variety of ailments and exhaustion, in Valladolid, Spain, while pursuing a successful effort to secure financial benefits for his heirs from King Ferdinand II. He was buried in Valladolid, his temporary residence. Although Columbus died surrounded by his close loved ones, the death of the great explorer went almost unnoticed in Spain.

A few years after Columbus died, one of his sons, Diego, had his body transferred to the Carthusian monastery of Santa María de las Cuevas, near Seville, more than three hundred miles from Valladolid, where Columbus had rested for months after returning from his fourth voyage in 1504. In 1526, the bones of his son Diego were also buried there. Christopher Columbus had asked to be buried in Santo Domingo, his favorite island, and in 1537, his and Diego's remains were transferred to Santo Domingo, to a temporary location and then to the cathedral. In 1796, to avoid French control when Hispaniola was ceded to France, the Spanish government had Columbus's body moved again, this time to Havana, Cuba. When Spain lost Cuba to independence in 1898, Columbus's body was again transferred, this time to the Cathedral of Seville.

Meanwhile, in 1877, during renovation of the cathedral in Santo Domingo, a lead box had been found that was inscribed with Columbus's name; the box contained thirteen large and twenty-eight small bone fragments. Despite questions about the location of the lead box, Santo Domingo claimed that the wrong remains (perhaps those of Columbus's son Diego) had been sent to Havana, and that it had the true remains of Columbus.

In 2002, Marcial Castro, a historian and teacher from the Seville area, began a project that would perform DNA (deoxyribonucleic acid) analysis on the reputed Columbus remains held at the Cathedral of Seville. José

Tourists walk past the tomb of explorer Christopher Columbus in the Cathedral of Seville, Spain. The remains tested by researchers are housed in the casket held high by figures representing the Kingdoms of Spain. *(AP/Wide World Photos)*

Antonio Lorente, a forensic geneticist who had worked on criminal cases and had helped to identify the bodies of victims of brutal Latin American regimes of the 1970's, was enlisted as the leader of a team of genetic experts. By June, 2003, the researchers had obtained fragments of the remains believed to be those of Christopher Columbus as well as fragments from known relatives of Columbus: his son Hernando and his brother Diego, both of whom had been buried in Seville. Comparison of the Y (male) chromosomes of the remains attributed to Columbus and those of Hernando proved impossible because of deteriorated conditions.

In January, 2005, the researchers gained permission to view the purported Columbus remains in Santo Domingo, but Dominican authorities then withdrew permission and refused to allow any attempt to extract DNA from the bones, citing religious objections. In May, 2006, the researchers announced that they had matched the mitochondrial (maternally inherited) DNA of the remains in Seville claimed to be those of Columbus with the mitochondrial DNA of Columbus's brother Diego, proving that the two sets of remains were those of brothers. Despite this evidence, controversy about the true burial site of Christopher Columbus remains because of Santo Domingo's refusal to allow testing on the remains in its possession.

Abraham D. Lavender

Further Reading

Dugard, Martin. *The Last Voyage of Columbus*. New York: Little, Brown, 2005.

Wilford, John Noble. *The Mysterious History of Columbus: An Exploration of the Man, the Myth, the Legacy*. New York: Alfred A. Knopf, 1991.

See also: Anastasia remains identification; Anthropometry; Buried body locating; DNA analysis; DNA extraction from hair, bodily fluids, and tissues; DNA typing; Exhumation; Louis XVII remains identification; Mitochondrial DNA analysis and typing; Nicholas II remains identification; Y chromosome analysis.

Column chromatography

Definition: Technique used to analyze complex samples by separating the mixture of chemical species into individual components so their identities and concentrations can be determined.

Significance: Forensic samples can be complex mixtures of components, and determination of the individual components in a sample may provide investigators with valuable information. The components, once separated, are normally evaluated by a detector that is able to determine specific chemical or physical information about each component. The similarity between samples or the likelihood that samples have a common origin may be determined after individual components are evaluated.

The term "column chromatography" is applied to variety of techniques that can be classified by the phase of the material that is moving through the column. When this mobile phase is a gas, the technique is called gas chromatography (GC); when the phase is a liquid, it is called liquid chromatography. The column can be filled with particles, which is called a stationary phase, that allow a separation of individual components to take place. Instrumentation is often used to push the mobile phase through the column at higher pressures, allowing faster and improved separation of components.

Capillary GC is a common technique that requires that chemical components be analyzed in their gas state. It uses narrow glass columns that can be as long as 100 meters (roughly 330 feet). The insides of the columns can be coated with different chemical polymers so different types of chemical species can be separated. These columns are coiled for easy placement in an oven so the temperature can be controlled accurately. By changing the temperature, the scientist can analyze different chemical species. GC is commonly used to analyze samples taken from fire scenes in arson investigations.

High-performance liquid chromatography (HPLC) is a widely used analysis technique that employs high-pressure pumps to force a liquid phase through columns packed with small particles. Columns come in a variety of sizes, with inside dimensions smaller than 0.10 millimeters (0.004 inches) to as large as a few centimeters. To handle the high pressure, the columns are commonly made of stainless steel, but they may be made out of plastic for specific applications such as ion chromatography. Solvents such as methanol and water are commonly used as mobile phases. HPLC can be used to separate and analyze a range of forensically important samples; it is commonly used to determine the presence of illegal drugs and to determine what substances were used in suspected poisonings.

Solid phase extraction (SPE) is a specific type of column chromatography designed for sample preparation. It uses plastic columns filled with particles specifically designed to either attract or ignore different chemical compounds that would be found in a sample. For example, it can be used to concentrate drugs of abuse from urine.

Dwight Tshudy

Further Reading

Dong, Michael. *Modern HPLC for Practicing Scientists*. Hoboken, N.J.: Wiley-Interscience, 2006.

Grob, Robert L., and Eugene F. Barry, eds. *Modern Practice of Gas Chromatography*. 4th ed. Hoboken, N.J.: Wiley-Interscience; 2004.

Telepchak, Michael. *Forensic and Clinical Applications of Solid Phase Extraction*. Totowa, N.J.: Humana Press, 2004.

See also: Accelerants; Analytical instrumentation; Chromatography; Fax machine, copier, and printer analysis; Forensic toxicology; Gas chromatography; High-performance liquid chromatography; Micro-Fourier transform infrared spectrometry; Quantitative and qualitative analysis of chemicals; Questioned document analysis; Separation tests; Thin-layer chromatography.

Combined DNA Index System. *See* CODIS

Competency. *See* Legal competency

Competency evaluation and assessment instruments

Definition: Psychological evaluation instruments that assess the ability of persons to function meaningfully and knowingly, without serious deficiencies, in understanding legal proceedings, communicating with attorneys, understanding their roles in proceedings, and making legally relevant decisions.

Significance: Legal competency is the capacity to understand the nature and purposes of legal rights, obligations, and proceedings. Forensic psychiatrists are often involved in conducting competency evaluations, which assist in protecting the rights of those being evaluated by determining the subjects' competency to stand trial.

In 1960, the U.S. Supreme Court established a law based on an appeal filed by a man named Milton Dusky, who was diagnosed with schizophrenia, after he received a forty-five-year jail sentence for kidnapping and assisting two teenagers in carrying out the rape of a sixteen-year-old girl. In its decision in *Dusky v. United States*, the Court ruled that to be deemed competent to stand trial, individuals must have a minimum level of understanding of the legal proceedings and the ability to assist their attorneys in their own defense. As a result, Dusky's sentence was reduced to twenty years.

The perception of competency is related to a defendant's ability to understand charges, relevant facts, legal issues and procedures, potential legal defenses, and possible dispositions, pleas, and penalties as well as the roles of the lawyers, judge, jury, witnesses, and defendant. Also important are the individual's abilities to identify witnesses, to communicate rationally with counsel, to comprehend instructions and advice, to make decisions, to help plan legal strategy, to follow testimony for contradictions or errors, to testify and be cross-examined, to challenge prosecution witnesses, to tolerate stress at trial and while awaiting trial, to refrain from irrational behavior during trial, to disclose pertinent facts surrounding alleged offenses, and to use available legal safeguards.

Aside from competency, two other areas of defense are related to mental capacity: diminished capacity and mitigating circumstances. Diminished capacity evaluations focus on the ability of defendants to intend to commit the crimes of which they are accused. Evaluations of mitigating circumstances focus on defendants' ability to understand that their behavior was wrong.

Evaluation Process

An evaluation of a defendant's competency to stand trial can be ordered by the defense, the prosecution, or the judge. Competency to stand trial involves the defendant's ability to understand the legal proceedings, the charges, the roles of court personnel, the difference between pleas of guilty and not guilty, and the meaning of a plea bargain. It also encompasses the defendant's ability to assist in his or her defense, to work with the attorney, and to take an active part in the defense.

A psychological evaluation of an individual's competency to stand trial includes a review of the person's medical and psychological histories as provided by the individual being evaluated as well as by that person's family members. Assessment for brain damage caused by head injuries, dementias, and acute or chronic alcohol and drug abuse may also be included. A clinical interview follows and includes assessments regarding orientation, short-term memory, and ability to reason. After the clinical interview, psychological testing is performed based on the results of the interview.

In criminal court, a defendant must be competent to waive Miranda rights if a confession is being used, to stand trial, to be sentenced, and to serve a sentence if found guilty. Additionally, the defendant must have been competent at the time of the offense and must be competent to be executed if a death penalty is ruled. Individual competency determinations do not automatically lead to determinations of competency in other areas. For example, competency at the time of the offense does not guarantee that the defendant will be competent to stand trial later. The courts can dismiss charges against individuals if there is no indication that competency will return following treatment.

Competencies to waive constitutional rights and to waive the right to counsel are addressed in the evaluator's report on competency to stand trial. Such a report includes the following elements: information regarding the source of the referral; date, place, and time of evaluation; nonconfidentiality statement; references and interviews used to prepare the report; criteria for competency to stand trial; background information on the defendant; information on the defendant's history of psychiatric and medical treatment and substance abuse; results of the mental status exam; the evaluator's findings on the defendant's level of mental function and ability to understand the proceedings; and statements from the defendant that demonstrate the defendant's understanding of the issues of the case (charges, legal situation, roles of courtroom personnel, differences between pleas, and range of possible verdicts). The report also assesses the defendant's ability to assist in the defense (based on the defendant's ability to recount his or her whereabouts and activities at the time of the offense) and to interact with the defense attorney and behave in an acceptable manner in the courtroom. Some reasons that defendants are deemed incompetent to stand trial are low intelligence, dementia, depression, mania, and paranoid delusions.

Assessment Instruments

Many psychological tests have been developed for use in evaluating mental competency. Among those most frequently employed by forensic psychiatrists are the Competency Screening Test, the Competency Assessment Instrument, the Interdisciplinary Fitness Interview, and the Georgia Court Competency Test.

The long form of the Competency Screening Test (CST), developed by a group of Harvard psychologists, comprises twenty-two sentence stems concerning hypothetical legal situations; the person being evaluated is asked to complete each sentence. An example item is "When I go to court, the lawyer will ______." The evaluator scores each answer as indicating competency, questionable competency, or incompetency. A short form of the CST is also sometimes used; the short form comprises just five sentence stems.

The Competency Assessment Instrument (CAI), developed by the same group of psychologists who created the CST, requires a one-hour structured clinical interview that explores the thoughts and feelings of the person being evaluated in thirteen topic areas, including coping with stress and sense of optimism as well as an understanding of legal proceedings. The CAI provides sample questions for each topic area, and the evaluator scores the responses of the person being evaluated using a five-point scale of competency.

The Interdisciplinary Fitness Interview (IFI) is administered jointly by a mental health professional and an attorney. The IFI, which takes thirty minutes, addresses both legal and mental health issues, with greater focus on mental illness than some other instruments.

The Georgia Court Competency Test (GCCT) consists of twenty-one questions related to the client's general legal knowledge and knowledge of such specifics as the judge's job and the lawyers' job. This tool is particularly useful for measuring behavioral aspects of competency.

Other competency tests that have shown promise but have not yet been determined to be both reliable and valid include the MacArthur Competence Assessment Tool-Criminal Adjudication, the Computer-Assisted Determination of Competence to Proceed, and the Competence Assessment for Standing Trial for Defendants with Mental Retardation.

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Further Reading

Bardwell, Mark C., and Bruce A. Arrigo. *Criminal Competency on Trial: The Case of Colin Ferguson*. Durham, N.C.: Carolina Academic Press, 2002. Case study of a notorious mass murderer examines the legal and psychological issues associated with his competency to stand trial.

Dagher-Margosian, Jeanice. "Representing the Cognitively Disabled Client in a Criminal Case." *Disabilities Project Newsletter* (State Bar of Michigan) 2 (March, 2006). Presents an overview of the types of mental incapacities that may be reviewed in considering a person's competency to stand trial.

Grisso, Thomas. *Evaluating Competencies: Forensic Assessments and Instruments*. 2d ed. New York: Springer. 2002. Offers useful tools for evaluating legal competency in both criminal and civil cases.

Resnick, Phillip J., and Stephen Noffsinger. "Competency to Stand Trial and the Insanity Defense." In *Textbook of Forensic Psychiatry*, edited by Robert I. Simon and Liza H. Gold. Arlington, Va.: American Psychiatric Publishing, 2003. Uses case vignettes to illustrate various aspects of the determination of competency to stand trial.

Rogers, Richard, and Daniel W. Shuman. *Fundamentals of Criminal Practice: Mental Health and Criminal Law*. New York: Springer, 2005. Textbook covers all aspects of criminal law as it applies to issues of mental health, including competency to stand trial.

Swerdlow-Freed, Daniel H. "Assessment of Competency to Stand Trial and Criminal Responsibility." *Michigan Criminal Law Annual Journal* (2003). Discusses the protocols and procedures involved in legal proceedings concerning the evaluation of a defendant's mental competency to stand trial.

See also: *Diagnostic and Statistical Manual of Mental Disorders*; Forensic linguistics and stylistics; Forensic psychiatry; Forensic psychology; Innocence Project; Insanity defense; Legal competency; Living forensics; Trial consultants.

Composite drawing

Definition: Artistic rendering of the facial features of unknown persons, often crime suspects, based on eyewitness information for use in narrowing law-enforcement searches.

Significance: The ability of law-enforcement officials to solve a crime depends largely on the cooperation and participation of private citizens in the investigatory process. Without eyewitness identification, many offenders remain at large and are never brought to justice for their crimes. Police sketch artists often contribute to investigations by creating composite drawings of the perpetrators of crimes based on descriptions provided by victims or other eyewitnesses. The productions of sketch artists have been instrumental in the capture of many notorious criminals, including the serial killer Ted Bundy and Richard Allen Davis, the kidnapper and murderer of twelve-year-old Polly Klaas.

Forensic artists, also known as police artists or sketch artists, are specially trained professionals whose work assists law-enforcement investigators in the identification, apprehension, and conviction of unknown suspects in unsolved criminal cases. Certified by the Forensic Art Certification Board of the International Association for Identification, forensic artists contribute to the investigatory process primarily through their creation of composite drawings or sketches, called composite imagery.

Forensic artists create composite drawings of unknown suspects on the basis of reports from victims or other witnesses (informants) about the perpetrators of unsolved crimes. From memory, an informant provides a sketch artist with a description of a suspect, and the artist creates a composite drawing that emerges as the artist obtains increasingly specific information about the suspect's facial features. With the exception of the largest police departments in the United States, few American law-enforcement agencies employ full-time sketch artists. Most share the services of police artists with other agencies or hire local professional artists on an ad hoc basis to create composite imagery.

Beginnings of Forensic Art

The field of forensic art has a long history. In the United States, the earliest practitioners were the artists of the Old West who created the posters depicting wanted criminals that were displayed in a wide range of public settings, including in churches, schools, saloons, and post offices. During the late nineteenth century, French criminologist Alphonse Bertillon created the first formal system of criminal identification, which included techniques that became the forerunners of forensic art. Bertillon's book on anthropometry (the study of the dimensions of the human body), *Identification anthropométrique; instructions signalétiques* (1893; *Signaletic Instructions Including the Theory and Practice of Anthropometrical Identification*, 1896), laid the groundwork for the basic procedures of composite drawing that continue to influence practitioners of the art.

During the 1950's, a kit designed to aid in the creation of composite imagery, the Identi-Kit, became a huge commercial success. Use of the Identi-Kit became standard practice among U.S. law-enforcement agencies, especially in cases involving multiple victims or other witnesses. The kit contained a large collection of hand-drawn facial features (hairlines, mouths, cheekbones, eyes, noses, ears, and so on) from which informants could choose in building composite faces. By the 1970's, police sketch artists had replaced the use of the Identi-Kit with composite drawings, which produced richer and less contrived portraits of unknown suspects.

A police sketch artist refers to a catalog of facial features in creating a composite drawing of a crime suspect. *(AP/Wide World Photos)*

Uses of Composite Imagery

Composite drawings can be used in several ways. In most cases, a composite drawing is created to capture the facial appearance of an unknown suspect so that law-enforcement investigators can begin to narrow the pool of viable suspects and better target their search for the unknown offender. Although composite drawings are usually of faces, forensic artists also sometimes provide useful visual depictions of evidence in criminal cases, such as stolen property or automobiles, or of actions that transpired at crime scenes. All of these kinds of images can be submitted as demonstrative evidence in the trial process.

Composite drawings can be modified to simulate how suspects might appear as they naturally change or age or as they might attempt to alter their appearance by adopting various disguises. For example, a sketch artist can modify the original image of a suspect by adding or subtracting weight or by adding signs of aging. Other image modifications might include the addition of various types of facial hair (mustaches, beards, sideburns) and different types of glasses, hats, or piercings.

Creating the Drawings

Forensic artists can create two-dimensional depictions of suspects by hand or with the aid of computer-imaging software. The success of either technique depends largely on the ability of the informant to describe the suspect accurately and on the talent of the police artist in translating the informant's description into a precise re-creation of the suspect's facial features.

Police sketch artists must possess not only artistic ability but also effective interviewing, listening, and intuitive skills. The creation of a composite drawing necessitates close communication between the informant and the sketch artist. To jog the informant's memory, the artist asks the informant a series of questions covering all aspects of the crime incident, including questions about the length of time the perpetrator was observed, the lighting conditions at the crime scene, the distance between the perpetrator and the informant during the incident, and any obstacles that obstructed the informant's view of the perpetrator.

Helping the informant return to the crime scene in his or her mind's eye is a critical first step in the composite-drawing process. A well-executed rendering based on inaccurate information about a suspect's appearance can be costly to a criminal investigation, wasting police time and resources and allowing an offender to remain at large to commit subsequent crimes. The sketch artist must take care to elicit precise details from the informant that will enable the creation of a successful drawing.

The process of creating the composite image continues with the sketch artist showing the informant a series of photographs that depict various face shapes as well as various types of eyes, noses, hair, ears, and so on. The informant selects from those choices the characteristics that most closely resemble those of the perpetrator, and the police artist assembles the selected features to create the first draft of the composite. The artist then carefully refines the drawing through several iterations until the informant decides that the artist has achieved a match.

The most common type of composite image is a freehand drawing that represents the artist's attempt to reproduce the informant's reports as closely as possible. The drawing's approximation of the suspect's actual appearance might be close enough to generate productive leads for police investigation, and it might also be close enough to jog the memories of other possible witnesses among the general public.

Some law-enforcement agencies employ computer-based assemblages of features in creating composite drawings, instead of or in tandem with the renderings of sketch artists. Although such software packages are useful, they do have shortcomings. For example, basic packages are restricted in the variations they can generate in terms of human features, which in reality are virtually limitless in their shapes, sizes, and shades of color. Stocking such programs with greater numbers of features is costly and makes the programs more challenging to operate; in addition, it takes more time to find the correct feature when the pool is large. Even with an abundant stock of features, an image program might lack a particular feature or combination of features that fits a given unknown suspect, especially one with an uncommon profile (for example, a middle-aged Asian woman).

Identifying the Dead

In addition to creating images of suspects for use in criminal investigations, police sketch artists are sometimes called upon to lend their skills to the identification of unknown deceased persons whose faces are unrecognizable because of suicide-related trauma, homicide, or accident, or as a result of decay, decomposition, or skeletonization. In such facial reconstruction or approximation, tissue depth markers and special drawing techniques are used to produce three-dimensional images.

A thorough examination of the human skull by a forensic anthropologist can reveal a great deal of information about the deceased, including the unknown person's gender, approximate age, race, and overall size. A forensic artist can then use existing knowledge about the likely depths of tissue covering various parts of the face to fill in missing areas or to correct facial distortions in front- and profile-angle portraits or models so that the decedent's re-created face can be used for postmortem identification. In some cases, forensic artists use clay to build three-dimensional faces on casts of the skulls of unidentified deceased persons. Facial reconstruction is usually employed only after other avenues of identifying an individual—such as by matching fingerprints, DNA (deoxyribonucleic acid), or dental records—have failed.

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Further Reading

Boylan, Jeanne. *Portraits of Guilt: The Woman Who Profiles the Faces of America's Deadliest Criminals*. New York: Pocket Books, 2001. Provides a behind-the-scenes look at the career of Boylan, a nationally renowned police sketch artist. Dramatic narrative relates the author's participation in several high-profile cases, including the searches for the Unabomber and for the perpetrators of the bombing of the Alfred P. Murrah Federal Building in Oklahoma City. Enables readers with no law-enforcement background to understand the painstaking work of criminal investigations.

Clement, John G., and Murray K. Marks. *Computer-Graphic Facial Reconstruction*. New York: Academic Press, 2005. Focuses on a variety of approaches to computer-aided identification of deceased persons based on skull structure.

Fridell, Ron. *Forensic Science*. Minneapolis: Lerner, 2007. Brief volume intended for young readers includes an outstanding chapter on identification that describes methods of forensic facial reconstruction.

Gibson, Lois, and Deanie Francis Mills. *Faces of Evil: Kidnappers, Murderers, Rapists, and the Forensic Artist Who Puts Them Behind Bars*. Liberty Corner, N.J.: New Horizon Press, 2005. Interesting volume intended for a general audience discusses the work of Gibson, a forensic artist, on thirteen individual cases.

Taylor, Karen T. *Forensic Art and Illustration*. Boca Raton, Fla.: CRC Press, 2001. Definitive compendium on the subject by an internationally recognized forensic artist and in-demand instructor in law-enforcement agencies and universities. Highly illustrated work covers all aspects of the field, including chapters on the history of forensic art, lessons in human anatomy, and step-by-step descriptions of the practical methods and techniques that are used by top practitioners in the investigatory process. Features numerous interesting case studies that show how forensic artistry is used in solving crimes and identifying dead persons.

See also: Anthropometry; Biometric identification systems; Child abduction and kidnapping; Cognitive interview techniques; *Cold Case*; Crime scene investigation; Crime scene sketching and diagramming; Facial recognition technology; Forensic anthropology; Forensic sculpture; Tattoo identification.

Computer crimes

Definition: Crimes in which computers, computer networks or databases, digital devices, or the Internet have been attacked or infiltrated as well as crimes that are facilitated by computers, wireless Web devices, or the Internet.

Significance: The investigation and prosecution of computer crimes are concerns for the private, public, and government sectors responsible for information security. Computer crime, also called cybercrime, is ranked third in priority by the Federal Bureau of Investigation, behind terrorism and espionage.

Computer-based crimes caused an estimated $14.2 billion in damages to businesses throughout the world in 2005, including the cost of repairing systems and lost business. Costs to individuals who were victims of identity theft were also tremendous. Criminals are committing traditional and high-tech crimes using their own computers, hijacked computers, cellular telephones, personal digital assistants (PDAs), credit card readers, iPods, and BlackBerry devices.

Because computer crime can be committed anonymously from anywhere in the world, and because it is difficult to prove who was at the keyboard in any given case, the number of computer criminals successfully captured and prosecuted remains very low. The people who carry out such crimes are difficult to identify or locate in part because they work hard to hide the electronic tracks left by their activities. They can disguise or hide their identities by hacking into and taking control of Internet-connected computers anywhere in the world and routing their activities through them.

With few effective deterrents in place, traditional criminals such as con artists, extortionists, child pornographers, money launderers, industrial spies, and drug dealers have been able to increase the scope and frequency of their crimes by using computer and communication technologies. In addition, with increasing numbers of users connected to the Internet, particularly in developing countries, geographic barriers to entry into criminal activity have been eliminated. One of the greatest financial threats in computer crime comes from spyware programs sent from developing countries that secretly record passwords, banking information, or other keystrokes. These confidential data are then sent to data thieves who sell them to money launderers or other criminals.

Serious crimes involving the exploitation of children have moved online. Pedophiles cultivate relationships with children using social network Web sites and then arrange to meet them in public places. Child pornographers use file servers, chat rooms, and e-mail to distribute images.

Computer crimes do leave electronic evidence on individual computers, on computer networks, and in log files. The downloading, storage, and distribution of images or files leave electronic evidence. Because spyware programs get installed on victims' computers, evidence of their existence can be found in the receiving computers' registries. Although different types of computer crimes are investigated differently, a number of generally accepted policies and procedures, if strictly followed, can help investigators to locate, acquire, and recover electronic evidence that is admissible in court.

History

In its earliest forms, cybercrime was carried out with hacker tools that required computer expertise to use. During the 1970's, most computer criminals were hackers who were highly motivated people with technical knowledge; some worked at universities or computer centers. In 1988, Robert Morris, Jr., a graduate student at Cornell University and son of a chief scientist at the U.S. National Security Agency, developed an Internet worm that infected thousands of computers and cost an estimated $100 million in cleanup.

In 1992, the Federal Bureau of Investigation (FBI) proposed expanding federal wiretapping laws to require all public and private networks in the United States to be capable of intercepting an intruder's or suspect's activities. The FBI wanted real-time remote access to all data, fax, voice, and video traffic in the United States. Civil liberties groups contested this proposal, however, and were able to defeat it.

The first federal computer crime statute was the Computer Fraud and Abuse Act of 1984 (CFAA). Only one indictment was made under the CFAA before it was amended in 1986. By the mid-1990's, almost every U.S. state had enacted a computer crime statute. These statutes criminalize any wrongful access into a computer, regardless of whether any damage occurs as a result. Other statutes under which the FBI investigates computer-related crimes include the Economic Espionage Act and the Trade Secrets Act.

Many countries have adopted similar statutes designed to protect electronic commerce, the financial industry, and information stored on computers. An ongoing challenge for those investigating computer crime is keeping up with hardware and software advances that can affect forensic analysis.

Computer Crime and Physical Investigations

Because considerable overlap exists between computer crimes and traditional physical and financial crimes, traditional criminal personality profiling is valuable in computer forensic investigations, where computers and the Internet are the electronic crime scenes. For example, fraud and extortion are age-old crimes that are more easily committed using computer technol-

The FBI and Cybercrime

The Federal Bureau of Investigation's stated fourfold "cyber mission" is as follows:

First and foremost, to stop those behind the most serious computer intrusions and the spread of malicious code; second, to identify and thwart online sexual predators who use the Internet to meet and exploit children and to produce, possess, or share child pornography; third, to counteract operations that target U.S. intellectual property, endangering our national security and competitiveness; and fourth, to dismantle national and transnational organized criminal enterprises engaging in Internet fraud.

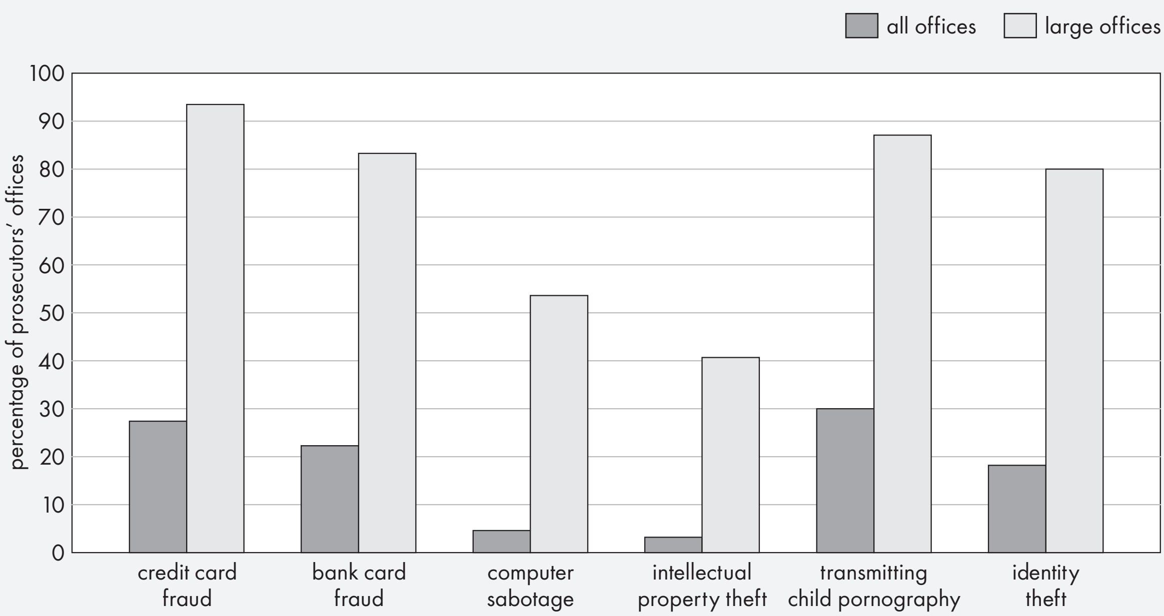
ogy. Cyberterrorists have extorted millions of British pounds by threatening to knock out computer-dependent financial systems, and extortionists have hacked into corporate databases and demanded huge payoffs in exchange for not destroying or publishing the data stored there. Investigators should assess how they would investigate particular crimes or criminals in the physical world and then apply that knowledge to the digital world. By examining the similarities between crimes committed through physical methods and those committed using electronic methods, investigators can better understand the perpetrators and where to search for evidence.

Given the dramatic increase in the incidence of computer crimes, prosecutors and law-enforcement agents must be knowledgeable concerning how to go about obtaining the electronic evidence stored in computers. Electronic records such as computer network logs, e-mails, word-processing files, and electronic picture files increasingly provide authorities with essential evidence in criminal cases. Computer hard drives and other storage media are the digital equivalents of filing cabinets holding information that investigators can turn into proof of a variety of crimes, including the distribution of child pornography, embezzlement, drug trafficking, money laundering, identity theft, sexual harassment, theft of trade secrets, cyberterrorism, and cyberstalking.

Computer investigations, like other forensic investigations, require specialized knowledge to acquire, preserve, analyze, and interpret the evidence. Incriminating evidence may be found in e-mail and logs of Internet activity on a single computer or may reside on many computers that cannot be physically located. Complicating computer investigations are criminals' attempts to avoid detection by deleting electronic files or formatting hard drives to hide the evi-

Prosecutor Offices and Types of Computer Crime

This chart shows the percentages of all U.S. prosecutor offices that reported prosecuting computer-related crimes in 2001. The left column for each category shows the percentage of all offices that prosecuted related cases; the right column shows the percentage for offices serving populations of at least one million people.



Source: U.S. Bureau of Justice Statistics.

dence, but even in such cases, trained computer forensic examiners can almost always find electronic evidence of crimes as well as evidence of the efforts made to hide or delete incriminating material. In some ways, computer forensic examiners must take even greater care than investigators of traditional crime scenes because of the extremely fragile and easily altered nature of electronic evidence.

Because electronic evidence has become increasingly crucial to many civil and criminal cases, the field of computer forensics has gained national recognition. In the United States, the FBI has established fourteen state-of-the-art Regional Computer Forensics Laboratories (RCFLs). In these labs, computer forensics techniques are increasingly applied to the investigation of a variety of crimes, not just those involving computers, as Internet and mobile phone technologies become a pervasive part of everyday life and criminal activity. The U.S. Secret Service has established a national computer forensics lab in Alabama with partial funding by the Department of Homeland Security's National Cyber Security Division. The facility serves as a national cybercrimes training center for prosecutors and judges as well as law-enforcement investigators.

Preserving Electronic Evidence

Computers can be the instruments used to commit crimes as well as the targets of crimes. These crimes leave electronic evidence, but that evidence is rarely readily apparent. To obtain and protect potential legal evidence for use in criminal prosecutions, investigators must search computers, computer networks, and data storage devices using generally accepted computer forensics methods and tools. Experts use established investigative and analysis techniques to uncover information and system data, including damaged, deleted, hidden, or encrypted files. They seize and collect digital evidence at crime scenes, conduct impartial examination of the computer evidence, and then testify as required.

In matters of evidence, it is mandatory that law-enforcement personnel observe strict procedures regarding chain of custody, and all items must be preserved for independent analysis. The successful prosecution of computer criminals depends on the presentation of evidence that shows the connections between the suspects and the crimes. All records concerning the illegal intrusions or incidents of interest must be preserved; nothing should be deleted, tampered with, or altered.

To ensure the preservation of electronic evidence, an investigator needs to be prepared with a forensic kit that includes the following: tools such as screwdrivers, pliers, and scissors; duct tape; watertight and static-resistant plastic bags to store collected evidence; labels to use in marking items such as cables, connections, and evidence bags; bootable media such as DOS start-up diskettes, bootable CDs, and bootable USB drives; power, USB, printer, and FireWire cables; logbook to record the investigator's actions; and external USB hard drive to transfer large amounts of data or images.

Steps in the Forensic Examination

When the evidence arrives at the computer forensic lab, the investigator must document the time and date and complete the appropriate chain-of-custody forms. The evidence must be stored in a secure area, where access to it is limited and controlled.

The acquisition phase of a computer investigation can take place either on-site or in the forensic lab. In either case, steps must be taken to ensure the integrity of the evidence. The preferred method is to conduct this phase in the trusted environment of the laboratory whenever circumstances permit. The acquisition of electronic evidence is a crucial step in the investigation because this is where the potential for alteration of the original evidence is greatest. It is vitally important that the investigator follow standard procedures and document all actions in order to ensure the integrity of the evidence beyond a reasonable doubt.

At the start of the acquisition process, the investigator must document the computer hardware and software that will be used to conduct the acquisition and analysis. After this documentation is complete, the next step is to disassemble the suspect computer. The main purpose of this is to allow the investigator access to the storage device on the suspect computer. The investigator must have access to the storage device to get data off the label of the device and to identify all storage devices, both internal and external, that are part of the computer.

The acquisition of evidence then proceeds with the copying of the suspect computer's hard drive; this process is called imaging or mirroring. The acquired forensic image must be verified to be an exact copy of the original. Specialized computer forensics software, such as EnCase or Forensic Toolkit (FTK), is typically used to create and verify the image. After a forensic image has been created, the investigator makes a duplicate to have a working copy of the image to analyze, so that if one image is destroyed or damaged or becomes corrupted, another copy is available without having to involve the original evidence.

The next phase is examination of the forensic image. Although computer forensic examiners should always follow certain basic procedures and start the examination phase in particular areas, an experienced examiner will also try to understand how the suspect thinks and works and then use that information to steer the examination method. For example, if the suspect is a novice computer user, the examination will usually cover only the basics. In contrast, examining the machine of an expert user who can hide or manipulate data forces the examiner to look for stealth activities when searching for evidence. Usually, this work is done with an image of the suspect's drive, and a separate hard drive is used to save evidence and tools for the case.

In the extraction phase, the examiner extracts data files for further analysis. It is during this step of the investigation that the data are searched for proof of crimes. The files are searched using key words, names, dates, and other file properties. One challenge faced by computer forensic examiners is data hiding—that is, the files to be examined may be password protected, encrypted, disguised, compressed, deleted, or corrupted. To crack a password, an examiner needs password-cracking software for the specific data file type. The difficulty of cracking a password is usually in direct correlation to the sophistication of the computer user.

One form of data hiding is the disguising of files by changing their file extensions. This is easily detected by most forensic software packages that do an analysis of file headers and compare them to established file extensions. Passwords on files usually yield clues in and of themselves, in that some passwords are very personal in nature and connect users to particular files. Another reason passwords are evidentiary in nature is that they help to prove that suspects intended to hide the contents of their files.

For file compression, forensic examiners use utilities that simply let the software reverse the compression process and specify where the uncompressed versions are to be saved. Dealing with encrypted files is much more difficult, as the encryption of a file itself may be so strong it can literally take years to decrypt.

Another method of data hiding is steganography, in which data are hidden within another file, such as a picture or music file. The technologies used in steganography vary, but the basic premise is that a small portion of an existing file is replaced by an embedded or hidden file. If a suspect has used "stego," it is very hard for an investigator to find the hidden file unless "before-and-after" versions of the file in which it is hidden are available. If the user has kept the original file on the computer's storage device and embedded data in a copy, the investigator can literally compare the two files bit by bit to determine whether they are different. The investigator must then find out which stego program was used to embed the file, because only the software used can realistically reverse the process.

In the final step of a computer forensic examination, the examiner completes the necessary documentation and writes a report of the processing, analysis, and interpretation of the evidence. Most organizations have standard sets of forms that forensic examiners must use in documenting their cases; these forms also provide examiners with guidelines to follow.

Tracking Criminals in Internet Relay Chat

Investigators sometimes track criminals through their use of Internet chat rooms. Pedophiles and other criminals often meet in such chat rooms to find victims, advertise, learn new skills, or teach others. They may also dis-

A special agent of the Federal Bureau of Investigation explains how the bureau tracked down and arrested thirty-nine suspects on child pornography charges in early 2005. Its "Operation Guardian" benefited from major advances in the technologies used to detect child pornography files shared over the Internet. The rapid expansion of the Internet since the early 1990's has enabled an explosion in online child pornography that has required federal and local law-enforcement agencies to devote ever-greater resources to combating the crime. *(AP/Wide World Photos)*

cuss their personal lives, allowing law-enforcement personnel to learn more about the social cultures of these criminals. System logs can enable investigators to track down criminals because such logs hold evidence that crimes have been committed and where the intrusions occurred. These logs cannot identify intruders, however—that is, they cannot indicate who was physically using given keyboards at any particular times. In Internet Relay Chat (IRC), however, individuals can be identified.

Hackers often do not connect to IRC directly. By using a variety of servers or hosts, hackers can subvert bans or trick others into thinking they are other people. Usually, hackers seek to hide their real IP addresses so that no one can find them and monitor their activities. They do so by using bounce programs (such as BNC and WinGate), which read from one port and write to another. These programs allow users to make a connection, connect to a destination, and then relay anything from the original connection to the destination. Hackers who have access to such programs can "bounce" through proxy servers to hide their tracks. Even if a complete audit trail shows that an intruder came from a specific account on a specific ISP, the only evidence will be billing information for the account, which does not prove identity.

Linda Volonino

Further Reading

Casey, Eoghan. *Digital Evidence and Computer Crime: Forensic Science, Computers, and the Internet*. 2d ed. New York: Elsevier, 2003. Explains how computers and networks function, how they can be involved in crimes, and how they can be used as sources of evidence. Includes a CD-ROM that provides valuable hands-on training.

_______, ed. *Handbook of Computer Crime Investigation: Forensic Tools and Technology*. San Diego, Calif.: Academic Press, 2002. Collection of fourteen chapters directed toward law-enforcement personnel and forensic examiners. Numerous case studies make this a good reference manual for both new and experienced investigators. Describes how to search hard drives for remnants of illicit images, illegal software, and harassing e-mails.

Kipper, Gregory. *Wireless Crime and Forensic Investigation*. New York: Auerbach, 2007. Presents an overview of the various types of wireless crimes and the computer forensic investigation techniques used with wireless devices and wireless networks. Explores a wide range of wireless technologies, including short text messaging and war driving.

Thomas, Douglas, and Brian D. Loader, eds. *Cybercrime: Law Enforcement, Security, and Surveillance in the Information Age*. New York: Routledge, 2000. Collection of articles covers topics such as criminality on the electronic frontier, hackers, cyberpunks, and international attitudes toward hackers. Points out mistakes that law-enforcement personnel and prosecutors sometimes make during the investigation of computer crimes.

U.S. Department of Justice. Criminal Division. *Federal Guidelines for Searching and Seizing Computers and Obtaining Electronic Evidence in Criminal Investigations*. Washington, D.C.: Government Printing Office, 2002. Explains the guidelines developed by the Justice Department's Computer Crime and Intellectual Property Section in conjunction with an informal group of federal agencies known as the Computer Search and Seizure Working Group.

Volonino, Linda, Reynaldo Anzaldua, and Jana Godwin. *Computer Forensics: Principles and Practice*. Upper Saddle River, N.J.: Prentice Hall, 2007. Explains the use of investigative tools and procedures to maximize the effectiveness of evidence gathering. Also covers the legal foundations for handling electronic evidence, how to keep evidence in pristine condition so it will be admissible in a legal action, and how to investigate large-scale attacks such as identity theft, fraud, extortion, and malware infections.

See also: Computer forensics; Computer Fraud and Abuse Act of 1984; Computer hacking; Computer viruses and worms; Cryptology and number theory; Cyberstalking; Identity theft; Internet tracking and tracing; Steganography.

Computer forensics

Definition: Forensic specialty that applies science to the acquisition and analysis of electronic data from computers, other digital devices, and the Internet to assist in civil and criminal investigations.

Significance: Every use of a computer or other digital device is recorded, leaving a digital trail of evidence. Because computer crimes as well as physical crimes—and the criminals who commit them—often leave trails of electronic evidence, computer forensics has come to play an increasingly prominent role in law enforcement, crime investigations, civil cases, and homeland security.

Since 1991, when the World Wide Web was developed, rapid growth has been seen in personal, professional, and criminal uses of the Internet—through e-mail, instant messaging, online chat rooms, social networking Web sites, Web logs, and more—and of networked computers and cellular devices. Computers and digital communication devices create and store huge amounts of details in their memory or log files. When computer files are saved, sent, or downloaded, the computer's operating system and other software automatically record and store this information. The records and files stored on computers and other digital devices can be used as evidence to support or defend against allegations of wrongdoing.

Rule 34 of the Federal Rules of Civil Procedure

In 1970, Rule 34 of the Federal Rules of Civil Procedure was amended to address changing technology and communication methods. The amended Rule 34 made electronically stored information subject to subpoena and discovery. Therefore, any communication or file storage device is subject to computer forensic searches to identify, examine, and preserve potential electronic evidence—the electronic equivalent of a "smoking gun."

This rule has had far-reaching implications for electronic records and communications—gateways to evidence of a person's or organization's activities and conduct. Every computer-based activity—whether it is using the Internet for money laundering or identity theft or sending e-mail containing incriminating or threatening messages—leaves an electronic trace that computer forensics may recover. Thus a good probability exists that, deleted or not, electronic mail, histories of Web site visits, drafts and revisions of documents, spreadsheets, and other materials can be retrieved. Computer forensics is playing a growing and major role in legal cases, as new legislation is passed to combat cybercrimes, traditional crimes, and terrorism.

Rarely are users aware that their activities have left multiple trails of evidence, and many may not even attempt to purge those trails regardless of how incriminating they are. Even technology-savvy users who want their activities to go undetected may not be able to delete or disguise all their trails of evidence completely. Often it is impossible to delete all traces of electronic evidence. The work of computer forensic investigators involves finding, analyzing, and preserving relevant digital files or data for use as electronic evidence.

The three primary types of evidence presented in legal proceedings are the testimony of witnesses, physical evidence, and electronic evidence. The newest of these is electronic evidence. Common types of electronic evidence are the contents of e-mail and instant messages and chat-room conversations, records of Web sites visited, downloaded and uploaded files, word-processing documents, spreadsheets, digital pictures, Global Positioning System (GPS) records, and data from personal digital assistants (PDAs). Investigations of computer crimes, identity theft, computer hacking and viruses, electronic espionage, and cyberterrorism require computer forensic technical and investigative skills and tools because of the digital or electronic nature of the evidence.

The thorough investigation and unbiased analysis of electronic evidence requires specialized computer forensics tools used by experts who understand both computer technologies and legal procedures. It may seem that because electronic evidence falls into the category of hearsay evidence, which is secondhand evidence, it would not be admissible in court, but electronic evidence is one of the exceptions to the hearsay rule. It is considered reliable provided that it is handled properly.

Principles of Computer Forensics

A computer forensics investigation uses science and technology to acquire and examine electronic data in order to develop and test theories that can be entered into a court of law to answer questions about events that have occurred. Generally accepted computer forensics principles have been established to ensure that the chain of custody of the evidence can be verified later in court or other legal proceedings. Like physical evidence, electronic evidence can be easily contaminated if investigators ignore the forensic science principle of "do no harm." The crime scene, which is the state of the computer, must be preserved to protect the integrity of the evidence; simply turning on a computer and searching through the files can alter those files and the computer's records.

Forensic investigators are aware that they will need to defend their findings. Their electronic evidence-processing methods, tools, and techniques may be challenged rigorously by the opposing side in a court case. Documentation is important so that investigators can refresh their memories about the steps taken and duplicate the results of processing if necessary. Investigators must thus follow rigorous processes and procedures in the acquisition, authentication, analysis, and interpretation of electronic evidence.

The first step in any computer forensics investigation is acquisition of the evidence through the careful collection and preservation of the original files on a hard drive (or other storage device); this is accomplished through the creation of an exact bit-stream duplicate copy of the entire hard drive using computer forensics software, such as Forensic Toolkit (FTK) or EnCase, that is recognized by the courts as acceptable for verifying evidence. This duplicate, which is referred to as the mirror image or drive image, is used for the analysis; the original evidence is used only in extreme situations. Making a mirror image of a hard drive is simple in theory, but the accuracy of the image must meet evidence standards. To guarantee accuracy, imaging programs rely on mathematical cyclic redundancy check (CRC) computations to validate that the copies made are exactly the same as the originals. CRC validation processes compare the bit stream of the original source data with the bit stream of the acquired data.

The second step in the computer forensics investigation is authentication of the mirror image, or verification that the copy is identical to the original or source. Evidence verification depends not only on the use of the proper software and hardware tools but also on the equipment, environment, and documentation of the steps taken during evidence processing. At a minimum, preservation of the chain of custody for electronic evidence requires proving that no information was added, deleted, or altered in the copying process or during analysis, that a complete mirror image copy was made and verified, that a reliable copying process was used, and that all data that should have been copied were copied. This is accomplished when the mirror image is "fingerprinted" using an encryption technique called hashing. Hashing ensures the integrity of the file because it makes any modification of the data detectable.

The third and often most extensive step in the investigation is the technical analysis and evaluation of the evidence, which must be done is a manner that is fair and impartial to the person or persons being investigated. Investigators evaluate what could have happened as well as what could not have happened. The key to effective electronic evidence searches is careful preparation. Poor preparation during the early stages of an investigation can lead to failures in prosecution, as information can be ignored, destroyed, or compromised. Experienced computer forensics examiners are skilled in formulating search strategies that are likely to find relevant revealing data. Analyses are more productive when examiners have some sense of what they are seeking before they begin their searches. For example, if the focus is on documents, the investigators need to know names, key words, or parts of words that are likely to be found within

A computer forensic specialist of the Virginia State Police holds a hard drive from a computer seized during an investigation in late 2007. The growing demand for expert analysis of digital evidence has forced an increasing number of law-enforcement agencies to create special cybercrime investigation units. *(AP/Wide World Photos)* those documents. If the issue is trade secrets, it is helpful for the examiners to know which search terms are uniquely associated with the proprietary data. If the focus is child pornography, Web site addresses uniquely associated with prohibited content are valuable.

The final steps are the interpretation and reporting of the results. Examiners' conclusions must be accurate, complete, and usable in legal proceedings. Explaining the findings of computer forensic investigations in court can be difficult, especially when the evidence must be presented to persons with little technical knowledge. The value of the evidence ultimately depends on the way it is presented and defended in court. Because of the complexity of many of the tools involved in computer forensics, investigators must be trained and certified in their use. General training and certifications are also available for computer forensics investigators.

Regional Computer Forensics Labs

In 1999, the Federal Bureau of Investigation (FBI) launched an innovative pilot program in San Diego, California. The Regional Computer Forensics Laboratory (RCFL) program was designed to help state, local, and other federal law enforcement gather electronic evidence from computers, PDAs, cell phones, digital cameras, and other digital devices. The FBI undertook the project because computer forensics was one of the fastest-growing disciplines within law enforcement, and the RCFL program quickly became a dynamic tool for fighting crime and terrorism. By 2007, the RCFL program had evolved into a network of cutting-edge electronic evidence labs created to meet a rapidly increasing need. The RFCLs have supported high-profile investigations such as the Enron case, the bribery case against former California congressman Randy "Duke" Cunningham, the public corruption case against former Illinois governor George Ryan, and the dissolution of an international child pornography ring.

Each RCFL is a full-service forensics laboratory and training center devoted to the examination of electronic evidence in support of criminal investigations, including terrorism, child pornography, crimes of violence, the theft or destruction of intellectual property, Internet crimes, and fraud. In 2006, the RCFLs, which are staffed by trained computer analysts from the FBI and more than one hundred other agencies, collectively analyzed almost sixty thousand media items, including CDs, cell phones, hard drives, and PDAs. During 2006, requests for assistance on computer crimes, which included child pornography and other violent acts against children, were the most frequent kinds of requests in eleven of fourteen RCFLs, followed by violent crimes, major thefts, and white-collar crimes.

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Further Reading

Carrier, Brian. *File System Forensic Analysis*. Boston: Addison-Wesley, 2005. Good reference source for anyone who wants to understand file systems; aimed at professionals who need to be able to testify about how file system analysis is performed.

Kipper, Gregory. *Wireless Crime and Forensic Investigation*. New York: Auerbach, 2007. Presents an overview of the various types of wireless crimes and the computer forensic investigation techniques used with wireless devices and wireless networks.

Sheetz, Michael. *Computer Forensics: An Essential Guide for Accountants, Lawyers, and Managers*. Hoboken, N.J.: John Wiley & Sons, 2007. Provides a useful introduction to the essentials of preserving evidence on a computer, understanding how computer crime occurs, and what to do when it is found and suspected.

Steel, Chad. *Windows Forensics: The Field Guide for Corporate Computer Investigations*. Hoboken, N.J.: John Wiley & Sons, 2006. Presents a primer on how Windows file systems work and how to perform forensic analysis on these systems.

Volonino, Linda, Reynaldo Anzaldua, and Jana Godwin. *Computer Forensics: Principles and Practice*. Upper Saddle River, N.J.: Prentice Hall, 2007. Comprehensive work addresses how investigators use forensically sound methodologies and software to acquire admissible electronic evidence. Includes discussion of computer and e-mail forensics, cell phone forensics, and PDA and BlackBerry forensics.

See also: Chain of custody; Computer crimes; Computer hacking; Computer viruses and worms; Crime scene documentation; Crime scene investigation; Cyberstalking; Evidence processing; Forensic accounting; Internet tracking and tracing.

Computer Fraud and Abuse Act of 1984

Date: Enacted on October 12, 1984, and amended in 1986, 1996, and 2001

The Law: First comprehensive federal legislation in the United States designed to address concerns about the growth of computer fraud and other computer-related crimes.

Significance: The enactment of the Computer Fraud and Abuse Act of 1984 generated computer-specific criminal laws and sentencing guidelines for computer criminals.

Prior to the passage of the Counterfeit Access Device and Computer Fraud and Abuse Act of 1984 (commonly referred to as the Computer Fraud and Abuse Act, or CFAA), computer crimes in the United States were prosecuted under a number of statutes generally dealing with interstate communications, wire fraud, and attacks against government property. Little legislation had been passed to deal specifically with computer crimes. Federal statutes addressed crimes against federal institutions, interstate crimes, and acts against the country's security, such as terrorism. Because of the nature of computer networks, hackers were often prosecuted under interstate commerce and federal telecommunications laws originally written to address telephone fraud.

Content

Technological advances during the mid-1980's brought computers into mainstream American homes as well as into high schools, colleges, and businesses. The rapid growth of interconnectivity of computers by telephone lines and modems and the storage of vast numbers of confidential documents on computers compelled the passage of legislation to protect computer users. Existing laws were no longer sufficient to handle the kinds of theft and trespass that were possible using the new technology.

Originally limited in scope to interstate crime and instances involving government computers or those of financial institutions, the purpose of the 1984 Computer Fraud and Abuse Act was to protect classified, financial, and credit information that was maintained on federal government computers. The act made it a crime to knowingly access a federal-interest computer without authorization to obtain certain defense, foreign relations, or financial information or atomic secrets. A federal-interest computer was defined as a computer used by a financial institution, a computer used by the U.S. government, or one of two or more computers used in committing the offense, not all of which were located in the same state. The act also made it a criminal offense to use a computer to commit fraud, to "trespass" on a computer, and to traffic in unauthorized computer passwords.

Amendments

The Computer Fraud and Abuse Act of 1986 was designed to strengthen, expand, and clarify the intentionally narrow 1984 act. It safeguarded sensitive data harbored by government agencies and related organizations, nuclear systems, financial institutions, and medical records. The 1986 act forbade interference with any federal-interest computer system or any system that crossed state lines. It also prohibited the unauthorized access of any computer system containing classified government information. It specified three categories of classified information: information belonging to a financial institution, credit card issuer, or consumer reporting agency; information from a department or agency of the United States; and information from any computer deemed "protected" or used exclusively by a financial institution, by the U.S. government, or in interstate or foreign commerce or communication.

The 1986 act aimed to safeguard the integrity of computer systems with specific prohibitions against computer vandalism, including transmission of a virus or similar code intended to cause damage to a computer or system, unauthorized access that caused damage recklessly, or unauthorized access of a computer without malicious intent. The law established punishments of prison sentences up to twenty years and fines up to $250,000 for the perpetration of knowing and reckless damage to any computer system. Establishing criminal intent at time of trial, however, can prove difficult.

As computing evolved, the CFAA was further amended in 1996 by the National Information Infrastructure Protection Act, which broadened the law's scope to include conduct committed by or through the use of the Internet, World Wide Web, or other computer networks. It also removed the wording "federal-interest computer" and replaced it with "protected computer." In so doing, Congress broadened the scope of the act's protection from federal computers to include all computers involved in interstate and foreign commerce.

The Patriot Act of 2001 amended the CFAA again, raising the maximum penalties for some violations to ten years for a first offense and twenty years for a second offense, ensuring that violators who cause damage generally can be punished, and enhancing punishments for violations involving any damage to government computers involved in criminal justice or the military, including damage to foreign computers involved in interstate commerce. In addition, the 2001 amendments expanded the act's definition of "loss" to include the time spent by authorities in investigating and responding to damage assessment and restitution.

In its decision in the 2003 case *Theofel v. Farey Jones*, the U.S. Court of Appeals for the Ninth Circuit referred to the Computer Fraud and Abuse Act, holding that disclosure by the plaintiff's Internet service provider of e-mail messages pursuant to the defendant's invalid and overly broad subpoena did not constitute an "authorized" disclosure. This decision has potentially serious implications for law-enforcement authorities because of the limitations it places on their ability to obtain information from Internet service providers without having to obtain search warrants.

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Further Reading

Cantos, Lisa, Chad Chambers, Lorin Fine, and Randi Singer. "Internet Security Legislation Introduced in the Senate." *Journal of Proprietary Rights* 12 (May, 2000): 15-16. Provides a concise summary of the Computer Fraud and Abuse Act.

Conley, John M., and Robert M. Bryan. "A Survey of Computer Crime Legislation in the United States." *Information and Communications Technology Law* 8 (March, 1999): 35-58. Presents information on the various laws passed by local, state, and federal governments to attempt to address the issue of computer crime.

Montana, John C. "Viruses and the Law: Why the Law Is Ineffective." *Information Management Journal* 34 (October, 2000): 57-60. Addresses the difficulty of creating laws that can have any impact on the global problem of computer crime.

Toren, Peter J. *Intellectual Property and Computer Crimes*. New York: Law Journal Press, 2003. Treatise intended for attorneys and computer security professionals includes useful references to sources of information on intellectual property issues.

See also: Computer crimes; Computer hacking; Computer viruses and worms; Cyberstalking; Forensic accounting; Legal competency.

Computer hacking

Definition: Intrusions, unauthorized access, or attempts to circumvent or bypass the security mechanisms of a computer, computer network, computer program, or information system. Unauthorized access includes approaching, trespassing within, communicating with, storing data in, retrieving data from, or otherwise intercepting and changing computer resources without authorized consent.

Significance: The financial damage, destruction, and disruption caused by computer hackers worldwide have been tremendous. The incidence and severity of computer hacking have severely worsened since the 1980's, when hackers' primary aims were to steal bandwidth or gain fame in the hacker community. Since 2001, computer hacking has expanded into a global form of white-collar crime motivated by profit, with hackers engaging in data theft, identity theft, computer hijacking, sabotage, extortion, and money laundering for personal financial gain or to fund illegal activities.

The term "hacking" has various meanings, but it is commonly used to refer to forms of intrusion into a computer, computer database, or computer network without authority or in excess of authority. Hackers are criminals who exploit vulnerabilities in computers, information systems, e-mail systems, and digital devices. Hackers routinely break into computer networks through the Internet by "spoofing" the identities of computers that the networks expect to be present.

Hackers may be thieves, corporate spies, or disgruntled individuals; they may work for organized crime organizations or for nations or political groups. Hackers motivated by personal grievances who attack individuals they know or their own companies are the easiest to track down. In contrast, the investigation of hacking and Web-based illegal activities used to finance terrorism is complex, requiring the cooperation of national intelligence agencies. Common to all computer hacking investigations is the use of computer and network forensic tools and techniques to follow digital trails back to the computers used for hacking, to determine the identities of the hackers, or to learn how and why hackers' attacks were successful.

Computer hacking is one type of computer crime that might violate several federal laws in the United States as well as laws in many individual U.S. states. The federal laws under which hacking might be prosecuted include the Computer Fraud and Abuse Act of 1984, the Electronic Communications Privacy Act of 1986, and, depending on whether copies of materials have been made, the Copyright Act.

Electronic Evidence Left by Hackers

Although hackers vary in their intentions, all tend to use similar techniques, all of which require expertise in computers and computer networks; those who investigate hacking must have this expertise as well. The first step in hacking is usually to gain access to a networked computer and install an unauthorized hacker program, such as a Trojan horse or backdoor. All computer networks create logs that record the exact times of all attempts to log in, the IP (Internet protocol) addresses of the source computers, the commands that were used, and the programs that were installed. Those logs are valuable sources of information in the investigation of hack attacks unless the hackers covered their tracks by deleting entries from log files. Investigators can examine a computer's registry for stored information on installed software.

Not all hacking involves great technical skill. A hacker can sometimes gain access to a corporate system by calling an employee and pretending to be a coworker who needs help logging in. Because hackers can gain access through authorized accounts, investigators must consider the possibility that a person whose account was used to hack was not the hacker.

Tracing Hackers' Locations

Software programs such as Netstat are available that enable investigators to trace hackers' IP addresses to geographic locations. Hackers often use computers owned by other parties, however, such as those in public libraries or in public Internet cafés. This complicates investigations because such hackers must be prosecuted using evidence they leave on other people's computers. The longer hackers are allowed to compromise particular computers or networks, the more evidence can be collected against them to build solid cases. It is important that law-enforcement investigators are aware of this fact, but in some cases it may be neces-

Teenagers use computers at an Internet "café" in Beijing, China. A major problem in tracking the locations of computer hackers is that many of them operate from computers in public places such as libraries and commercial cafés. In late 2001, the Chinese government responded to the problem of Internet crime by closing down more than eight thousand Internet cafés across the country. *(AP/Wide World Photos)*

sary to shut down networks immediately to protect them.

In addition to needing an IP address, investigators need to identify the Internet service provider (ISP) from which an attack originated. Software is available that can reveal this information.

Hackers may try to hide their locations and identities by using software that routes Internet communications through untraceable IP addresses. Determining the IP address of the computer used to launch an attack is an important first step in discovering a hacker's identity. Most often, the IP address will be traceable back to a particular ISP. ISPs usually own "blocks" of IP addresses, in which only the last few digits differ, through which their customers connect to the Internet. These IP addresses are either statically or dynamically assigned, depending on the configuration of the ISP. An IP address of a static cable modem user constitutes a constant, traceable "fingerprint" of both the ISP provider and the specific user's computer terminal.

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Further Reading

Casey, Eoghan. *Digital Evidence and Computer Crime: Forensic Science, Computers, and the Internet*. 2d ed. New York: Elsevier, 2003. Explains how computers and networks function, how they can be involved in crimes, and how they can be used as sources of evidence.

Kipper, Gregory. *Wireless Crime and Forensic Investigation*. New York: Auerbach, 2007. Presents an overview of the various types of wireless crimes and the computer forensic investigation techniques used with wireless devices and wireless networks.

Thomas, Douglas, and Brian D. Loader, eds. *Cybercrime: Law Enforcement, Security, and Surveillance in the Information Age*. New York: Routledge, 2000. Collection of articles covers topics such as criminality on the electronic frontier, hackers, cyberpunks, and international attitudes toward hackers. Points out mistakes that law-enforcement personnel and prosecutors sometimes make during the investigation of computer crimes.

Thomas, Timothy L. "Al Qaeda and the Internet: The Danger of 'Cyberplanning.'" *Parameters: U.S. Army War College Quarterly* 33 (Spring, 2003): 112-119. Discusses how the Internet is used to support and fund terrorism.

U.S. Department of Justice. Criminal Division. *Federal Guidelines for Searching and Seizing Computers and Obtaining Electronic Evidence in Criminal Investigations*. Washington, D.C.: Government Printing Office, 2002. Explains the guidelines developed by the Justice Department's Computer Crime and Intellectual Property Section in conjunction with an informal group of federal agencies known as the Computer Search and Seizure Working Group.

Volonino, Linda, Reynaldo Anzaldua, and Jana Godwin. *Computer Forensics: Principles and Practice*. Upper Saddle River, N.J.: Prentice Hall, 2007. Explains the use of investigative

tools and procedures to maximize the effectiveness of evidence gathering. Chapter 10 discusses how investigators track down hackers and conduct large-scale investigations.

See also: Computer crimes; Computer forensics; Computer Fraud and Abuse Act of 1984; Cyberstalking; Steganography.

Computer viruses and worms

Definition: Malicious computer programs, also known as malware, that use embedded instructions to carry out destructive behavior on computers, computer networks, and digital devices.

Significance: Computer viruses and worms have the potential to disrupt computer networks and thus to cause great damage to a nation's economy. The U.S. Department of Justice has devoted significant resources to investigating and prosecuting persons who release viruses or worms on the Internet. In addition, government agencies investigate connections between malware and organized crime, identity theft, and terrorism.

Given the capacity of computer viruses and worms to spread to millions of computers within minutes and cause billions of dollars in damage, the distribution of malware is a criminal act. In the United States, causing damage to a computer connected to the Internet is a federal crime that carries substantial penalties for those convicted. The principal U.S. law-enforcement weapon against malware is the Computer Fraud and Abuse Act of 1984.

Many dangerous computer viruses have been spread through e-mail attachments and files downloaded from Web sites, and a rise has been seen in the numbers of professional virus writers—that is, people who are paid to infect computers with malware. Tracking down and catching virus authors is extremely difficult. The investigative methods used in this work include analyzing virus code for clues about the authors; searching online bulletin boards, where virus authors may boast of their accomplishments; and reviewing network log files for originating IP (Internet protocol) addresses of viruses. Even when law-enforcement agencies make concerted efforts in applying these techniques, it is still near impossible to track down virus and worm authors.

Some malware authors have been apprehended, however. When the Melissa virus overwhelmed commercial, government, and military computer systems in 1999, the Federal Bureau of Investigation (FBI) launched the largest Internet manhunt ever. Investigators

Members of the Computer Emergency Response Team who battled the outbreak of the Melissa computer virus in 1999 from the Software Engineering Institute at Carnegie Mellon University in Pittsburgh, Pennsylvania (from left): Jeff Carpenter, Shawn Hernan, and Tom Longstaff. *(AP/Wide World Photos)* succeeded in tracking down the virus creator by following several evidence trails. They identified David L. Smith of Aberdeen, New Jersey, as the suspect by analyzing the virus and the e-mail account used to send it, by searching America Online (AOL) log files that showed whose phone line had been used to send the virus, and by searching online bulletin boards intended for people interested in learning how to write viruses. Smith tried to hide the electronic evidence related to Melissa by deleting files from his computer and then disposing of it. The FBI found the computer, however, and used computer forensics techniques to recover incriminating evidence. Smith was caught within two weeks. He was the first person prosecuted for spreading a computer virus.

In August, 2005, Turkish and Moroccan hackers released an Internet worm, named Zotob, to steal credit card numbers and other financial information from infected computers. Zotob crashed innumerable computer systems worldwide. Investigators gathered data, including IP addresses, e-mail addresses, names linked to those addresses, hacker nicknames, and other clues uncovered in the computer code. Less than eight days after the malicious code hit the Internet, two suspects were arrested. Computer forensic experts on the FBI's Cyber Action Team (CAT) verified that the code found on seized computers matched what was released into cyberspace.

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Further Reading

Dwight, Ken. *Bug-Free Computing: Stop Viruses, Squash Worms, and Smash Trojan Horses*. Houston: TeleProcessors, 2006.

Erbschloe, Michael. *Trojans, Worms, and Spyware: A Computer Security Professional's Guide to Malicious Code*. Boston: Butterworth-Heinemann, 2005.

See also: Computer crimes; Computer forensics; Computer hacking; Cryptology and number theory; Steganography.

Confocal microscopy

Definition: Optical imaging technique often used when a high degree of contrast or reconstruction of a three-dimensional image is desired.

Significance: Confocal microscopy has rapidly gained popularity in forensic science as a method of choice for imaging evidence samples because confocal microscopes produce images of a quality superior to what can be achieved with conventional fluorescence microscopes.

Forensic scientists can use various microscopic methods to examine samples obtained from accident or crime scenes. The choice of technique is determined in part by the size of the target. Confocal microscopy utilizes point illumination and a pinhole in an optically conjugate plane to eliminate light flare, producing high-quality images.

Three types of confocal microscopes are available: confocal laser scanning microscopes (CLSMs), spinning-disk (Nipkow disk) confocal microscopes, and programmable array microscopes (PAMs). Modern instruments are highly evolved compared with the earliest versions, but the principles of confocal imaging established by Marvin Minsky in 1957 are shared by all confocal microscopes. The method of image formation in confocal microscopes is fundamentally different from that of wide-field microscopes, which light entire specimens. Confocal microscopes produce in-focus images of thick specimens through a process called optical sectioning using focused beams of light. Through the use of digital image-processing technology, serial (consecutive) images can be reassembled to construct three-dimensional representations of the sample or structures being studied.

Prior to imaging with confocal microscopy, specimens are usually fixed and stained. The preparatory protocols (that is, cutting, fixing, and staining of specimens) are largely derived from those used in conventional microscopy. During the staining stage, specific regions of specimens (such as specific organelles) can be labeled with antibodies conjugated with fluo-

A scientist with the Centers for Disease Control and Prevention uses a confocal microscope to examine a sample in three dimensions. *(Centers for Disease Control and Prevention)*

rescent probes. By examining the relative distribution of epitopes of interest, investigators can ascertain many details about a sample, including the type of specimen, pathological condition, and phase in the cell cycle.

Live-cell imaging and time-lapse imaging can be achieved with confocal microscopy, and inert and nonbiological specimens can also be examined using this technique. Forensic scientists can use confocal microscopes to examine evidence samples that are not easily visualized with conventional microscopes, such as the marks on bullets and cartridge cases as well as gunshot residue that is expelled when a firearm is discharged.

Another application of confocal microscopes in forensic science is in the analysis of paper documents. Specifically, confocal microscopy can enable an analyst to determine the sequence of two crossing strokes in different colors or different types of inks. Because confocal microscopes are able to capture serial images in various depths, with computer reconstruction imaging techniques, scientists can identify the sequence in which marks were made on a given document.

Rena Christina Tabata

Further Reading

Matsumoto, Brian, ed. *Cell Biological Applications of Confocal Microscopy*. 2d ed. San Diego, Calif.: Academic Press, 2002.

Paddock, Stephen W., ed. *Confocal Microscopy Methods and Protocols*. Totowa, N.J.: Humana Press, 1999.

Pawley, James B., ed. *Handbook of Biological Confocal Microscopy*. 3d ed. New York: Springer, 2006.

See also: Analytical instrumentation; Fibers and filaments; Imaging; Micro-Fourier transform infrared spectrometry; Microscopes; Microspectrophotometry; Paper; Polarized light microscopy; Quantitative and qualitative analysis of chemicals; Scanning electron microscopy.

Control samples

Definition: Samples of known substances used to ensure that laboratory analyses produce reliable results.

Significance: Quality control is an important part of eliminating inaccuracy in laboratory results. Control samples ensure that laboratory results are reliable and can be duplicated in other laboratories following the same quality-control standards.

Control samples (also called controls, known samples, or knowns) provide a level of quality control that can verify laboratory test results. When a control sample is not used, it is possible for a laboratory result to be a false positive (a result that indicates something is true when, in fact, it is false) or a false negative (a result that indicates something is false when, in fact, it is true).

Forensic laboratories may use a variety of control samples to ensure accurate results. For example, they may use known combustibles to verify that particular combustibles are present in arson cases and known drug samples to verify that particular drugs are present in drug cases. Known DNA (deoxyribonucleic acid) samples are used to compare with unknown DNA samples (for example, in the comparison of a suspect's DNA with DNA found at a crime scene).

In many cases, forensic laboratories acquire the known samples they use as controls from reliable outside sources. For example, the Forensic Science Service in England, an internationally recognized leader in applied forensic technology, is a widely respected source of reliable control samples for fibers and paints. Crime labs around the world use control samples from such sources to ensure that they are meeting the quality standards necessary for their results to be accepted in courts of law.

Another type of control sample is a blank, or a control sample that is known to contain nothing. In this type of control, the sample is known to not contain the substance for which an investigator is testing. For example, if a known blank and a substance suspected of being an illegal drug are tested and both tests produce positive results, indicating the presence of the drug, something is wrong with the quality control in the laboratory. It is possible that the equipment is contaminated by previous drug testing and needs to be sterilized, that there is some problem with the questioned sample, or that the control sample has been contaminated in some way.

Marianne M. Madsen

Strategies for Obtaining DNA Samples Legally

DNA samples collected in the course of criminal investigations are of limited value unless they can be matched with control samples taken from known individuals. Four basic strategies provide law enforcement with legal means of collecting DNA samples from suspects:

- **Noncompulsory compliance:** Asking suspects to provide samples voluntarily by permitting their blood to be drawn or, more commonly, by submitting to the swabbing of the insides of their cheeks.
- **Court orders:** Obtaining court orders by showing reasonable cause to compel suspects to submit DNA samples.
- **Statutory law:** Taking advantage of the fact that certain defined groups, such as convicted offenders or arrestees, are required by law to submit samples for inclusion in state DNA databases.
- **Abandonment:** Collecting items containing suspects' DNA, such as cigarette butts and gum, that suspects have clearly intended to discard and abandon.

Further Reading

Evans, Colin. *The Casebook of Forensic Detection: How Science Solved One Hundred of the World's Most Baffling Crimes*. Updated ed. New York: Berkley Books, 2007.

Fisher, Barry A. J. *Techniques of Crime Scene Investigation*. 7th ed. Boca Raton, Fla.: CRC Press, 2004.

Genge, N. E. *The Forensic Casebook: The Science of Crime Scene Investigation*. New York: Ballantine, 2002.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005.

See also: Blood residue and bloodstains; DNA extraction from hair, bodily fluids, and tissues; Drug confirmation tests; Ethics of DNA analysis; Evidence processing; Fire debris; Forensic Science Service; Mitochondrial DNA analysis and typing; National DNA Index System; Quality control of evidence; Trace and transfer evidence.

Controlled Substances Act of 1970

Date: Enacted on October 27, 1970

The Law: Legislation that established rules and regulations for the federal control of drugs in the United States in terms of drug classifications and punishments for violations of the legislation's provisions.

Significance: Law-enforcement agencies in the United States are frequently concerned with crimes related to trafficking in drugs that are classified as illegal under the Controlled Substances Act.

Part of the Comprehensive Drug Abuse Prevention and Control Act of 1970, the Controlled Substances Act replaced the Harrison Narcotic Drug Act of 1914 by creating five schedules, or classifications, of controlled substances. Drugs fall into different schedules based on three main factors: their potential for abuse, whether or not (or to what extent) they have medical uses, and their potential to lead to psychological or physical dependence. Schedule I drugs, which include lysergic acid diethylamide (LSD) and marijuana, are defined as drugs with the highest potential for abuse and dependence, without any accepted medical use in the United States; these drugs are believed to be unsafe to administer and may not be prescribed. Schedule II drugs, which include amphetamines and morphine, are classified as drugs with high abuse potential, some accepted medical use, and potential to lead to significant psychological or physical dependence.

Schedule III drugs have less potential for abuse than Schedule I or II drugs, have some accepted medical uses, and present moderate to low potential for physical dependence or high potential for psychological dependence. Schedule III and IV drugs are available only by prescription with limitations (only five refills within six months). Schedule IV drugs, which include benzodiazapines, are defined as drugs that have a lower potential for abuse compared with Schedule III drugs. They also have some accepted medical uses and may lead to limited physical or psychological dependence. Schedule V drugs are sometimes available without a prescription and can include medications with small amounts of codeine. Drugs in the Schedule V classification are considered to have the lowest potential for abuse compared with those in all the other schedules, and they have accepted medical uses. These drugs may lead to limited physical or psychological dependence, but the likelihood of dependence is lower than with drugs in the other schedules.

The processes laid out in the act for changing the classification of a drug from one schedule to another or adding a newly developed drug to a schedule are complex, but ultimately the Department of Justice and the Department of Health and Human Services determine the schedules into which drugs are classified. A number of interested parties may petition for changes in drug classifications, including the Drug Enforcement Administration, the Department of Health and Human Services, medical associations, public interest groups, drug manufacturers, state or local government agencies, and individual citizens. The Drug Enforcement Administration investigates all such petitions.

The Controlled Substances Act also requires that any individual or agency authorized by the Drug Enforcement Administration to handle controlled substances must be registered, must securely store the controlled substances, and must keep accurate inventories and records of all transactions involving those substances.

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Further Reading

Califano, Joseph A., Jr. *High Society: How Substance Abuse Ravages America and What to Do About It*. New York: PublicAffairs, 2007.

Smith, Frederick P., ed. *Handbook of Forensic Drug Analysis*. Burlington, Mass.: Elsevier Academic Press, 2005.

See also: Amphetamines; Anabolic Steroid Control Act of 2004; Barbiturates; Drug classification; Drug Enforcement Administration, U.S.; Harrison Narcotic Drug Act of 1914; Illicit substances; Narcotics; Opioids; Psychotropic drugs; Stimulants.

Copier analysis. *See* Fax machine, copier, and printer analysis

Coroners

Definition: Presiding officers of special courts, medical officers, or officers of the law responsible for investigating deaths, particularly those that have taken place under unusual circumstances.

Significance: The work of coroners ensures that wrongful deaths are noted as such and are investigated, so that the interests of both government and the families of the deceased are served.

The office of coroner seems to have been established in Western culture after the Norman invasion of England in 1066. The term "coroner" is derived from the Latin word *corona*, which means crown, because the original coroners were servants of the crown appointed at the local level to protect the financial interests of the monarch. Although coroners' duties overlapped with the emerging duties of sheriffs, eventually coroners focused primarily on protecting the crown's financial interests, particularly in matters of the property of deceased persons that might be claimed by the crown. Coroners are thus part of the common-law tradition and appear in most of the nations colonized by England, including Australia and the United States. Elsewhere in the world, functions similar to those of coroners are often performed by medical practitioners.

Coroners may be either elected or appointed, depending on jurisdiction (a jurisdiction is usually a county). As the investigator of cause of death, the coroner generally has power to subpoena testimony concerning given deaths and to conduct inquests (reviews of the facts of deaths by panels of jurors). Coroners are not judicial officers; rather, they are considered to be part of the executive branch of government.

Qualifications

The qualifications required of coroners vary across jurisdictions. In many jurisdictions coroners must have medical degrees, but this is not always a requirement. A general trend has been seen in recent years toward increasing demand for professionalism in the office of coroner. Some U.S. jurisdictions have replaced the office of coroner with that of medical examiner, which differs from coroner in several ways. For example, coroners are generally placed in office through countywide elections (usually serving terms of four years), whereas medical examiners are typically appointed by the chairs of county boards or by county executives. Most jurisdictions with medical examiners require that these officials be qualified medical doctors licensed to practice in the states in which they serve and that they be certified as licensed pathologists in anatomic and forensic pathology.

After coroners or medical examiners are installed in office, they are usually required to attend specialized training programs. In Illinois, for example, new coroners must apply for admittance to the coroners' training program run by the Illinois Law Enforcement Training Standards Board and must then complete the program within six months. In addition, all coroners are required to send their deputy coroners to the same training program.

Responsibilities

The responsibilities of coroners include, but are not limited to, responding or dispatching deputy coroners to death scenes, collection of toxicological samples and their analysis, making death notifications to next of kin, and coordination and facilitation of organ donation. Coroners also determine the necessity for autopsy in individual deaths, facilitate the autopsy process, coordinate transport of deceased persons from death scenes, conduct death investigations when necessary, schedule and conduct inquests, summon juries for inquests, and issue temporary and permanent death certificates. Coroners are responsible for establishing the autopsy protocols used in their jurisdictions—that is, they determine what must be identified in autopsies and in the toxicology reports that list foreign substances found in the bodies of deceased persons.

Coroners in many jurisdictions are responsible for facilitating the burial of indigent persons, issuing cremation permits, maintaining records of all deaths reported, maintaining permanent records of all inquested cases, and

Coroners remove the body of a homicide victim from an Indianapolis motel room in 2004. The specific duties of coroners vary greatly from jurisdiction to jurisdiction, but in most jurisdictions they have primary responsibility for transporting bodies from suspected homicide scenes and for determining whether autopsies are necessary. *(AP/Wide World Photos)* maintaining vital statistics related to all cases reported. Coroners also generally take charge of the personal property of deceased persons until the property can be released. In addition to these duties, coroners are expected to be generally prepared for all possible disaster situations, during which they may need to hire and supervise "disaster deputy coroners."

In some states, coroners have duties beyond those related to death investigations. In Illinois, for example, coroners have the same powers as county sheriffs with regard to conservation of the peace; in the absence of a jurisdiction's sheriff, the coroner is empowered to act as sheriff. In Louisiana, coroners assist in determining the nature and extent of mental illness in living people.

Coroners and medical examiners are called upon to investigate many different types of deaths, including those resulting from criminal violence, suicide, and accident. Coroners become involved when persons who were apparently in good condition die suddenly, when deaths are unattended by practicing licensed physicians, and when deaths take place under suspicious or unusual circumstances. Coroners often investigate cases of death attributable to criminal abortion, poisoning, adverse reaction to drugs or alcohol, disease constituting a threat to public health, or injury or toxic agent resulting from employment. They also investigate deaths that have taken place during medical diagnostic or therapeutic procedures and deaths that have occurred to those confined in penal institutions or in police custody. In addition, coroners are generally involved when dead bodies are transported into medicolegal jurisdictions without proper medical certification and whenever any human body is to be cremated, dissected, or buried at sea.

David R. Struckhoff

Further Reading

Gerber, Samuel M., and Richard Saferstein, eds. *More Chemistry and Crime: From Marsh Arsenic Test to DNA Profile*. Washington, D.C.: American Chemical Society, 1997. Collection of chapters covers the history of forensic science as well as developments in the field through the 1990's.

Hendrix, Robert C. *Investigation of Violent and Sudden Death: A Manual for Medical Examiners*. Springfield, Ill.: Charles C Thomas, 1972. Classic work in the field describes the duties of coroners.

National Medicolegal Review Panel. *Death Investigation: A Guide for the Scene Investigator*. Washington, D.C.: U.S. Department of Justice, 1999. Brief work provides guidelines for coroners and medical examiners working at crime scenes.

Spitz, Werner U., ed. *Spitz and Fisher's Medicolegal Investigation of Death: Guidelines for the Application of Pathology to Crime Investigation*. 4th ed. Springfield, Ill.: Charles C Thomas, 2006. Indispensable volume for those conducting forensic investigations and forensic pathology. Includes comprehensive sections on specific cases along with their pathological findings.

Timmermans, Stefan. *Postmortem: How Medical Examiners Explain Suspicious Deaths*. Chicago: University of Chicago Press, 2006. Outstanding work on forensic pathology explains the autopsy process and gives case study examples.

See also: Autopsies; DNA typing; Drug confirmation tests; Exhumation; Forensic pathology; Forensic toxicology; Homicide; Medicine; Oral autopsy; Poisons and antidotes; Psychological autopsy; Quantitative and qualitative analysis of chemicals.

Counterfeit-detection pens

Definition: Devices that use a chemical reaction to detect some types of counterfeit money.

Significance: Counterfeit-detection pens allow users with no significant training to check paper money for genuineness quickly and cheaply. These tools offer an effective way of combating counterfeiting that is done using computers, copiers, and printers instead of high-technology counterfeiting equipment.

A store clerk uses a counterfeit-detection pen to check the authenticity of a fifty-dollar bill. Counterfeit-detection pens contain solutions of iodine that react with the starch in common photocopier or computer printer paper, leaving easily recognizable dark marks on counterfeit bills printed on such paper. *(AP/Wide World Photos)*

The growing use and availability of technologically advanced devices for reproducing images on paper since the 1990's has created a new breed of counterfeiters, many of whom are amateurs. According to the U.S. Secret Service, the federal agency responsible for fighting attempts to counterfeit American currency, in 1995 less than 1 percent of the money that was confiscated as counterfeit in the United States was created using devices such as commonly available copiers and printers. By the year 2000, however, nearly half of all counterfeited U.S. bills that were confiscated had been created using such relatively simple methods. This large increase in the use of widely available technology such as color copiers and laser printers in counterfeiting meant that new methods of detection and prevention were needed.

The paper on which real currency is printed contains cotton and other fibers and does not contain significant amounts of starch. The types of paper used for photocopying and computer printing, in contrast, contain large amounts of starch. The chemical element iodine reacts in a predictable way when combined with starch, and this reaction was the basis for the pens that were developed to help detect counterfeit bills. The first such pen received a patent from the U.S. Patent Office on November 5, 1991.

The user of a counterfeit-detection pen swipes the point of the pen across the surface of a piece of paper currency. Instead of ink, the pen contains a solution of iodine that will react with starch, turning dark brown or black. When such a pen is swiped on a bill that was counterfeited using copier or printer paper, an easily recognizable dark mark appears. If the bill has no starch present, the mark made by the iodine solution remains clear or turns a light amber color. Some counterfeit-detection pens have colored dyes added to the iodine solution, so that users can easily tell which bills they have already verified. The color usually fades after a day or so, so that no permanent marks are left on the bills.

Counterfeit-detection pens are important tools in the ongoing battle against counterfeiting. They are inexpensive, usually less than five dollars each, and cashiers and other users need no significant training to be able to use them effectively. They are not, however, generally useful for detecting bills made by relatively sophisticated counterfeiting operations, which are more likely to use paper that is somewhat similar to that used in the printing of legitimate currency. The lack of a significant amount of starch in such bills makes them unlikely to be detected with the iodine solution used in counterfeit-detection pens.

Helen Davidson

Further Reading

Van Renesse, Rudolf L., ed. *Optical Security and Counterfeit Deterrence Techniques*. Bellingham, Wash.: SPIE, 2006.

Williams, Marcela M. *Handicapping Currency*

Design: Counterfeit Deterrence and Visual Accessibility in the United States and Abroad. St. Louis: Federal Reserve Bank of St. Louis, 2007.

See also: Counterfeiting; Fax machine, copier, and printer analysis; Forgery; Identity theft; Paper; Questioned document analysis; Secret Service, U.S.

Counterfeiting

Definition: Creation of false currency or other items that are intended to be used, sold, or passed off as original or real.

Significance: Counterfeiting, both of currency and of objects such as clothing, accessories, antiques, and pharmaceuticals, costs consumers, governments, and businesses millions of dollars annually. Counterfeiters range from amateurs trying their luck to international rings of professional criminals organized solely for the purpose of manufacturing and selling counterfeit merchandise.

The counterfeiting of coins, currency, and artifacts for profit has been a problem for as long as such items have existed. Counterfeiting operations cost honest individuals and businesses millions of dollars every year, and governments spend millions more in attempts to prevent and detect counterfeiting and on enforcement of laws against the practice. Methods for detecting counterfeiting and for gathering evidence to use in the prosecution of counterfeiters are constantly evolving as counterfeiters find new ways around them.

History of Counterfeiting

The first currency ever produced is believed to have originated around 600 B.C.E. in Lydia, a Greek province located in what is today known as Turkey. The first attempts at counterfeiting soon followed. Ancient coins were generally made of precious metals, such as gold, silver, and copper, and were minted by local rulers or national governments. The process of making the coins usually involved heating small pieces of metal and then stamping them with likenesses of rulers, animals, or objects or with inscriptions. Because precious metals were valued by weight, each coin was supposed to weigh a certain amount, corresponding with the prescribed amount of metal. The first attempts to alter or counterfeit coins were often made by individuals who removed small amounts of metal from the edges of legitimate coins and then melted the removed bits of metal together to make more coins. Some counterfeiters melted legitimate coins, mixed in other, less valuable, metals, and stamped the mixtures into larger numbers of coins.

The introduction of paper currency presented new opportunities for counterfeiters as well as new challenges for the groups charged with protecting the integrity of the currency. In the early United States, paper currency was not issued by the federal government; rather, more than sixteen hundred different banks printed their own currency. Each of these banks used a different design for each different denomination of bill, resulting in a total of more than seven thousand designs of bills that were valid currency. It is not hard to imagine how difficult it must have been to determine real bills from counterfeit ones, as people were constantly presented with bills that looked different from any other bills they had encountered before. During the Revolutionary War, the British capitalized on this situation by counterfeiting American currency at a very high rate.

The problem of widespread counterfeiting that was encouraged by varying bill designs was a concern of many early American government leaders, but it was not until 1862 that the U.S. government adopted a national currency and took over responsibility for printing that currency. Counterfeiting was reduced by this action, but it did not stop, and in 1865 the U.S. Secret Service was created to protect American currency and to investigate and combat counterfeiting.

Although the designs used in modern U.S. currency are much more complex than those used in the mid-nineteenth century, counterfeiting is still a significant problem. The Department of the Treasury is constantly seeking new ways to prevent and detect counterfeiting; frequent changes to the designs of bills are part of the department's efforts to make counterfeiting more difficult. The invention and widespread availability of computerized scanning devices and laser printers has allowed increasing numbers of amateur counterfeiters to experiment cheaply with producing false bills. The counterfeiting of items other than currency, such as clothing, accessories, antiques, and medicines, has also emerged as a widespread problem.

Counterfeiting Currency

At one time, the counterfeiting of American currency was a labor-, time-, and equipment-intensive process. Many counterfeiters used hand-carved metal printing plates, special presses, and carefully created dyes to imitate the printing on legitimate bills. Although the end of the twentieth century saw a surge in counterfeiters' use of materials and technologies available to many people in their homes, the counterfeiting of U.S. currency remains a difficult process, as many complicated security measures have been introduced into modern bills.

Counterfeiters often use high-quality scanners with very high resolutions to create pictures of the bills they want to counterfeit. Such high-resolution images contain many of the features of the original bills, even many of the features intended to prevent counterfeiting. Such bills usually do not look exactly right, but many people do not examine the bills they receive very closely, especially in crowded, busy shopping areas or in dark places such as bars or nightclubs.

Security Features in U.S. Currency

The U.S. Department of the Treasury's Bureau of Engraving and Printing provides the following description of the anticounterfeiting security features added to several U.S. currency denominations since 2003.

There are two distinct security features on the $5, $10, $20 and $50 bills the public can use to check the authenticity of their bills. Hold the bill up to the light and check for:

- **Watermark:** Each redesigned bill includes a watermark, which is a faint image within the paper itself. There are now two watermarks on the redesigned $5 bill. A large number "5" watermark is located to the right of the portrait, replacing the watermark portrait of President Lincoln found on the older design $5 bill. Its location is highlighted by a blank window incorporated into the background design. A second watermark—a column of three smaller "5"s—has been added to the new $5 bill design and is positioned to the left of the portrait. The watermarks for the $10, $20 and $50 bills are images of portraits located to the right of the larger portrait found on each denomination. On the $20 bill, the watermark is similar to the large portrait of President Jackson; on the $50 bill, there is a watermark portrait of President Grant; and on the $10 bill, there is a watermark portrait of Treasury Secretary Hamilton.
- **Security thread:** Each redesigned bill includes an embedded security thread in the paper, which is a plastic strip that runs vertically through each bill. If you look closely, you can see the letters "USA" followed by the number "5" printed in an alternating pattern along the thread on the new $5 bill, "USA TEN" printed on the $10 bill thread, "USA TWENTY" on the $20 bill thread, and "USA 50" on the $50 bill thread. The security thread is visible from both sides of the bill.

The higher-denomination $10, $20 and $50 bills have a third easy-to-check security feature:

- **Color-shifting ink:** Look at the number in the lower right-hand corner on the front of the new $10, $20 and $50 bills, depicting each bill's denomination. The color-shifting ink changes from copper to green when you tilt the bill up and down.

One difficulty encountered by counterfeiters who use computer scanners is in printing bills from even excellent digitized images. High-quality printers can print very small lines, but the lines on modern currency have been designed to be small enough to foil most computer printers. In addition, computer printers cannot reproduce the effects of the special inks used in legitimate currency, which change color depending on the way light hits them. Bills printed by laser printer also do not contain the small blue fibers present in real bills, nor can such bills contain the metallic strip that has been added to U.S. currency as a security device.

Even with all of these shortcomings, the bills that counterfeiters can create using many widely available laser printers can look very much like real bills, and many could survive the quick glance that bills generally receive during a transaction, except for one important feature: the paper. The kinds of paper used by photocopiers and computer printers is not the same as the paper on which the U.S. Treasury prints money. U.S. currency is printed on paper made of linen and cotton fibers; it is thinner than copier and printer paper, and it has a distinctive feel to the touch. The types of paper normally used in copiers and printers are made out of tree fibers that contain cellulose, a starch; the paper on which real currency is printed does not contain starch.

Although some counterfeiters may be able to obtain paper made of linen and cotton fibers, it is highly unlikely that any can obtain the same paper as that used by the Treasury Department, as possession of such paper is very tightly controlled. In many cases, however, similar types of paper may suffice.

Although many modern counterfeiters use widely available means to produce moderate- to low-quality imitation currency, some use other techniques to make counterfeit bills. Some counterfeiters bleach the parts of small-denomination bills that show the denomination and then print the resulting blank areas with images from larger-denomination bills. In this way, they use real Treasury paper, so the counterfeited bill has the feel of a real bill, because in a way it is a real bill. In this technique, the original bill's serial number can be left on, so each counterfeited bill has a distinct serial number, making the counterfeiting somewhat more difficult to detect. Large-scale counterfeiting operations may use metal printing plates, special inks, and other devices in their attempts to imitate actual currency.

Detection of Counterfeit Currency

Some types of counterfeiting can be detected through the visual and tactile examination of the currency in question. Counterfeit bills created using printers and photocopiers do not feel like real bills, and close visual inspection of such bills often reveals lines that run together and images that appear to be slightly off in color. An important first line of defense against counterfeiting is proper training in recognizing the signs of counterfeit bills; bank tellers, cashiers, clerks, and anyone else who frequently accepts money in exchange for goods, services, or credit should receive such training. Many counterfeiting operations, especially those being run by relative amateurs, have been stopped after their bills were detected by just such individuals.

Not every clerk or cashier is likely to receive thorough training in spotting counterfeit bills, however, and during busy times with many customers making transactions, it is often not reasonable for businesses to expect employees to inspect closely all bills that pass through their hands. For these reasons, devices have been developed that can make counterfeit detection easier and more efficient. Counterfeit-detection pens offer a fast, easy, and inexpensive way for persons with little or no training to check the authenticity of currency. Such pens contain iodine, which reacts with starch; when the iodine comes into contact with a counterfeit bill made on a printer or photocopier, the mark turns a dark color because of the starch in the paper. On genuine bills, these pens' marks do not change color because the paper in the bills does not contain significant amounts of starch. Ultraviolet counterfeit-detection machines are also fast and effective. Cashiers or tellers quickly view bills under the devices' ultraviolet lights to ensure that the bills contain the security threads found in genuine U.S. currency.

Over time, the U.S. Treasury has added many complex features to paper currency to help prevent counterfeiting. Among these is the use of special types of ink. For example, the denomination is printed in the lower left-hand corner of the front of each bill in a special optically variable ink, which appears to be different colors when the bill is viewed from different angles. This aspect of genuine bills is extremely difficult to reproduce. Another special ink used in the printing of genuine bills is magnetic ink, which can be detected by the bill-accepting devices in vending machines. Such machines will automatically reject bills on which they cannot detect the presence of such ink.

Counterfeit bills are almost always detected eventually. Some are detected very quickly by cashiers or tellers who notice telltale signs, such as bills that feel wrong or multiple bills with the same serial number. Others are not detected until long after the individuals who originally passed them are gone. Many businesses, including banks, scan bills regularly using a variety of devices available to detect counterfeits. The U.S. Treasury Department also regularly scans bills that come back to it, using machines that are extremely complex, with more than thirty separate sensors to help evaluate all aspects of a bill.

Cases of possible counterfeiting are investigated by the U.S. Secret Service. Although it is permissible to make copies of American currency for novelty purposes, the copies must differ from real currency in one or more of these ways: printed in black-and-white ink, 50 percent larger than real bills, or 25 percent smaller than real bills. Anything else can be considered counterfeiting, and the Secret Service has a strict zero-tolerance policy for counterfeiters. Counterfeiting is a felony offense in the United States, punishable by up to fifteen years in prison, a fine, or both. Bleaching and reprinting real currency with larger denominations is also considered counterfeiting and is punishable in the same way.

Other Types of Counterfeiting

Noncurrency counterfeiting is also a crime of increasing concern in the United States and throughout the world. In general, in such counterfeiting an imitation of something of high monetary value—produced using lower-quality, inferior materials and workmanship—is sold or passed off as the high-value item. In some cases, the aspects of the imitated items that give them value are their age or their historical significance rather than their strict monetary value.

One of the most common types of counterfeiting that involves noncurrency items is the counterfeiting of clothing and accessories. Brand-name merchandise is often expensive, and many consumers are happy to find low prices on what they believe to be brand-name goods. Designer and brand-name goods are often made of high-quality fabrics, metals, or plastics and bear trademarked names and logos. Such clothing and accessories are often relatively costly to produce, with the cost including the value of the designs themselves.

The counterfeiters of designer and brand-name clothing and accessories often have complex operations, often of a very large scale; they frequently operate outside the United States, where manufacturing and copyright regulations are not stringently enforced. They create very similar products out of inferior-quality components and infringe on trademarks and copyrights by using brand names and logos without permission. They then sell the products to consumers, leading the consumers to believe that the items are genuine. In many cases, counterfeiters attach fake labels and tags to their products to increase their plausibility. Some of these items are easily understood by most consumers to be fakes, such as the "Rolex" watches often sold on urban streets. Others, however, are much harder to identify, and even wary consumers might purchase counterfeit goods occasionally without ever realizing it.

In addition to clothing and accessories, toys, auto parts, and even edible goods such as baby formula have been known to be counterfeited. When goods such as these are counterfeited, they are not produced under the supervision of any regulatory body, so consumers who purchase and use these products are at serious risk of getting inferior, and even possibly dangerous, goods.

The rising prices of prescription drugs in the United States, in conjunction with the fact that large numbers of Americans have no health insurance or inadequate insurance, have led to what is probably the most dangerous of the many kinds of counterfeiting operations: the counterfeiting of medications. This is a problem that presents many different dangers to unaware consumers. Pharmaceutical companies spend millions of dollars developing new drugs and putting them through the extensive testing required before they can be approved for sale by the U.S. Food and Drug Administration. Although this process contributes to the high cost of drugs, it also allows consumers access to many lifesaving medications that have been tested for safety and effectiveness.

If You Receive a Counterfeit

The U.S. Secret Service provides these instructions for anyone who receives a counterfeit U.S. bill.

- Do not return it to the passer.
- Delay the passer if possible.
- Observe the passer's description, as well as that of any companions, and the license plate numbers of any vehicles used.
- Contact your local police department or United States Secret Service field office. These numbers can be found on the inside front page of your local telephone directory.
- Write your initials and the date in the white border areas of the suspect note.
- Limit the handling of the note. Carefully place it in a protective covering, such as an envelope.
- Surrender the note or coin only to a properly identified police officer or a U.S. Secret Service special agent.

Counterfeit drugs, in contrast, may be manufactured under unsanitary conditions, as the factories that produce them are not regulated. Some counterfeit drugs are not even produced in factories at all; rather, they are made in home "laboratories" or warehouses. These products may not contain the ingredients that make the genuine drugs they imitate effective (the active ingredients), or they may contain the wrong amount. In some cases, unsanitary manufacturing conditions or the substitution of ingredients may lead to serious side effects and even death. Counterfeit drugs are often sold over the Internet, although they may also be sold in other locations as well. To protect themselves against the dangers of counterfeit drugs, consumers should always have prescriptions filled at state-licensed pharmacies and should be aware of what the medicines they receive should look like.

Helen Davidson

Further Reading

Eban, Katherine. *Dangerous Doses: How Counterfeiters Are Contaminating America's Drug Supply*. Orlando, Fla.: Harcourt, 2005. An experienced investigative reporter uncovers the truth about counterfeit pharmaceuticals and their effects on U.S. society. Includes an account of law-enforcement investigators' pursuit of a national criminal group involved in the counterfeit drug trade.

Mihm, Stephen. *A Nation of Counterfeiters: Capitalists, Con Men, and the Making of the United States*. Cambridge, Mass.: Harvard University Press, 2007. Provides historical perspective, presenting true stories of counterfeiting before the Civil War and discussion of the impact counterfeiting had on the economy and growth of the nation.

Phillips, Tim. *Knockoff: The Deadly Trade in Counterfeit Goods—The True Story of the World's Fastest Growing Crime Wave*. Sterling, Va.: Kogan Page, 2005. Discusses the economic consequences of the worldwide trade in counterfeits and introduces some of the people who have been its victims. Argues that the violence associated with the counterfeit trade warrants greater attention.

Sayles, Wayne G. *Classical Deception: Counterfeits, Forgeries, and Reproductions of Ancient Coins*. Iola, Wis.: Krause, 2001. Provides a vast array of information about the creation and detection of counterfeit ancient coins. Discusses the history of coin counterfeiting and presents interesting accounts of the careers of some people who have successfully created counterfeit ancient coins.

Travers, Scott A., ed. *Official Guide to Coin Grading and Counterfeit Detection*. 2d ed. New York: Random House, 2004. Comprehensive volume contains all the information anyone needs to know to determine whether or not a coin is legitimate as well as detailed information on coin grading. Features numerous high-detail photographs.

Tremmel, George B. *Counterfeit Currency of the Confederate States of America*. Jefferson, N.C.: McFarland, 2003. Provides an exciting look at the counterfeiting of Confederate currency, which was common during the commotion of the Civil War, and how the Treasury of the Confederacy acted to try to stop the counterfeiters. Includes illustrations of the counterfeit currency and information on the methods used to produce it.

Williams, Marcela M., and Richard G. Anderson. *Handicapping Currency Design: Counterfeit Deterrence and Visual Accessibility in the United States and Abroad*. St. Louis: Federal Reserve Bank of St. Louis, 2007. Discusses the various trade-offs that governments make when deciding how best to design currency and the necessity of periodic design changes to help protect currency against counterfeiting. Pays special attention to currency design in relation to the needs of persons who are visually impaired.

See also: Art forgery; Counterfeit-detection pens; Fax machine, copier, and printer analysis; Forgery; Identity theft; Microscopes; Paper; Photograph alteration detection; Questioned document analysis; Secret Service, U.S.

Courts and forensic evidence

Significance: One of the most important reasons law-enforcement investigators gather evidence is to prove guilt in a court of law. The techniques used by forensic scientists must be acceptable to courts in order for the evidence obtained through those techniques to be admissible. Forensic scientists must thus be familiar with the types of evidence and the techniques used to gather and examine evidence that are most likely to be admissible in court.

Any evidence that has been gained through the application of scientific means can be considered forensic evidence. However, not all forensic evidence is considered legitimate; in the United States, federal, state, and military courts have had varied histories in regard to different types of forensic evidence. Many types of forensic techniques have not always been accepted, and the legitimacy of many continues to be debated.

Before evidence gathered through the use of a particular forensic technique can be considered admissible in a court of law, the technique must first be proven reliable. Most often, forensic techniques become accepted through common law, which is the practice of following prior decisions made in court. Any new forensic technique must be vetted by a judge; usually, this means that an attorney presents the technique in court and argues that the evidence produced using the technique should be admitted in a case.

For example, one of the first courts in the United States to accept the use of DNA (deoxyribonucleic acid) evidence was the Circuit Court in Orange County, Florida. In 1987, Assistant State Attorney Tim Berry successfully argued that the DNA from semen found on a murder victim matched DNA from a blood sample taken from the defendant, Tommy Lee Andrews, and that DNA comparison was a reliable method of establishing identity. To support his argument, Berry presented testimony by David Houseman, a research biologist from the Massachusetts Institute of Technology, and Michael Baird, a scientist at the laboratory where the samples where analyzed. Berry also compared the use of DNA matching to fingerprint identification, an already commonly accepted forensic method. In 1989, in the case of *People v. Castro*, the use of DNA for identification was seriously challenged in the New York Supreme Court. Over twelve weeks of testimony and arguments, the cases for and against DNA evidence were presented. In the end, the court found that DNA evidence is accepted by the scientific community and that DNA comparison is an accepted forensic technique. Since then, cases that use DNA evidence usually cite the case of *People v. Castro* to establish the admissibility of DNA evidence.

Admissibility of New Forensic Techniques

Before judges will accept evidence produced by new types of techniques, the evidence must first pass several tests. The first of these is the traditional relevance test. To pass this test, evidence must bring some fact to light and must not tend to confuse jurors more often than it enlightens them. Beyond that test, differences exist between the federal admissibility standard and the standard used by many state courts, the *Frye* standard, established in the case of *Frye v. United States* in 1923. The *Frye* standard's "general acceptance" test requires merely that the techniques used to obtain or produce evidence must be generally accepted by the scientific community.

Federal courts, in contrast, as well as many state courts, now follow a standard established by the U.S. Supreme Court case of *Daubert v. Merrell Dow Pharmaceuticals* in 1993. The so-called *Daubert* standard has multiple parts: For evidence to be admissible, the technique used to obtain or produce it must be tested and peer-reviewed, the technique's margin of error must be known and controlled, and the technique must be accepted within a relevant scientific community. The determination of whether these tests have been met is the responsibility of the trial judge. Since the *Daubert* decision, a great deal of debate has taken place concerning the role of judges as the "gatekeepers" of evidence. Many experts have lauded the decision as a way to keep pseudoscience out of the courtroom, whereas others have argued that *Daubert* gives judges too much individual discretion over what constitutes acceptable expert testimony.

Unlike fingerprint identification and DNA identification, some forensic techniques have not been accepted by U.S. courts. In 1999, a Washington appeals court had to address an unusual new identification technique used by investigators in the case of *State of Washington v. Kunze*. An intruder who had killed two people in a house before robbing the house of most of its valuables had left a full impression of one of his ears on a wall in a hallway at the crime scene. An investigator from the Washington State Crime Laboratory was able to lift the ear print from the wall using a technique normally used for fingerprints. This print was compared with ear prints taken from the suspect, David Wayne Kunze, and a criminologist from the laboratory, Michael Grubb, concluded that the print from the wall was a likely match to the suspect. During pretrial hearings, however, Grubb admitted that he had never worked with ear prints for identification before and that he had not seen any studies about how often a particular ear shape might occur in the general population. Even though several other identification experts were called in, the prosecution could not establish that ear-print identification was generally accepted by the scientific community (the court in Washington followed the *Frye* test, not the *Daubert* test), and the court refused to accept ear-print identification as a legitimate forensic technique.

Some types of forensic evidence that were accepted by U.S. courts for years have later been found to be unreliable. One forensic technique that has been discredited, comparative bullet-lead analysis (CBLA), was long practiced by the Federal Bureau of Investigation (FBI) and had been accepted by U.S. courts since the 1960s. The technique involves comparing the composition of the metal in a bullet that was used in a crime with the composition of the metal in other bullets to establish the origins of the crime scene bullet. The technique is based on the idea that if the composition of two bullets is the same, then the bullets must have been made by the same manufacturer on the same day, using the same batch of material. This technique was used to produce the key evidence in a 1986 case against a man in North Carolina named Lee Wayne Hunt. He was convicted of two counts of murder and has been in prison for more than twenty years. However, in a 2004 report on a study requested by the FBI, the National Research Council of the National Academy of Sciences stated that CBLA is unreliable and can produce misleading results. Because of this, many cases like the one against Hunt are under review, and it is probable that some verdicts may be overturned.

Even forensic techniques that have come to be thoroughly accepted have not always been viewed as so reliable. In 1873, in the case of *Tome v. Parkersburg Railroad Company*, the court rejected photographic evidence because it said that photographs produced only "secondary impressions of the original" and that they were susceptible to changes in lighting. Only one year later, in the case of *Udderzook v. Commonwealth*, the Supreme Court of Pennsylvania found that photographs taken by an insurance company should be admitted as evidence. These photographs were used to prove that a body found in the woods was that of a particular man whom the insurance company had photographed when he took out his policy. The court wrote, "The [photographic] process has become one in general use, so common that we cannot refuse to take judicial cognizance of it as a proper means of producing correct likeness." Since that day, attorneys have cited the case of *Udderzook v. Commonwealth* when presenting photographic evidence in court.

Federal, State, and Military Standards

Case law, also known as common law, is not the only source of determination for admissibility of evidence in court. In 1934, the U.S. Congress passed the Rules Enabling Act, which gave the U.S. Supreme Court the power to prescribe rules of practice and procedure and rules of evidence for the federal courts. Following this mandate, in 1965 Chief Justice Earl Warren appointed an advisory committee to write a comprehensive federal code of evidence. Over a ten-year period the committee debated, researched, drafted, heard public commentary, rewrote, and finally issued its code, the Federal Rules of Evidence (FRE). This code was debated in both houses of Congress and signed into law on January 2, 1975. The advisory committee was then disbanded and the rules were left unreviewed until 1992, when the Evidence Advisory Committee was re-created to oversee revisions to the FRE. Since that time, the committee has made few substantive changes to the code. The FRE is the codification of decades of precedence, and it is the core of admissibility standards in federal courts.

The FRE applies to all federal courts throughout the United States, but cases tried in state courts are subject to the states' own individual standards of evidence. For the most part, states have followed the federal standards, but some, such as California, have entirely separate sets of rules. Even in states that follow the federal standards, some important differences exist. For example, some states (including Connecticut, Massachusetts, and Texas) follow the federal *Daubert* test, whereas others (including California, Florida, and New York) continue to apply the *Frye* test; still others (such as Delaware, Oregon, and Vermont) follow their own standards regarding the admissibility of forensic evidence. It is important for forensic scientists to understand the evidence standards that apply to their particular states.

In September of 1980, the U.S. military established its own separate rules of evidence to apply to courts-martial and other military courts. Although these rules were designed to follow the FRE closely, there are some noteworthy differences. One such difference stems from the 2005 Detainee Treatment Act, which says that military judges must, for statements made after the act was passed, determine whether the statements were obtained through cruel, inhuman, or degrading treatment before the statements can be considered as evidence. Some significant differences also exist between the FRE and military rules regarding hearsay, because witnesses in military trials are likely to be foreign nationals who are not amenable to the process.

The American legal system has had a difficult relationship with new forensic techniques because of the important role that forensic evidence can play. A case can turn on a single piece of evidence, such as the composition of the metal in a bullet, and the justice system must be careful in the decisions it makes about allowing particular evidence-gathering practices and the admissibility of specific kinds of expert testimony. If a process is not carefully vetted and established, then injustices are likely to occur.

Robert Bockstiegel

Further Reading

Best, Arthur. *Evidence: Examples and Explanations*. 6th ed. New York: Aspen, 2007. Uses the Federal Rules of Evidence to organize examples and explanations of types of evidence, relevance requirements, and exclusionary rules.

Genge, N. E. *The Forensic Casebook: The Science of Crime Scene Investigation*. New York: Ballantine, 2002. Provides examples of court cases in which forensic science was able to provide critical evidence.

Karagiozis, Michael Fitting, and Richard Saglio. *Forensic Investigation Handbook: An Introduction to the Collection, Preservation, Analysis, and Presentation of Evidence*. Springfield, Ill.: Charles C Thomas, 2005. Provides a thorough overview of the forensic investigation process, from the gathering of evidence to its use in the courtroom.

Kiely, Terrence F. *Forensic Evidence: Science and the Criminal Law*. 2d ed. Boca Raton, Fla.: CRC Press, 2006. Introductory textbook discusses the acceptance of different types of forensic evidence by U.S. state and federal courts. Presents examples from actual court decisions.

Lissitzyn, Christine Beck. *Forensic Evidence in Court: A Case Study Approach*. Durham, N.C.: Carolina Academic Press, 2008. Uses the case of a 1973 murder that took place in New Haven, Connecticut, to address the various aspects of the admissibility of forensic evidence.

Sapse, Danielle S. *Legal Aspects of Forensics*. New York: Chelsea House, 2006. Discusses the legal issues relating to forensic science techniques and the presentation of forensic findings in the courtroom.

See also: ALI standard; *Daubert v. Merrell Dow Pharmaceuticals*; Direct versus circumstantial evidence; Drug and alcohol evidence rules; Evidence processing; Expert witnesses; Eyewitness testimony; Federal Rules of Evidence; *Frye v. United States*; *Holland v. United States*; Legal competency; *Miranda v. Arizona*; *People v. Lee*; Quality control of evidence; *Tarasoff* rule; Trial consultants.

Crack cocaine

Definition: Form of cocaine that transforms into rocklike chips during its creation and is believed to produce a more intense high than powder cocaine.

Significance: Crack cocaine emerged during the early 1980's, and a seeming epidemic of use of the drug led to an intense media frenzy in the United States. Powder cocaine had been in use in the United States for many years, but crack cocaine quickly became the more popular of the two because of its cheap price and intense high. The hysteria surrounding the drug was in part a reaction to the amount of systemic violence created by crack cocaine dealers establishing territories within the black market.

Crack cocaine remains one of the most problematic drugs in the United States because of its impacts on users and their communities. Significant resources are spent on attempts to decrease the supply of crack cocaine within the United States through law-enforcement efforts, to decrease demand for the drug through education and prevention programs, and to decrease the number of those addicted to it through drug treatment. Cocaine is listed as a Schedule II drug under the Controlled Substances Act of 1970, meaning that it has a high potential for abuse, is used medically with restrictions, and can lead to severe physical and psychological dependence.

Production of Crack

Crack cocaine is a pure form of cocaine that is manufactured by a simpler method than that used to create freebase cocaine. In making freebase cocaine, which was popular in the 1970's, powder cocaine is dissolved in water with ammonia and ether added; a solid cocaine base is then separated from the solution and used for smoking. Freebase cocaine was overshadowed by crack during the 1980's.

Unlike other forms of cocaine, crack does not include hydrochloride salt. In the manufacture of crack, cocaine is mixed with water and baking soda; this mixture is then heated, and when it cools, cocaine "rocks" are formed. The rocks can be smoked in pipes, heated and then inhaled, or even injected. One reason for crack cocaine's popularity is that, unlike powder cocaine, it can be produced in small quantities; thus users at all income levels can buy the drug.

Effects of the Drug

Most crack users typically place the drug in a glass pipe with a steel wool filter and heat the pipe from below. When smoked, crack cocaine passes into a user's bloodstream much faster than cocaine that is snorted. The drug is then transported to the brain, where it interferes with a neurotransmitter, or chemical messenger, called dopamine. Dopamine sends signals of pleasure from neuron to neuron during pleasant activities. It does so by attaching to the synapse of the neuron, sending a message, and then being reabsorbed back into the neuron. Crack cocaine disrupts this process and slows the absorption of dopamine, creating longer-lasting feelings of pleasure. Crack is thus considered to be a stimulant drug because it causes dopamine to build up and send exaggerated feelings of exhilaration. Users generally begin to feel the effects of crack cocaine in fifteen seconds, compared with fifteen to twenty minutes for cocaine that is snorted.

Cocaine is a highly addictive drug, and there seems to be a higher correlation between addiction and cocaine in its crack form as opposed to its powder form. Researchers have not been able to rule out extraneous factors that may affect this correlation, however, such as the income levels of the users of crack cocaine. In other words, it has not been determined conclusively whether crack cocaine is more highly addictive than powder cocaine or whether its users, who are generally poor, may be more susceptible to drug addiction than users of other forms of cocaine.

The use of crack cocaine is associated with many of the same physical problems found in users of powder cocaine: constricted blood vessels, increased blood pressure, and risk of heart attack and stroke. Crack cocaine users may also experience extreme respiratory problems, including lung trauma and coughing. Crack use can also affect the digestive tract, causing users to lose their appetites or to feel nauseated. In large amounts, crack can make users feel restless, anxious, or even paranoid.

Unlike heroin addiction, for which treatment with methadone maintenance is available, addiction to crack cocaine has no proven effective medical treatment, although a number of medications have begun to be investigated for this purpose. Other treatment strategies are used to counteract crack addiction, including cognitive therapy, psychotherapy, and twelve-step programs.

Brion Sever and Ryan Kelly

Further Reading

Brownstein, Henry. *The Rise and Fall of a Violent Crime Wave: Crack Cocaine and the Social Construction of a Crime Problem*. Guilderland, N.Y.: Harrow & Heston, 1996. Examines the crack cocaine crime wave of the 1980's as well as the responses of the mass media and governments. Discusses the crime problem posed by crack cocaine as a social construction and analyzes the reasons behind the phenomenon.

Cooper, Edith. *The Emergence of Crack Cocaine Abuse*. New York: Novinka Books, 2002. Discusses the evolution of crack cocaine, its emergence in the black market during the early 1980's, and the factors that led to the drug epidemic that surrounded crack cocaine during the mid- to late 1980's. Also reviews the process by which crack cocaine is made and the effects the drug has on users' health.

Smith, Frederick P., ed. *Handbook of Forensic Drug Analysis*. Burlington, Mass.: Elsevier Academic Press, 2005. Focuses on methods used to detect drugs in the human body. Presents analyses of a number of drugs, including cocaine, and discusses their chemical properties and the ways they are identified in tests.

Washton, Arnold. *Cocaine Addiction: Treatment, Recovery, and Relapse Prevention*. New York: W. W. Norton, 1991. Focuses on some of the causes of crack addiction, including the psychological state of the cocaine addict. Discusses the various stages of addiction as well as addiction treatment.

See also: Amphetamines; Antianxiety agents; Drug abuse and dependence; Drug classification; Drug confirmation tests; Drug Enforcement Administration, U.S.; Drug paraphernalia; Harrison Narcotic Drug Act of 1914; Illicit substances; Psychotropic drugs; Stimulants.

Crime laboratories

Definition: Public and private facilities at which forensic specialists analyze materials collected from crime scenes for purposes of identification and interpretation.

Significance: Since the founding of the first such facility in France in 1910, crime laboratories have employed a scientific approach to dealing with evidence collected by crime scene investigators. The work conducted by crime labs provides invaluable assistance to criminal investigators and legal professionals around the world.

Forensic scientists, also known as criminalists, apply scientific methods to the analysis, identification, and interpretation of evidence gathered at crime scenes. They conduct much of their work at crime laboratories, facilities that are specially equipped with the technological and other tools they need to carry out the careful examination of evidence.

Sherlock Holmes and Early Crime Laboratories

A direct connection can be drawn between the detective novels of Sir Arthur Conan Doyle and the establishment of the first crime laboratory. Renowned for the creation of the fictional detective Sherlock Holmes, Doyle was well trained in science. He was a practicing physician with a strongly held conviction that scientific method can be applied logically and effectively to solving crimes. In 1887, Doyle introduced the world to Sherlock Holmes and his sidekick, Dr. Watson. He continued to write about them for the next thirty-five years.

Among Doyle's most ardent fans was Edmond Locard, a Frenchman who devoured the Sherlock Holmes stories. Convinced of the efficacy of applying scientific method to solving crimes, Locard established the world's first forensic crime laboratory, the Institute of Criminalistics for the Rhone Prefecture of the University of Lyon in France. This early laboratory occupied modest quarters in the Lyon courthouse. Locard, whose laboratory equipment consisted of a microscope and a spectroscope, gained credibility by using scientific means to solve a puzzle surrounding the counterfeiting of coins in the Lyon area. Obtaining some clothes belonging to a suspect, he extracted from them samples of dirt in which he found traces of metal that matched the metal in the counterfeit coins. This discovery caused the suspect to confess and gave people confidence in Locard's methods.

The first crime laboratory in the United States was established in Los Angeles by August Vollmer in 1923. It was not until 1932 that the Federal Bureau of Investigation (FBI), under the leadership of J. Edgar Hoover, established its first crime laboratory. From modest beginnings, equipped with only a microscope and minimal ultraviolet light equipment, the FBI Laboratory grew to become the most extensive and sophisticated crime laboratory in the world.

Discovering and Preserving Evidence

One of the most important elements in gathering evidence from the scene of a crime or accident is the preservation of that evidence so that it is not contaminated following its discovery. For each piece of evidence, a record (referred to as the chain of custody) is kept of every single person who deals with the evidence from the time it is discovered to the day the evidence is used in court or in some other official venue.

Evidence must be gathered by people trained in forensic science techniques. Before evidence samples are collected for transportation to a crime laboratory, investigators examine the evidence as they find it at the crime or accident scene, which the police preserve as nearly as they can, making it inaccessible to unauthorized or untrained people. In the early stages of an investigation, the scene is photographed from a variety of angles and careful measure-

A crime scene analyst works on identifying unknown substances in Arizona's Western Region Crime Lab in Lake Havasu City. Not all crime laboratories are equipped to provide all possible services. This small lab, which serves a lightly populated region, specializes in analyzing latent prints, dangerous drugs, and blood alcohol. Evidence requiring more advanced types of analyses is sent to Arizona's Central Lab in Phoenix, the state's capital and largest city. *(AP/Wide World Photos)*

ments are taken; a forensic artist also sketches the scene.

Among the kinds of evidence that criminalists gather are fingerprints. Surfaces that may hold prints are carefully dusted with a powder that creates strong contrasts in the ridges and valleys of such prints. Fingerprints that are uncovered in this way are first photographed and then are lifted from the surface with a sterile adhesive tape and transferred to a fingerprint card. Visible prints, such as those found on surfaces in blood or grease, are photographed and transferred to fingerprint cards.

Criminalists also collect tire-track and footprint evidence, measuring and photographing such impressions and often making plaster casts of them to preserve them for analysis. Trace evidence—substances such as hairs, fibers, and fragments of glass or paint—is collected with vacuum cleaners specially designed for this purpose. Items such as knives, shell casings, and instruments that may have been used as weapons are carefully collected so that any fingerprints or traces of blood, hair, or flesh on them are preserved. Each piece of evidence collected is properly packaged and carefully labeled before it is transported to the laboratory for analysis.

Laboratory Equipment and Techniques

Crime laboratories are equipped with a variety of specialized microscopes that are used to examine closely the materials found at crime scenes. Stereoscopic binocular microscopes are essential for the examination of trace elements detected at the scenes of crimes and are also used to examine and classify handwriting and text created by typewriters and computer printers.

Polarizing microscopes enable forensic scientists to examine and identify minerals, narcotics, and other elements by enlarging their crystal forms. Essential to those engaged in ballistic examinations, comparison microscopes enable forensic scientists to compare the markings on shells and casings found at crime scenes with other samples, possibly linking them to particular weapons.

Using spectrophotometry, investigators can uncover light and heat rays that the human eye cannot see. The spectrophotometer shows the patterns of such rays, and by examining these patterns criminalists can detect alterations on documents, such as erasures, that may indicate fraud or forgery. The gas chromatograph, a sophisticated instrument that identifies the constituent components of substances and measures each component, is used to identify many different unknown substances. It is also the instrument that forensic scientists employ to determine the blood alcohol levels of persons suspected of driving under the influence.

The analysis of DNA (deoxyribonucleic acid) evidence has become an increasingly important part of the work of crime laboratories. By comparing DNA profiles derived from the DNA extracted from biological materials—such as blood, semen, saliva, and hair—found at crime scenes with the DNA profiles of known persons, forensic scientists can identify victims, link suspects to crimes, and exclude innocent persons from suspicion.

Training of Crime Lab Personnel

Nearly all law-enforcement officers receive some training in identifying and handling the evidence with which they come into contact at crime scenes. Because of the growing level of sophistication of the work done in crime laboratories, many colleges and universities in the United States have established special programs designed to train forensic scientists.

Generally, one requirement for employment in a crime laboratory in the United States is an undergraduate degree in chemistry or in some aspect of criminology. The undergraduate preparation of forensic scientists usually includes extensive course work in a variety of chemistry subdisciplines as well as courses in anatomy, physics, biology, geology, and psychology.

Some major American universities offer training in forensic science that leads to a master of science degree; some offer doctorates in criminalistics or forensic science. Many institutions of higher learning provide short training courses in forensic science for law-enforcement personnel and for practicing attorneys; these are helpful for persons within the criminal justice system who lack the typical undergraduate background in forensics or who seek to update their training.

Most forensic scientists in the United States work for local, state, or federal public agencies, although some are private consultants for businesses, industry groups, or other private organizations. The American Academy of Forensic Sciences encourages training and research in the field. Its quarterly publication, the *Journal of Forensic Sciences*, informs readers about current research in all branches of the forensic sciences. The American Society of Crime Laboratory Direc-

Media Perceptions Versus Real-Life Caseloads

As crime labs have become increasingly important in the investigation of crime, they have faced a growing number of challenges. One of these is overwhelming caseloads and limited personnel and budgets. In 2002, for example, the fifty largest crime labs in the United States received more than 1.2 million requests for services. Although these labs had 4,300 full-time employees, they had a backlog of 270,000 requests by the end of that year. As a result of such backlogs, and contrary to what is often depicted in popular television shows such as *CSI: Crime Scene Investigation*, real-life law-enforcement agencies must often wait more than a month to obtain the results of scientific analyses. This situation contributes to slowing down the criminal justice system's response to crimes. The delays allow some guilty people to escape justice, and suspects who are in fact innocent are detained for longer periods than they would be if forensic analyses could be performed more quickly.

Phyllis B. Gerstenfeld

tors, a professional society open to past and current laboratory directors and forensic science educators, was established in 1974 to grant accreditation to crime laboratories that voluntarily invite examiners to evaluate their programs.

R. Baird Shuman

Further Reading

Baden, Michael, and Marion Roach. *Dead Reckoning: The New Science of Catching Killers*. New York: Simon & Schuster, 2001. Provides detailed information on how law-enforcement agencies track down criminals through the use of modern forensic techniques. Shows how Sherlock Holmes stories led to the founding of the first crime laboratory in 1910.

Bass, Bill, and Jon Jefferson. *Death's Acre: Inside the Legendary Forensic Lab the Body Farm Where the Dead Do Tell Tales*. New York: G. P. Putnam's Sons, 2003. Presents a fascinating account of the University of Tennessee's Body Farm, the facility that Bass established to study the process of decomposition of the human body.

Bell, Suzanne. *Encyclopedia of Forensic Science*. New York: Facts On File, 2004. Provides a brief and incisive account of the development of crime laboratories in France, the United States, and other countries.

Campbell, Andrea. *Forensic Science: Evidence, Clues, and Investigation*. Philadelphia: Chelsea House, 2000. Overview of the forensic sciences intended for young adult readers includes information about the genesis and importance of crime laboratories.

Conklin, Barbara Gardner, Robert Gardner, and Dennis Shortelle. *Encyclopedia of Forensic Science: A Compendium of Detective Fact and Fiction*. Westport, Conn.: Oryx Press, 2002. Includes an overall account of crime laboratories and also deals separately with the FBI Laboratory.

Innes, Brian. *Bodies of Evidence*. Pleasantville, N.Y.: Reader's Digest Association, 2000. Presents extensive forensic case studies and devotes a section to the establishment of crime labs in England.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005. Section III contains eleven chapters that focus on the functions of crime laboratories.

See also: American Academy of Forensic Sciences; American Society of Crime Laboratory Directors; Analytical instrumentation; CODIS; Control samples; Environmental Measurements Laboratory; European Network of Forensic Science Institutes; Federal Bureau of Investigation Forensic Science Research and Training Center; Federal Bureau of Investigation Laboratory; Forensic Science Service; National Crime Information Center; Quality control of evidence; University of Tennessee Anthropological Research Facility.

Crime scene cleaning

Definition: Professional cleaning and decontamination of a crime scene, including disposing of biologically or chemically hazardous materials and restoring the site to habitable condition.

Significance: Crime scene cleaners restore a site after forensic investigators have documented the event, collected evidence, and released the scene. Sometimes, in the course of complete restoration of a crime scene, professional cleaners uncover forensic evidence previously overlooked by investigators.

Police and forensic investigators officially release a crime scene after it has been documented and all victims and evidence have been physically removed. Such a scene, particularly if it was the site of a violent crime or drug-related activity, may then be uninhabitable and unusable until it has been cleaned by specialists. The owners of crime scene locations may hire professional cleaning services to avoid the psychological and emotional impact of cleaning these sites themselves. In addition, crime scenes often pose a hazard of contamination by blood-borne

Two employees of a crime scene cleaning business pose in the protective suits they wear to avoid contact with possible biological hazards in their work. Their company specializes in erasing evidence of violent crimes, such as bloodstains, from scenes after law-enforcement investigators have completed their evidence collection. *(AP/Wide World Photos)*

pathogens, microscopic organisms that can cause disease, including hepatitis B, hepatitis C, and human immunodeficiency virus (HIV). In the United States, federal law prohibits employers from exposing workers to blood-borne pathogens unless they have been trained to handle blood; thus commercial enterprises, landlords, and business owners usually hire specialists rather than have their janitorial staff restore crime scenes where blood has been spilled.

Crime scene cleaning is sometimes referred to as biohazard remediation, bioremediation, crime and trauma scene decontamination, or biorecovery. Crime scene cleaners are also called biorecovery technicians or trauma scene practitioners. Technicians in the United States can be trained and certified by occupational groups according to standards set by the U.S. Occupational Safety and Health Administration (OSHA).

Crime scene cleaning involves complete disinfection of floors, walls, ceilings, plumbing, and furniture, where possible, and safe disposition of irretrievably damaged furniture and personal items. Potentially infectious substances—such as bone fragments, blood and other bodily fluids, human tissue, and insects—are isolated, packaged, and disposed of in accordance with state and federal regulations for handling biohazardous material. Chemicals left behind by emergency medical personnel or investigators are completely removed.

Biohazard technicians also clean areas where suicides have occurred or where bodies have decomposed over time, accident scenes, and places damaged by animal waste or remains, mold, water or fire, odors, and chemicals left behind by illegal drug manufacturing (typically the poisonous substances used to make methamphetamine). Some are prepared to respond to bioterrorism, decontaminating areas where disease-bearing bacteria have been deployed.

Beyond surface cleaning, professional crime scene cleaners search for bodily fluids and other materials hidden under floors, in plumbing, and underneath or behind installed furnishings. They may therefore find evidence relevant to an investigation that was not immediately apparent to police or forensic investigators. Crime scene cleaners should be trained to identify and report such findings; otherwise, their thorough cleaning and remediation of a scene will completely destroy any evidence left behind.

Maureen Puffer-Rothenberg

Further Reading

Cooperman, Stephanie. *Biohazard Technicians: Life on a Trauma Scene Cleanup Crew*. New York: Rosen, 2004.

Jacobs, Andrew. "Cleaning Needed, in the Worst Way." *The New York Times*, November 22, 2005, pp. B1-B6.

Reavill, Gil. *Aftermath, Inc.: Cleaning up After CSI Goes Home*. New York: Gotham Books, 2007.

See also: Bacterial biology; Blood agents; Blood residue and bloodstains; Chemical Biological

Incident Response Force, U.S.; Crime scene protective gear; Decomposition of bodies; Decontamination methods; Illicit substances; Pathogen transmission.

Crime scene documentation

Definition: All documents, notes, sketches, and photographs generated in the processing and recording of a crime scene.

Significance: The very act of processing a crime scene alters the scene. The purpose of crime scene documentation is to create as accurate a record as possible of all information about the scene that may be relevant to the investigation. This documentation subsequently provides the only permanent record of the scene and is the only way of conveying information about the scene to investigators, scientists, lawyers, and the court.

Any type of environment or location has the potential to become a crime scene. Crimes can occur in urban, suburban, or rural areas, indoors or outdoors, in commercial or residential buildings, in public or private areas, in sparse, clean, tidy locations or hideously filthy and cluttered locations. Each crime scene, and each crime event, is in some way unique, and, correspondingly, each scene has unique aspects that are relevant to the investigation.

One of the primary purposes of the crime scene examination is to produce accurate and comprehensive records of everything at the crime scene that has the potential to be relevant to the current criminal investigation and any subsequent prosecution. The information in the records must be sufficient to support any expert interpretations, conclusions, or opinions.

At the early stages of an investigation, the information available to the scene examiner may be very limited. It may be that the only thing known is that a body is in an alley. It is often difficult, sometimes impossible, to predict how an investigation will progress and develop over time. Some item, fact, or detail that does not appear to be particularly significant during the scene examination may turn out to be crucial. Because poor documentation of a crime scene can greatly affect the investigation's progress and outcome and, ultimately, any trial that may eventuate, crime scene examinations and their resulting documentation have become increasingly comprehensive.

Background Scene Information

The first law-enforcement officer to arrive at a crime scene may be one of the few individuals to see the scene in a pristine condition. The observations of that first officer often direct the actions or the focus of any investigators subsequently involved with examination of the scene. For example, the first officer on the scene could observe a trail of shoe prints leading away from the scene on grass wet with early-morning dew, whereas scene examiners attending later in the day would not be able to see those prints. If such observations are not documented appropriately and conveyed to the scene examiners, important aspects of the scene exam may be missed.

From the moment a crime scene is made secure, it is important that investigators are able to demonstrate that control of any items within the scene has been maintained. Scene logs are used to record information regarding who has had access to the scene and therefore access to items within it. The chain of custody of scene items begins at the scene and is recorded in exhibit registers, or evidence logs.

Types of Documentation

Crime scene documentation can encompass a huge range of documents or records. In principle, records should be kept of all observations made and any actions taken by all persons involved in securing and processing the crime scene. This includes any handwritten notes and notes transcribed from audio recordings, any photographs taken, and any sketches made by investigators. Depending on the case circumstances, it may also include any notebook entries, or daily job sheets, from the first attending law-enforcement officers or paramedics, scene guard logs, and records from others who have had some contact or involvement with the scene that was peripheral to the actual scene examination.

Photography is a significant part of recording the crime scene, and comprehensive photographing of the scene prior to and during the scene examination is essential. The use of video recording of scenes can also be of value.

Where it was once considered sufficient for crime scene examiners to make notes regarding their observations and the various things they found at a crime scene, it has become increasingly common for examiners to make notes also regarding things they do not find. That is, absences of some kinds of items are often recorded, particularly where those absences allow conclusions to be drawn about actions or events that could subsequently be claimed or suggested.

End Users

In many cases, criminal trials take place months, or even years, after the crimes occurred. It is not realistic to expect anyone to remember accurately the minute details of a crime scene that he or she processed long ago when presenting evidence in court. Consequently, crime scene examiners are allowed the use their notes to aid their recall when they appear as witnesses. In fact, such notes are often deemed more accurate than an individual's recall if significant time has passed.

For many years, investigators' notes were precisely that—their own notes. Gradually, however, it has become accepted that crime scene notes are made to be reviewed, or scrutinized, by others. In many crime laboratories, peer review of notes is a standard quality-assurance practice. Correspondingly, it is expected that notes should be clear and comprehensive enough not only to support any findings, interpretations, and conclusions but also to allow other suitably qualified colleagues to reach those same findings, interpretations, and conclusions independently. Defense analysts may also request copies of scene notes for review. They rely solely on the information, or lack thereof, contained in the scene documentation.

Reviews of older unsolved crimes, or "cold cases," are becoming increasingly commonplace. These case reviews, many of which are driven by advances in technology, have revealed that gradual alterations and improvements have occurred over time in the practices of crime scene documentation. As is true of many things, some of the practices deemed acceptable as recently as ten years ago have come to be seen as lacking by more current standards. Crime scene examiners can make an effort to "future-proof" their scene examination notes by documenting every scene as thoroughly as possible.

R. K. Morgan-Smith

Further Reading

Elliot, Douglas. "Crime Scene Examination." In *Expert Evidence: Law, Practice, Procedure, and Advocacy*, edited by Ian Freckelton and Hugh Selby. 3d ed. Pyrmont, N.S.W.: Lawbook, 2005. Covers broad aspects of crime scene examination, including scene processing and recording.

O'Hara, Charles E., and Gregory L. O'Hara. *Fundamentals of Criminal Investigation*. 7th ed. Springfield, Ill.: Charles C Thomas, 2003. Detailed work devotes significant discussion to the processes of crime scene documentation.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007. Good general text covers a broad range of topics, including crime scene examination and documentation.

Walton, Richard H. *Cold Case Homicides: Practical Investigative Techniques*. Boca Raton, Fla.: CRC Press, 2006. Comprehensive volume on cold-case investigation includes discussion of the use of original crime scene documentation when old, unsolved cases are examined.

See also: Chain of custody; Crime scene investigation; Crime scene measurement; Crime scene reconstruction and staging; Crime scene sketching and diagramming; Evidence processing; Forensic photography; Quality control of evidence.

Crime scene investigation

Definition: Process of recognizing, preserving, collecting, analyzing, and reconstructing evidence located at a crime scene

Significance: By using proven principles and procedures to ensure that all physical evidence at a crime scene is discovered and analyzed, crime scene investigators help to clarify exactly what happened there. The information they gather can link possible suspects to the scene or eliminate them from suspicion.

"Crime scene investigation" is an umbrella term often used to refer to a range of methods and techniques applied during a criminal investigation. Focused on the discovery, recovery, and processing of evidence, crime scene investigation applies reasoned principles in the pursuit of truth. From the moment a crime is discovered until the final appeal in court, the methods and techniques employed during crime scene investigation are under scrutiny.

Modern crime scene investigators combine the logic of fictional detective Sherlock Holmes with advanced scientific techniques in identifying and processing evidence. The basic crime scene procedures used by forensic scientists focus on physical evidence recognition, documentation, collection, packaging, preservation, and analysis. A systematic approach to the investigative task reduces the likelihood of error and improves the investigators' chances of attaining the ultimate goal of justice.

Crime Scene Classification

Crime scenes are traditionally classified based on location, complexity, and relation to the crime in question. The first step in classifying a crime scene is to define the outer boundaries of the physical location. These boundaries establish the geographic limits within which the initial crime will be investigated; this area is known as the primary scene.

The nature of some crimes may involve more than one physical scene, and these are often identified as the secondary, tertiary, and subsequent scenes. For example, in a murder case the death may occur in one location and the body of the victim may be found in another. The primary scene is where the killing took place; the secondary scene is the location where the body was discovered. Both scenes may reveal relevant evidence, and the processing of both constitutes an important part of the criminal investigation.

Crime scenes are also classified as macroscopic or microscopic. A macroscopic crime scene is one that can be viewed and analyzed with the naked eye. Such a scene also includes the potential for several levels of the investigation. Each macroscopic scene is a part of the larger crime. For instance, the scene of a robbery at a convenience store may involve the doorway where the culprit entered, the cash register from which money was stolen, and the back room of the store where the offender placed the clerk before leaving. Each of these scenes is a part of the larger crime scene, but each also constitutes an individual scene for processing. The methods and techniques employed by crime scene investigators depend on both the larger scene and the individual portions within it.

A microscopic crime scene is one in which trace evidence, residues, and similar evidence may be found. Microscopic scenes are often parts of larger macroscopic scenes and therefore require individual processing as well. In processing these scenes, investigators usually require the aid of mechanical or other tools for examination and analysis. A microscopic scene may also be a secondary or higher-level scene that is independent of the primary macroscopic scene. An example is hair or fiber samples from a victim that may be found in a suspect's car. Such samples create a secondary scene that requires microscopic examination. Other examples of microscopic scenes include the clothing of a murder victim, the tire tread left by a getaway car, and the genetic material used in DNA (deoxyribonucleic acid) identification.

A third method of classifying crime scenes is based on the type of crime committed, as different kinds of evidence may be found at the scenes of homicides, robberies, sexual assaults, and other crimes. The methods for processing crime scenes are often determined by the types of crimes and the expected evidence. For example, the scene of a sexual assault is likely to involve evidence very different from the evidence found at the scene of a robbery.

The type of criminal behavior associated with particular crimes may also be used in classifying crime scenes. This is especially important when investigators are attempting to establish the perpetrator's modus operandi, or method of operation (MO), and to recognize potential "signatures" of the perpetrator. The MO used by the perpetrator of a particular crime can often help to define potential suspects, and forensic investigators can help identify and analyze elements of the crime scene that point to the perpetrator's MO.

Crime Scene Objectives

Each crime scene requires a specific systematic investigative approach that is adapted to the needs of that particular crime or scene. The objectives of any crime scene investigation are to identify, preserve, collect, and interpret each piece of evidence. In processing a scene and analyzing evidence, crime scene investigators typically follow a pattern aimed at meeting specific objectives.

The first objective is to determine the essential facts of the case as they relate to the establishment of a crime and its corpus delicti (Latin for "body of the crime"—commonly defined as the substantive nature of the crime). The corpus delicti makes up the essence of a crime, including the legal elements and proof arising from evidence. By first defining the essential facts, investigators can best determine the types of evidence likely to be found and the appropriate processes for recovery of that evidence.

The second objective of the crime scene investigator is to determine the perpetrator's MO. Each crime type requires that the perpetrator perform specific actions to achieve the criminal goal, but perpetrators use many different means for achieving their goals. Individual perpetrators may have specific methods they tend to use in carrying out given crimes. By establishing the MO, investigators can help to define the type of evidence as well as its application to the criminal conduct.

The third objective of the crime scene investigator is to identify witnesses and secure sufficient statements from them. This task includes verifying witness statements, corroborating the statements with other evidence, and, in some instances, disproving the statements as related to physical evidence. The identification of witnesses often helps define other processes and objectives for the crime scene investigation.

The next objective is the identification of suspects. Often a culmination of the earlier objectives, the identi-

A Crime Scene Example

Officers respond to a homicide call at a residence and discover the body of a young woman in the bedroom. After securing the scene, they set up the crime scene log, which controls all people having the right of access to the crime scene. The preliminary survey requires written notes, sketches, and identification of fragile evidence. Officers identify footprints outside the bedroom window. They alert investigators and crime scene specialists to the locations of fragile evidence.

Officers establish a pathway for medical personnel; this pathway prevents destruction of physical evidence. If emergency medical responders request assistance from the pathologist, the pathway allows such follow-up investigators opportunities to locate obvious physical evidence—for example, a weapon, blood, and footprints. The initial point-to-point search turns up additional evidence to be photographed.

Special attention to points of entry and exits assists in identifying the offender's travel pattern. Officers locate broken glass near a damaged window and notice a bloody fingerprint below the putty line. This is a strong indicator that the offender pulled the broken glass from the window frame.

The corpse represents a secondary crime scene. The autopsy examination provides essential information on the manner of death, which in this case is determined to be homicide (as opposed to the other four possible findings: natural, accidental, suicide, or undetermined). The autopsy report links trace evidence from the victim to the scene and the offender.

fication of suspects brings together physical evidence, witness statements, and evidentiary conclusions and allows the investigators to move to their final objective: reconstruction of the crime and the potential evidence related to it. Crime scene investigation focuses on the how and why of the criminal act. In crime scene reconstruction, investigators put together the pieces of evidence, including witness statements, to create a picture of the crime in question.

Methods of Crime Scene Investigation

Crime scene investigation often involves two distinct processes. The first, known as linear progression, focuses on the systematic identification of evidence. Often performed by technicians, this process follows specific guidelines and patterns for identification and management of evidence. In this process, proper procedure is crucial to guarantee the high quality of the evidence and thus support an effective investigation.

Linear progression focuses first on a system of recognition. Initial steps in this part of the crime scene investigation include scene survey and documentation. The investigators describe the crime scene in narrative reports that are often supplemented by diagrams, sketches, photographs, and related material.

The next step in linear progression is identification, which may include comparison and testing. In this step, the investigators identify potential evidence to separate it from irrelevant items found at the crime scene and to help in the collection, preservation, and processing of the evidence. For example, fingerprints discovered in the initial phase of identification of evidence may be lifted at the scene and later identified through a logical system of comparison. The testing of evidence may include chemical, biological, physical, and other methods.

A crime scene investigator places an evidence marker next to a handgun outside a bank in Philadelphia where a robber shot and killed two armored car guards who were servicing an automated teller machine on October 4, 2007. *(AP/Wide World Photos)*

Together, the collection and preservation of evidence constitute an important step in linear progression. Specific collection and preservation methods must be used for particular evidence types, so that the evidence is best protected for later use. In some instances, evidence may be collected and preserved for archival purposes, whereas in others it may be secured for later analysis. Investigators must follow a specific set of procedures for processing each type of evidence.

The final step of linear progression is known as individualization. This involves the evaluation of evidence and interpretation of the findings as related to the crime. For example, although many fingerprints may be found at a given crime scene, only select prints will be usable for helping to determine the suspect. The individualization of each set of prints allows investigators to identify persons on the scene, which in turn helps to build a better understanding of the crime itself.

The second process in crime scene investigation is known as nonlinear progression. This process focuses on patterns of recognition and reasonable inference. Also known as a dynamic process, in this step investigators search for patterns and links between evidence and the elements of the crime. This step focuses on critical scene analysis and specified definition techniques. During this process, which is less systematic than linear progression, investigators use inferences and logic to draw connections that lead to reasonable conclusions.

Processing the Crime Scene

The first step in processing a crime scene is to secure it. This begins when the first responding officer arrives at the scene. Initial concerns are for the safety of any victims, witnesses, and others who may be on the scene, but as soon as the responding officer is sure that no persons are in danger, the focus turns to the protection of potential evidence. In many instances, responding officers work to address these two concerns simultaneously.

Securing the crime scene allows investigators to control the potential for loss or destruction of evidence. It also provides an opportunity for investigators to begin the chain of custody—that is, the documentation of the location of all the evidence recovered during the investigation and its eventual use in the courts.

In large police departments, and especially on major crime scenes, the tasks associated with crime scene investigation may be assigned to different individuals. In some instances a lead investigator takes a proactive and supervisory role, controlling and monitoring all activities at the crime scene. In other agencies, a crime scene supervisor takes that role; in still others, various crime scene duties are assumed by individual units.

Small crime scenes and relatively low-level crimes may involve limited numbers of investigators. For example, a classic case of burglary may initially involve only the responding officer, who then has the duty to evaluate the scene and make recommendations concerning additional investigative needs. A crime scene technician may be called to the scene to process physical evidence, but in smaller departments this task may actually fall on the responding officer.

Forensic Science and Crime Scene Investigation

The tools, methods, and techniques used in modern crime scene investigation have made tremendous advances in the past fifty years. The role of forensic science in law-enforcement investigations has increased steadily as methods have improved. Scientific testing that was once prohibitively expensive is now readily available, and new technologies have increasingly improved the accuracy of the findings of criminal investigations.

These advances have come at some cost, however. For instance, jurors in general may have high expectations regarding what investigators can do at crime scenes, in part because of the fictional portrayals of forensic investigators that have become common on television and in films. This means that investigators must be particularly careful to follow standard operating procedures as well as the accepted techniques related to individual kinds of crimes.

Crime scene investigation has also changed dramatically because of changes in the investigative approach taken by many law-enforcement agencies. The trend toward community-oriented policing, among other developments, has led to more accommodating approaches to interagency investigation. The nature of criminal activity, especially when similar crimes take place across multiple jurisdictions, demands that agencies cooperate with each other in the investigation process.

The foundations of science change slowly, but the application of scientific methods to criminal investigations has changed very quickly. Forensic science has seen great improvements in technologies that enable the identification of trace or microscopic evidence, and crime scene investigators in the field have increasing access to devices that were once reserved for the laboratory.

Carl Franklin

Further Reading

Adams, Thomas F., Alan G. Caddell, and Jeffrey L. Krutsinger. *Crime Scene Investigation*. 2d ed. Upper Saddle River, N.J.: Prentice Hall, 2004. Handbook for law-enforcement professionals focuses on excellence in the conduct of crime scene procedures.

Bennett, Wayne W., and Kären M. Hess. *Criminal Investigation*. 8th ed. Belmont, Calif.: Wadsworth/Thomson Learning, 2007. Provides in-depth discussion of forensic techniques and procedures.

Fisher, Barry A. J. *Techniques of Crime Scene Investigation*. 7th ed. Boca Raton, Fla.: CRC Press, 2004. Provides a broad overview of many areas of forensics, including the specific methods used by investigators at crime scenes.

Gilbert, James N. *Criminal Investigation*. 6th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2004. Comprehensive text includes discussion of the procedures forensic scientists follow at crime scenes.

Ogle, Robert R., Jr. *Crime Scene Investigation and Reconstruction*. 2d ed. Upper Saddle River, N.J.: Prentice Hall, 2007. Well-organized text covers all aspects of the work of forensic scientists during criminal investigations.

See also: Chain of custody; Crime laboratories; Crime scene cleaning; Crime scene documentation; Crime scene measurement; Crime scene protective gear; Crime scene reconstruction and staging; Crime scene screening tests; Crime scene search patterns; Crime scene sketching and diagramming; Criminalistics; *CSI: Crime Scene Investigation*; Evidence processing; First responders; Forensic photography; Quality control of evidence.

Crime scene measurement

Definition: Precise recording of the exact locations of all elements of a crime scene, including all items found there and all evidence collected.

Significance: The accurate recording of all measurements of a crime scene, particularly the locations of the various items found there, enables investigators to reproduce the scene at a later date, so that they can examine each item in relationship to the others and to the overall scene.

After a crime scene has been identified and the evidence found there has been located, numbered, tagged, and photographed, the scene must be measured in detail. This procedure allows investigators to reproduce the scene later, with all items of evidence and other important items depicted. This reproduction, made to scale, may take the form of a detailed sketch; it may be used for investigative purposes, for courtroom presentation, or both. A three-dimensional reproduction of the crime scene may also be made to assist jurors in visualizing the scene as it was found. Photographs are helpful, but they are limited because they are two-dimensional and do not indicate the exact locations of all the items present and the relationships among the items.

When a crime scene is measured, it is critical that each item be measured from a fixed point, so that it can be repositioned in its exact location at a later date. It would not be helpful, for example, to position an item found in the street by measuring its position in relation to a car parked next to the curb, because the car will be moved at some point. The position of an item in the street should be measured from something that will not move, such as a piece of curb or a point on a building. For a crime scene in a house, a measurement could be made from a specific point on a given wall.

Using the example of a crime scene in the street, a measurement could be made from curb prolongations (usually employed in traffic accident investigations) or other fixed objects, such as buildings or power poles. For example, at the scene of a shooting in which investigators find an expended twelve-gauge shotgun shell in the street, a triangulation method of positioning the shell could be used. The notes on such a measurement might read as follows:

> Evidence item 1: One 12-gauge shotgun shell, Remington Express, 3″ mag, red, expended. Found in the center of First Street, south of Los Osos Blvd. Shell was 22′ southeast of ConEd Power Pole #3216, located on the southwest corner of First St. and Los Osos Blvd. and 29′8″ southwest of the northwest corner of Bean's Café located at 1608 First St., Big City.

The items noted can be cross-referenced with crime scene photographs.

New York City police officers take measurements at a crime scene where a shooting took place. The numbered tags mark the places where spent shell casings were found. *(AP/Wide World Photos)*

Using the example of a gun found on the floor of a room, the measurements could be made from the walls of the room:

> Evidence item 6: Gun, S&W blue steel revolver, 4″ barrel, Mod 28, serial number unknown. Found 6′3″ south of the north wall of bedroom number 3 and 18″ from the west wall of said bedroom.

In this example, two right angles are employed to fix the exact position of the gun on the floor of the bedroom; this is frequently referred to as the rectangle method.

In crime scene measurement, the most critical issue is precision. All measurements must be exact, so that the crime scene can later be reproduced accurately, with all items placed where they were found. Many law-enforcement agencies have begun to employ computer programs designed to assist in this endeavor.

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Further Reading

Gilbert, James N. *Criminal Investigation*. 6th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2004.

O'Hara, Charles E., and Gregory L. O'Hara. *Fundamentals of Criminal Investigation*. 7th ed. Springfield, Ill.: Charles C Thomas, 2003.

Weston, Paul B., and Charles A. Lushbaugh. *Criminal Investigation: Basic Perspectives*. 9th ed. Upper Saddle River, N.J.: Prentice Hall, 2003.

See also: Accident investigation and reconstruction; Crime laboratories; Crime scene documentation; Crime scene investigation; Crime scene reconstruction and staging; Crime scene search patterns; Crime scene sketching and diagramming; Forensic photography.

Crime scene protective gear

Definition: Clothing worn by forensic scientists at crime scenes to minimize their direct contact with materials at the scenes.

Significance: It is important that forensic scientists, as well as other professionals who attend crime scenes, take precautions to prevent the inadvertent transfer of potential evidence between them and the scenes. These precautions include the wearing of protective gear, which serves both to protect crime scenes from contamination and to protect forensic scientists from coming into direct contact with possibly dangerous substances.

The examination of a crime scene is essentially like the examination of any exhibit in a forensic laboratory, in that a main function of the crime scene examiner is to collect evidence from the scene, just as a laboratory scientist collects evidence from an exhibit. Both types of investigators should wear protective clothing during their respective examinations.

The wearing of protective gear at a crime scene serves three primary purposes. First, it minimizes the chances that a forensic scientist will leave trace evidence at the scene or on samples collected, which could result in contamination of the evidence and thus affect the interpretation of any results. Second, it minimizes that chances that a scientist will carry trace evidence from the scene to the laboratory or to other collected samples relating to the case being investigated or to other cases. Third, it helps protect the scientist from any biological, physical, or chemical hazards at the scene, which may or may not be directly related to the case being investigated.

Protecting the Scene

Simply wearing protective clothing is not enough. Forensic scientists must follow established procedures that specify the kinds of protective gear they must wear, when they must wear it, and when they must change it. They must also follow appropriate crime scene management procedures.

Protocols for the use of protective gear need to consider all the types of evidence that forensic scientists can leave at a scene or collect from a scene. Scientists may shed hairs from their heads or facial hairs. They could shed fibers from their clothing. They could leave fingerprints on any items they touch. In walking through the scene, they could leave shoe prints.

Increasingly, forensic scientists have come to realize that DNA (deoxyribonucleic acid) should be regarded as a form of trace evidence, especially given the steadily increasing sensitivity of DNA analysis. A bloodstain or semen stain is not a fixed deposit of potential DNA evidence. Rather, just as fibers can be shed from an item of clothing, DNA-containing cells can be shed from a biological stain onto other items or stains. Scientists who attend crime scenes need to be aware of this potential for contamination and must dress accordingly.

Scientists also need to be aware that they may shed DNA from themselves to crime scenes and thus contaminate items. By touching an item, a person can transfer skin cells that could give a DNA profile. Coughing, sneezing, or breathing on objects may also transfer cells. The analysis of this sort of DNA sample, often called trace DNA, is an important part of the work of forensic scientists.

Essential Gear

A minimum standard of protective gear for a forensic scientist generally involves gloves, appropriate footwear, and something that covers the scientist's clothing, such as overalls or a lab coat. Many crime laboratories are moving to the use of disposable overalls, eliminating the need to have overalls laundered. Disposable overalls make it easy for scientists to change their protective outerwear if it becomes stained or contaminated during crime scene examination, or when they must collect evidence from several areas of a crime scene that need to be kept separate or from multiple scenes associated with the same incident. In addition, because such overalls are disposed of according to protocols established for biohazardous waste, their use minimizes potential contamination from the scene to the laboratory.

Gloves are an essential part of crime scene examiners' gear because no matter how well-intentioned examiners are, they might accidentally touch important surfaces. Generally, disposable gloves made from vinyl or latex are worn. Some scientists wear two pairs of gloves at a time (a practice called double-gloving), especially when the samples collected are likely to be subjected to particularly sensitive DNA analysis techniques.

Forensic scientists have two options for footwear at crime scenes. Some prefer to keep dedicated pairs of scene boots or shoes, which they clean between scenes with 70 percent ethanol or a surface disinfectant such as TriGene. The other option is the use of disposable overshoes. Both approaches minimize the inadvertent transfer of trace or biological evidence from examiners to crime scenes.

Head coverings and face masks provide an extra level of protection at crime scenes. Forensic scientists may cover their heads with the hoods attached to most disposable overalls or with separate disposable caps. If trace DNA analysis is considered as a possible technique in a case, head coverings and masks should be regarded as essential. Low levels of DNA from persons examining the scene could contaminate these sample types if precautions are not taken, and such contamination could render the DNA results difficult or impossible to interpret. Some scientists consider head coverings and face masks to be essential for all scene examinations, whereas others prefer to address the level of protective gear needed based on individual case circumstances, which may change during their examinations.

Health and Safety Issues

At many crime scenes, forensic scientists can expect to encounter biological fluids. The standard protective gear discussed above should help scientists to avoid possible infection, but some may wish to consider additional precautions if particularly heavy dried or wet blood is present.

Crime scene investigators put on protective overalls, shoe coverings, and gloves as they prepare to enter a home in Deltona, Florida, where six people were found dead a few hours earlier. *(AP/Wide World Photos)*

Some scene types present particular physical and chemical hazards. For example, examiners collecting evidence at clandestine drug laboratories may encounter volatile chemicals, and they may need to protect themselves with body coverings and breathing apparatuses suitable for such exposure. Because they must often must move through unstable debris, arson investigators protect themselves with heavy footwear and hard hats or helmets.

In testing substances at crime scenes, scientists may need to use reagents that can present health hazards. For example, the reactive dyes used in presumptive testing for blood and semen can be carcinogenic. Also, crime scene examination techniques involving the use of luminol and leuco crystal violet (for the enhancement of bloodstains and bloodied shoe prints or other impressions) require the spraying of scenes with chemicals. In such cases, some kind of breathing apparatus may be needed, particularly if the area being examined is enclosed or not well ventilated.

Douglas Elliot

Further Reading

Elliot, Douglas. "Crime Scene Examination." In *Expert Evidence: Law, Practice, Procedure, and Advocacy*, edited by Ian Freckelton and Hugh Selby. 3d ed. Pyrmont, N.S.W.: Lawbook, 2005. Takes a multijuridictional point of view in discussing all aspects of crime scene examination.

Fisher, Barry A. J. *Techniques of Crime Scene Investigation*. 7th ed. Boca Raton, Fla.: CRC Press, 2004. Provides a broad overview of many areas of the forensic sciences. Includes discussion of the health and safety issues related to crime scene examination.

Geberth, Vernon J. *Practical Homicide Investigation: Tactics, Procedures, and Forensic Techniques*. 4th ed. Boca Raton, Fla.: CRC Press, 2006. Text used in many U.S. police academies includes discussion of the protective gear required for those involved in the collection and handling of evidence.

Houck, Max M., and Jay A. Siegel. *Fundamentals of Forensic Science*. Burlington, Mass.: Elsevier Academic Press, 2006. Good general textbook devotes a thorough section to the safety aspects of the work done by crime scene investigators.

See also: Blood residue and bloodstains; Chemical Biological Incident Response Force, U.S.; Crime scene cleaning; Crime scene investigation; Cross-contamination of evidence; Decontamination methods; DNA extraction from hair, bodily fluids, and tissues; Food supply protection; Footprints and shoe prints; Trace and transfer evidence.

Crime scene reconstruction and staging

Definitions: Crime scene reconstruction is an investigatory technique in which evidence is gathered, organized, and analyzed to recreate the precise sequence of events that occurred during the course of a crime. Crime scene staging is a stratagem sometimes used by criminal offenders in which a crime scene is rearranged or fabricated to disguise the true nature of the offense and suggest other causes or perpetrators of the crime.

Significance: Crime scene reconstruction is the process of piecing together the evidence in a criminal case to determine what, when, where, and how criminal actions occurred. This process is fundamental to the successful apprehension and conviction of criminals. Without painstaking examination of the crime scene, investigators can easily overlook crucial evidence; if the evidence is not then assembled to tell a coherent story of what happened, the perpetrator of the crime might never be apprehended or convicted. Law-enforcement investigators must also be alert to the possibility that the perpetrator has manipulated elements of the crime scene to mislead them. Crime scene reconstruction and staging are related in that both help answer important questions that can lead to the apprehension of perpetrators.

Criminal investigation is a systematic fact-finding endeavor that involves numerous professionals with special expertise and training. Law-enforcement officers arrive at the scene in response to a report that a crime has been committed. Their job is to preserve and protect the crime scene. Criminalists collect physical evidence at the crime scene and deliver that evidence to the laboratory. Crime scene investigators or detectives scour the scene for evidence, ask witnesses questions, and track leads concerning possible suspects. Laboratory scientists analyze and test physical evidence from the scene. In homicide cases, forensic pathologists perform autopsies to ascertain the manner and cause of death. The work of all of these professionals lays the groundwork for crime scene reconstruction.

Criminal investigations must adhere to a deliberate process. Physical evidence is carefully collected, handled, transported, and preserved for the purpose of solving a crime and bringing the offender to justice. Failure to protect the integrity of the evidence can render it inadmissible in court. Notwithstanding its importance, physical evidence, by itself, might not be enough to close a criminal case. Discrete bits of evidence must be properly collated and placed in a context to be useful in the arrest, prosecution, and conviction of offenders.

Reconstructing Crime Scenes

Crime scenes are locations where illegal acts have been committed and physical evidence is found. Crime scenes can be categorized as primary, secondary, or tertiary. For example, an offender may kidnap a victim from her home (a primary crime scene) and transport her by car (a secondary crime scene) to another location (a tertiary crime scene), where the offender murders her. The place where the offender disposes of the victim's body is yet another tertiary crime scene. Crime scenes thus include any indoor or outdoor locations that afford opportunities for the recovery of direct physical evidence of crimes. Connecting the activities and establishing the nature and sequence of events within and among those scenes is the essence of crime scene reconstruction.

Crime scene reconstruction is a methodology that is used to re-create the events of a crime, including the course of actions that unfolded immediately before, during, and after the incident. Forensic scientists reconstruct a crime scene by examining and interpreting physical evidence as well as the physical layout of the location. Reconstruction begins with the gathering of data from the scene; in the case of homicide, these may include data on blood spatter, gunshot residue, bullet trajectories, and objects from which DNA (deoxyribonucleic acid) evidence can be collected. In a homicide case, the positioning and condition of the victim's body can also yield valuable details about the specific unfolding and timing of the criminal act.

A thorough reconstruction includes photographs from the crime scene, results of laboratory analyses of physical evidence, and autopsy findings. Measurements and sketches of the scene are also carefully done and integrated to form a logical and evidence-based re-creation of the criminal act. Information from the crime scene is synthesized so that investigators can make educated guesses about what happened during the crime, where it happened, when it happened, and how it happened. Witness statements are compared with the physical evidence to determine whether the hypothesized sequence of actions is refuted or supported by witness recollections.

During the crime scene reconstruction process, investigators typically walk through the crime scene while attempting to apply the mind-set of an offender. They formulate realistic scenarios that might match the actual events of the crime. Investigators must be able to interpret the crime scene from every visual perspective in order to discover, interpret, and collate pertinent facts. One primary focus of investigation involves the determination of the offender's modus operandi, or method of operation, which consists of the actions that an offender employs to complete the crime (choice of target, method of entry, use of weapon, means to control the victim, and so on).

Crime Scene Staging

The possibility that a crime scene has been staged is another important consideration in crime scene reconstruction and analysis.

Staging is a deliberate attempt to thwart or confuse crime scene investigators by rearranging the crime scene. In one type of staging, the offender modifies the elements of the crime scene to make the offense appear as a suicide or an accident. Crime scene investigators must be careful in accepting evidence at face value. For example, a man found in his apartment with a fatal bullet wound in his head and gun in his right hand might not be a suicide victim. Detailed investigation may lead to the conclusion that the case is, in fact, a homicide, as evidenced by the angle of the exit wound, the gunshot residue on the victim's hand, the nature of the wound, the distance of the shell casings from the gun and the body, and the type of gun used in the crime. Crime investigators must be skeptical and methodical in their efforts to explore all possible aspects of a crime scene in order to differentiate between the actual events of the crime and any likely staging of the scene.

In another type of staging, serial killers position physical evidence and victims' bodies to humiliate, punish, and degrade victims and taunt the police. Some serial killers compulsively leave psychological markers, known as signatures, at their crime scenes. These can include posing the victims' bodies or concealing or inserting objects in the victims' bodies after death. A serial killer's signature is unnecessary for the completion of the crime but critical to the killer's psychological and sexual gratification.

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Further Reading

Clemens, Daryl W. "Introduction to Crime Scene Reconstruction." *MAFS Newsletter* 27 (April, 1998). Discusses the differences between crime scene reconstruction and criminal profiling. Also describes different types of reconstruction techniques, the steps in the reconstruction process, and how criminal profiling and crime scene reconstruction complement each other in helping investigators understand how and why crimes are committed.

Gardner, Ross M. *Practical Crime Scene Processing and Investigation*. Boca Raton, Fla.: CRC Press, 2005. Thoroughly illustrates and explains the importance of each step in a criminal investigation. Outstanding chapter titled "The Role of Crime Scene Analysis and Reconstruction" explicates the methodology of crime scene investigation and enumerates the steps in event analysis. Includes vivid photographs and sketches from crime scenes to illustrate the various stages of the reconstruction process.

Geberth, Vernon J. "The Homicide Crime Scene." In *Practical Homicide Investigation: Tactics, Procedures, and Forensic Techniques*. 4th ed. Boca Raton, Fla.: CRC Press, 2006. Describes the different types of crime scene staging and presents examples of actual crimes in which the scenes were staged in a section headed "The Staged Crime Scene." Written by a former commander for the Bronx Homicide Division of the New York City Police Department.

Gibson, Dirk. *Clues from Killers: Serial Murder and Crime Scene Messages*. Westport, Conn.: Praeger, 2004. Presents the details of the crimes committed by some of history's most notorious serial killers, including the Unabomber, Jack the Ripper, and the BTK Killer, and analyzes the messages and other forms of communication each of the perpetrators used. Opens with an excellent introduction that discusses the nature of serial killers' signatures and how these idiosyncratic and often cryptic expressions vary depending on what the killers are trying to accomplish.

Ogle, Robert R., Jr. *Crime Scene Investigation and Reconstruction*. 2d ed. Upper Saddle River, N.J.: Prentice Hall, 2007. Provides a good overview of all procedures used in crime scene investigation and discusses the steps taken and the kinds of physical evidence used in reconstructing the events that took place at a given scene.

See also: Accident investigation and reconstruction; Bomb damage assessment; Crime scene documentation; Crime scene investigation; Crime scene measurement; Crime scene sketching and diagramming; Criminal personality profiling; Criminalistics; DNA analysis; DNA fingerprinting; Forensic anthropology; Forensic photography; Forensic sculpture; Structural analysis.

Crime scene screening tests

Definition: Color tests that provide rapid information regarding the presence or absence of given classes of drugs or compounds.

Significance: At crime scenes, forensic scientists need to provide information to law-enforcement personnel on any possible illicit drugs or other compounds that may be present. They must also make decisions on the most appropriate samples to be collected. The use of crime scene screening tests, generally in the form of chemical reagents that show positive results with distinct color changes, can assist in these decision-making processes by providing initial indications of what questioned substances or compounds may or may not be.

Although crime scene screening tests, commonly known as spot tests, can be used to identify a wide range of compounds, forensic scientists most commonly use these tests at crime scenes related to the use and manufacture of illicit drugs. Spot tests are used to exclude or potentially identify given classes of drugs or compounds as being present in samples. Spot testing may be used to determine whether a large single package seized by police, such as a bulk powder, is homogeneous or to determine whether numerous packages or other items seized at a single scene are all the same. At crime scenes, spot tests can provide forensic scientists with information as to whether particular items should be sampled or whether they should be taken whole to the laboratory for further analysis.

Properties of a Spot Test

The ideal spot test would be specific for a given drug or compound, would be sensitive (so that only a small amount of sample need be subjected to analysis), and would provide an unambiguous result, allowing no misinterpretation. In the interests of efficiency and safety, the test reagents would be cheap and harmless, and the test itself would be quick and easy to carry out.

In reality, most spot tests sacrifice specificity in favor of fulfilling the other desired criteria; they do not individually identify specific drugs or compounds, but rather given classes. For example, Marquis reagent turns a positive purple color with an opiate alkaloid, whether it be morphine, diacetylmorphine, or one of the many other compounds in the same class.

As most spot tests are relatively sensitive, a negative result provides a good indication of the absence of the class of drug or compound that would normally provide a positive result. A positive result may develop with a compound outside the class of compound being screened for; such a result is commonly referred to as a false positive. Other compounds present in the sample may prevent an unambiguous identification of a drug. Sugars are often used as diluting agents in powered drug samples, and these can turn brown when combined with sulfuric acid (present in Marquis reagent). This brown color may obscure any color change resulting from a drug present

Spot Tests at Clandestine Drug Laboratories

The use of spot tests at clandestine laboratories manufacturing drugs can help forensic scientists to determine whether powdered materials found there are final products or precursors, in which case the whole items will need to be seized, or less important compounds that need only be sampled. Spot tests may also be used to determine the presence of other chemicals at such crime scenes. For example, the identities of common acids found at clandestine drug laboratories may be tentatively distinguished through the use of spot tests employing a silver nitrate solution. Hypophosphorous acid, commonly used in the manufacture of methamphetamine, will produce a black precipitate, although further testing is required to distinguish it from phosphorous acid. Hydrochloric acid will produce a white precipitate, and sulfuric acid will produce no reaction. Forensic scientists need to combine the results of spot tests with other observations to determine the nature of the acids at drug lab crime scenes, and, in all cases, further testing is required to confirm the identities of the acids.

in the sample, such as an amphetamine, which would produce a positive orange color.

Spot tests require no sophisticated equipment and can easily be carried out away from the laboratory at crime scenes. A forensic scientist generally carries out a spot test by adding the test reagent to a small amount of the sample material in a small glass tube or on the well of a spotting tile.

Spot tests tend to be destructive, but each test requires only a small amount of the sample material, leaving the bulk of the sample for further testing if required. The reagents are not necessarily harmless; they often contain strong acids or chemicals with undesirable properties. They are required only in small amounts, however, and can be safely transported to scenes in suitable containers.

Quality Control

The age of spot test reagents and the conditions under which they have been stored may affect the colors produced during use. Forensic scientists need to run positive and negative controls with spot test reagents on a regular basis to ensure that they are working correctly.

Little training or expertise is required in the use of spot tests, and such tests may be readily carried out by nonscientific staff, such as police or customs officers. Because it is unlikely that a positive control will be able to be carried out at every scene where a sample is tested, persons using spot tests should carry out their own positive and negative controls with the test reagents to ensure that they are familiar with the color changes expected. In addition, tests should be carried out on compounds known to produce "false positive" results. This will prevent misinterpretation of results owing to subjectivity when describing colors.

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Further Reading

Camilleri, Andrew M., and David Caldicott. "Underground Pill Testing, Down Under." *Forensic Science International* 151 (2005): 53-58. Evaluates the use of spot tests for identification of the drugs contained in so-called party pills.

Cole, Michael D. *The Analysis of Controlled Substances*. New York: John Wiley & Sons, 2003. Describes the major classes of drugs of abuse in a clear manner and addresses the use of spot testing, thin-layer chromatography, and instrumental analysis.

Horswell, John, ed. *The Practice of Crime Scene Investigation*. Boca Raton, Fla.: CRC Press, 2004. Collection of essays covering all aspects of scene investigations includes a chapter on drug operations that provides a good explanation of the use of spot tests and discusses how their use coincides with other important forensic aspects of such investigations.

Moffat, Anthony C., M. David Osselton, and Brian Widdop, eds. *Clarke's Analysis of Drugs and Poisons*. 3d ed. 2 vols. Chicago: Pharmaceutical Press, 2004. Comprehensive work provides data and describes methods relating to the detection, identification, and quantification of drugs and poisons.

O'Neal, Carol L., Dennis J. Crouch, and Alim A. Fatah. "Validation of Twelve Chemical Spot Tests for the Detection of Drugs of Abuse." *Forensic Science International* 109 (2000): 189-201. Presents the results of research that assessed the specificity and sensitivity of twelve spot tests commonly used in drug analysis.

United Nations. *Rapid Testing Methods of Drugs of Abuse*. New York: Author, 1995. Manual intended for forensic laboratories and law-enforcement personnel provides technical detail but is easy to read and includes clear information relating to the practical use of spot tests for drugs.

See also: Acid-base indicators; Crime scene investigation; Crime scene measurement; Drug classification; Evidence processing; Illicit substances; Meth labs; Presumptive tests for blood.

Crime scene search patterns

Definition: Geometric template method used to search for evidence at a crime scene.

Significance: The orderly approach of following a geometric pattern in the search for and gathering of evidence at a crime scene maximizes discovery efforts and minimizes the disturbance of evidence prior to discovery.

Law-enforcement investigators organize their searches of crime scenes to maximize the likelihood of finding evidence and to minimize the likelihood that they will fail to discover existing evidence. The discovery process itself should not cause undue disturbance of the scene, as this could cause evidence to be damaged or overlooked. To organize their searches, investigators choose from various geometric templates, which are then imposed on the scenes to be searched; four commonly used templates are the spiral, the strip, the wheel, and the zone pattern. Evidence discovery points at a crime scene can be diagrammed at corresponding points on a paper or digital record that serves as a blueprint of the crime scene.

A spiral search emanates from a center point and travels in widening curves from that point like a coiled snake. The search path may begin from either end of the spiral. For example, a bloody knife found on the street would most likely generate a spiral search path starting at the location of the knife (center of the spiral) and working outward. A crime scene with a victim inside a room having a single doorway would probably generate a spiral search pattern that starts from the doorway (outer end of the spiral) and works inward, toward the center.

A strip (or linear) search pattern divides a crime scene into long, narrow sections. Investi-

Law-enforcement investigators search for human remains within areas staked off into a grid pattern at a Cass County, Missouri, residence where bone fragments from at least two people had been found. *(AP/Wide World Photos)* gators may begin an evidence search at either end of the strip. This sort of search is often used across large land areas to look for evidence such as the presence of a person in that vicinity. In a typical strip pattern search, searchers walk shoulder to shoulder or separated by an arm's length in a line that moves simultaneously across an area.

The wheel pattern search has a center point from which spokes radiate outward to connect to a circle enclosing the search area. The sections of the wheel pattern search thus are shaped like slices of a pie. Searchers can investigate sections simultaneously from the outer perimeter toward the center without crossing or disturbing possible evidence in other sections. The wheel pattern search may be used when time for searching is limited, such as when adverse weather conditions make it likely that the crime scene will soon be disturbed.

The zone (or grid) search pattern uses perpendicular lines that form square search areas (quadrants); each quadrant can be further divided into smaller quadrants pertinent to the search. Crime scene investigators who need to search buildings often do so by dividing each floor into zones. Zoned investigations may quickly rule out particular zones that are not pertinent to the crime, thus freeing investigators to concentrate on the zones that do contain evidence.

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Further Reading

Genge, N. E. *The Forensic Casebook: The Science of Crime Scene Investigation*. New York: Ballantine, 2002.

Pentland, Peter, and Pennie Stoyles. *Forensic Science*. Philadelphia: Chelsea House, 2003.

Platt, Richard. *Crime Scene: The Ultimate Guide to Forensic Science*. New York: Dorling Kindersley, 2003.

See also: Blood residue and bloodstains; Buried body locating; Crime scene documentation; Crime scene investigation; Crime scene measurement; Crime scene sketching and diagramming; Disturbed evidence; Evidence processing; Forensic archaeology; Locard's exchange principle; Metal detectors; Physical evidence.

Crime scene sketching and diagramming

Definition: Creation of representative depictions of locations and appearances of important and relevant features and objects found at crime scenes.

Significance: In creating sketches and diagrams of crime scenes, examiners extract from the abundance of background visual information at such scenes only those features that are relevant and portray them in visual form. Such sketches are complementary to the scene notes and photographs that also document crime scenes.

Crime scenes are often very cluttered, jumbled, and confusing. Crime scene photographs can contain vast amounts of visual information, much of which may not relate to the particular incident being investigated. By making a sketch or diagram, a crime scene examiner can create a document that visually highlights only those aspects of the scene that are considered to be relevant to the crime. Like all crime scene documentation, sketches can be made to aid the recollection of the investigators who make them, but ultimately they serve to convey information to other investigators, attorneys, and courts.

An annotated sketch or diagram, with appropriate measurements marked, can provide a format for focusing the attention on one aspect, or a small number of aspects, of the crime scene that may be particularly relevant. For example, a single sketch of a light switch showing the general appearance and location of a bloodstain and indicating where a sample of the stain was taken from provides a clear, easily understood visual representation of one aspect of the scene examination. Another, more typical, example would be a sketch of the floor plan of a room indicating the location of a body relative to items of furniture and other significant objects, such as the murder weapon.

Rather than attempting to include a lot of information in a single sketch, which can lead to confusion, a crime scene examiner may create multiple sketches of the same area of interest.

A crime scene investigator for the Florida Department of Law Enforcement testifies in court, using a crime scene diagram to indicate the locations where six bodies were found inside a Deltona, Florida, home in August, 2004. *(AP/Wide World Photos)*

One such sketch might indicate the location of a body and other physical items relative to each other, a second might depict the locations of bloodstains, and a third might show the locations of shoe prints. This kind of separation of layers of information allows viewers of the sketches to comprehend the individual points of interest more easily.

Most crime scene sketches are not intended to be perfectly accurate scale re-creations of the scenes. Rather, they are nearly always companions to detailed scene photographs. Sketches are valuable because they are simple to create and can readily convey specific information. Increasingly, however, crime scene examiners are making use of modern surveying equipment and associated computer software to create accurate visual depictions of crime scenes and the locations of items within them.

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Further Reading

Elliot, Douglas. "Crime Scene Examination." In *Expert Evidence: Law, Practice, Procedure, and Advocacy*, edited by Ian Freckelton and Hugh Selby. 3d ed. Pyrmont, N.S.W.: Lawbook, 2005.

Horswell, John, ed. *The Practice of Crime Scene Investigation*. Boca Raton, Fla.: CRC Press, 2004.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007.

See also: Composite drawing; Crime scene documentation; Crime scene investigation; Crime scene measurement; Crime scene reconstruction and staging; Crime scene search patterns; Evidence processing.

Criminal personality profiling

Definition: Investigatory technique in which a detailed composite description of an unknown perpetrator is constructed on the basis of crime scene evidence.

Significance: By providing police officers with descriptive information about what type of individual probably committed an offense, including demographic and psychological characteristics, profiling narrows the range of likely offenders and helps investigators concentrate their limited resources and time in search of suspects.

Criminal personality profiling is based on the notion that serial offenders engage in similar patterns of behavior and that each serial offender leaves a unique trail of evidence with each crime. Profilers believe that the actions of serial offenders are deeply motivated, however bizarre, random, or senseless those actions might appear to untrained observers. The criminal activities in which these offenders engage are windows into their hidden desires, tendencies, and psychological traits. Conversely, these offenders' thoughts as well as their emotional and sexual needs drive their criminal behaviors.

Serial Criminals

Profiling is most often employed in cases of serial homicides or rapes. These crimes, which tend to receive widespread media coverage, often involve female victims with common physical characteristics. The general profile of serial murderers, which matches the actual characteristics of most of the persons apprehended for such crimes, is as follows: They are white men with average or above-average intelligence, in their mid-twenties to mid-thirties, who have an interest in criminal law and police work. Serial killers also tend to be interpersonally adept; they are typically friendly, charming, and engaging, which explains their success at attracting and luring victims to horrific deaths. Other types of serial criminals have also been the subjects of criminal personality profiling, including arsonists, bank robbers, kidnappers, and child molesters.

Profilers assume that perpetrators leave telltale signs of their psychopathology at their crime scenes (in the case of serial murderers, the locations where they kill, torture, and mutilate their victims) and in the areas where they conceal their victims' bodies—so-called dump sites. Profilers examine these clues to characterize an unknown suspect (that is, an individual who is likely to have committed the crime given the evidence at the scene). However, they rarely provide police investigators with the specific identity of an actual perpetrator.

Major Profiling Tasks

The three primary tasks of a criminal personality profiler are to generate details about an unknown perpetrator's personality and sociodemographic characteristics, to predict the items that are likely to be discovered in a suspected offender's possession, and to recommend various interrogation strategies for suspects in custody. In accomplishing the first of these tasks, the profiler provides police investigators with leads that narrow the pool of unknown suspects with respect to age, race, ethnicity, employment, education, and marital status. Profiling unfolds a biographical sketch of an at-large killer or rapist as the number of that person's crimes increases and more information becomes available to the profiler. Profiling can also give investigators insights into where a perpetrator might live relative to the locations of the crimes.

The most important aspect of the profiler's first task is to arrive at an educated guess about a likely offender on the basis of police and autopsy reports as well as the consistent elements found at different crime scenes, such as how the victims were killed (for example, stabbing, bludgeoning, strangling, suffocating) and how the bodies were positioned or displayed (for example, naked, partially clothed, posed). Based on these data, the profiler can help police officers to focus their attention on a certain type of suspect. The profiler can also provide police with information on where the offender is likely to live as well as when and where the offender is likely to strike again.

The defining aspects of a criminal's behaviors are the individual's modus operandi (MO) and signature. The modus operandi consists of the steps the offender follows and the techniques and tools the offender uses when engaging in criminal activities. An offender's MO can evolve. In other words, an individual's criminal skills are honed and practices are modified with experience. As criminals become more seasoned, their MOs becomes more effective and efficient; they also become less likely to leave clues that will lead to their capture. An example of an MO is that of the serial rapist who uses burglary tools to pry open the bedroom windows of women sleeping in basement apartments. He wears gloves and thus never leaves fingerprints, and he enters and exits the apartment through the same window.

This serial rapist might also display a signature—an action taken not to accomplish the crime but to satisfy the perpetrator's distinctive and perverse psychological needs. For example, the bedroom rapist might force his victims to assume degrading poses while he photographs them following the act of sexual violence. Signatures are unique to specific offenders because they emerge from the offenders' idiosyncrasies and personal tendencies. MOs can be replicated by other offenders, but signatures cannot. Offenders who appropriate the MOs of fellow criminals are committing so-called copycat crimes. Signatures are often tied to the pathological sexual satisfaction that serial killers obtain from their offenses.

The second profiling task occurs after a prime suspect or person of interest has been identified. Knowledge about the alleged offender's belongings can reinforce other evidence that ties that person to the crimes. For example, some serial killers collect crime scene souvenirs, newspaper clippings, photographs, fetish items, pornography, or other materials that help them remember, relive, and re-create their crimes, providing them with prolonged sexual or other types of gratification. The items taken from crime scenes for these purposes are sometimes referred to as "trophies." Jeffrey Dahmer, for example, showcased the macerated skulls and bones of his victims in his apartment and consumed pieces of his victims' flesh to re-create the pleasure he received from sexually violating their corpses.

The third profiling task follows the arrest of the suspect. Based on inferences about the suspect's personality traits and psychological disturbances, the profiler guides the police in the selection of interrogation techniques that will best elicit incriminating information from the suspected offender. Different strategies must be implemented with consideration of each suspect's personality and psychological disorders. For example, with some offenders, unrelenting and aggressive questioning is most productive, whereas with others, a more relaxed and conversational tone is most likely to elicit confession. Still other serial offenders respond best in interrogation situations in which they perceive themselves, rather than the police investigators, as being in full control.

Pioneers in Profiling

Cesare Lombroso (1836-1909) was among the first criminal profilers. He and many of his contemporaries believed that criminals, unlike noncriminals, could be identified by physical characteristics such as bushy eyebrows or a receding chin. Early profilers also noted criminals' tendency to wear shabby clothes and to be tattooed. Dr. James Brussel, a New York-based psychiatrist and the first renowned profiler in the United States, was influenced by these theories in his work with the New York Police Department. From the late 1950's to the early 1970's, Brussel helped investigators track suspects in cases of serial bombing, arson, and murder. His most famous criminal personality profile, of the "Mad Bomber," was uncanny in its accuracy.

From 1940 to 1956, New York City was terrorized by a series of bombs planted randomly in crowded public places, such as busy streets, stores, and movie theaters. These actions were attributed to the ever-mysterious, paranoid, and elusive character the city's newspapers called the "Mad Bomber." Over the years, the bombs became deadlier, and the Mad Bomber's letters to the police and the news media, signed "F.P." for "Fair Play," became increasingly hostile and grandiloquent.

Profiling Serial and Mass Murderers

Given that every serial and mass murderer is unique, it can be dangerous to generalize about "typical" offenders. Nevertheless, multiple-murder offenders have many characteristics in common.

Trait	*Patterns*
Gender	Most offenders are male. Female serial killers occur, but they are much less common than male killers. Female mass murderers are extremely rare.
Race	Most offenders are white, but there are exceptions to this rule. For example, Wayne Williams, the Atlanta child killer of 1979-1981, was African American.
Age	Serial killers usually begin killing when they are in their twenties. Mass murderers are typically ten to twenty years older than that when they begin killing.
Intelligence	Serial killers are typically intelligent but often have experienced severe failures in their careers and personal lives. Mass murderers are often unemployed, sometimes losing their jobs only shortly before they begin killing.
Personal histories	Serial killers often display patterns of sociopathic behavior and may have histories of deviant sexual or violent behavior, including animal abuse. Mass murderers usually do not display such patterns.
Fantasy lives	Serial killers often fantasize about their crimes.
Alcohol and drugs	Serial killers sometimes use drugs or alcohol before or while committing their crimes. Mass murderers rarely do so.
Childhoods	Serial killers often have had miserable childhoods and have suffered physical or mental abuse. They may also have histories of serious head trauma and neurological disorders.
Military	Mass murderers often have served in the military.

Despite the diligent efforts of seasoned police officers and investigators, no viable clues brought authorities any closer to identifying a suspect and ending the terror. Frustrated with traditional police measures to catch the Mad Bomber, Inspector Howard Finney of the New York City Crime Lab suggested a radical approach. After one of the Mad Bomber's devices injured six patrons in a movie theater on December 2, 1956, Finney summoned Brussel and posed basic questions that the police had failed to answer in their work on the case: "What kind of demented person would hurt innocent people in such a horrific manner?" "What is motivating the Mad Bomber?" "Who is he and what is the best way to catch him?" With his impressive background as assistant commissioner of mental hygiene for the state of New York and head of the U.S. Army's Neuropsychiatry Unit during the Korean War as well as his training as a psychoanalyst, Brussel was dubbed by the press the "Sherlock Holmes of the couch."

Brussel pored over the police records of the bombings and developed the following criminal personality profile. The bomber was a man—historically, most bombers had been male. His letters suggested that he was a former employee of Consolidated Edison, the city's electric power company, and that he harbored a deep-seated grudge against the company for real or imagined injuries. The bomber was paranoid and believed that the electric company and the public were "out to get him." Brussel surmised that the bomber was approximately fifty years old because paranoid ideation peaks at the age of thirty-five and the bombings had been occurring for sixteen years. He also surmised from the bomber's carefully crafted letters and explosive devices that the bomber was a deliberate person who dressed fastidiously and was highly sensitive to criticism.

Brussel concluded from his analysis of the Mad Bomber's letters that the bomber was from Eastern Europe (a part of the world where bombs were weapons of choice) and self-educated. The postmarks on the letters suggested to Brussel that the bomber lived in Connecticut and commuted to New York City for the purpose of planting his bombs. Brussel guessed that the unknown suspect was unmarried and that he lived with his brothers or sisters; he further conjectured that the bomber had been unable to form mature relationships with women because he suffered from an "Oedipus complex."

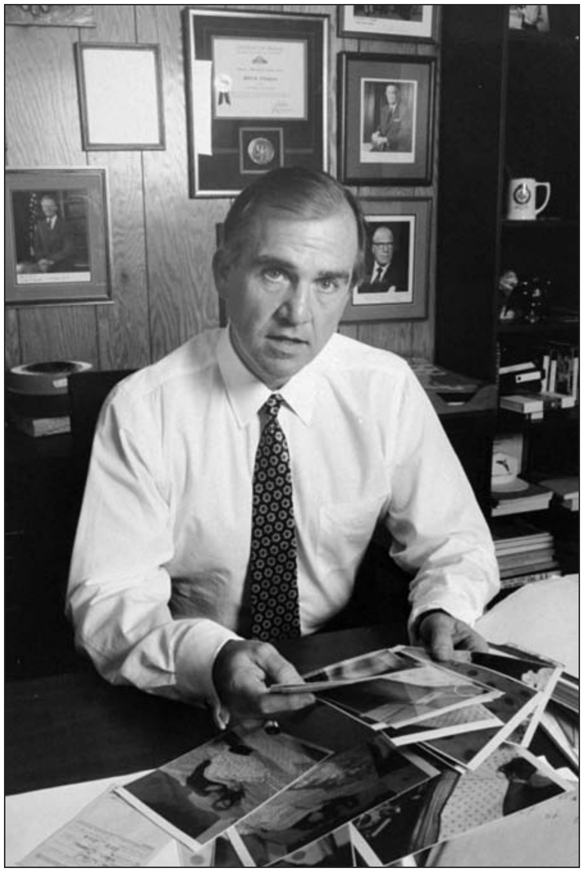
Brussel told the detectives that they should publicize his criminal personality profile of the Mad Bomber in order to antagonize the perpetrator and force him out into the open. He also instructed them to search the records of Consolidated Edison carefully for disgruntled former employees. Brussel's strategy worked. Soon after his profile was published in the newspapers, the Mad Bomber revealed his motive in a letter to the press: He had been injured on the job and believed the company was cheating him out of his worker's compensation payments. This revelation confirmed the bomber's identity and led to his capture.

The Mad Bomber was George Metesky. He lived in Connecticut with his two sisters. He was middle-aged, Slavic, and very well groomed. Before the detectives went to Metesky's home to place him under arrest, Brussel told them to expect Metesky to be wearing a double-breasted suit, buttoned. When the police took him into custody, he was indeed wearing a double-breasted suit—carefully buttoned. Metesky was found insane by the courts and was committed to the Matteawan Hospital for the Criminally Insane. In 1973, he was released and returned to his family home in Connecticut. In 1994, he died there quietly, and in obscurity, at the age of ninety.

Brussel attempted to systematize and standardize his profiling techniques, working with two agents of the Federal Bureau of Investigation (FBI), Howard Teten and Patrick J. Mullany. In the 1970's, they created a seminal course in applied criminology that helped to spawn the FBI's Behavioral Science Unit, later renamed the Behavioral Analysis Unit, which is now a part of the National Center for the Analysis of Violent Crime in Quantico, Virginia.

Types of Serial Criminals

Expert criminal personality profilers trained by the FBI have created several typologies or groupings of serial murderers. One scheme for categorizing these offenders focuses on their mobility. Geographically stable serial killers (examples include Ed Gein, Wayne Williams, and John Wayne Gacy) live in the same areas where they hunt for, kill, and bury their victims.



John Douglas in his office at the Federal Bureau of Investigation Training Facility in 1991. As an FBI agent, Douglas, along with agent Robert K. Ressler, developed one of the most widely known methods of criminal personality profiling. Douglas served as a consultant on the 1991 film *The Silence of the Lambs*, a thriller featuring an FBI profiler. *(Hulton Archive/Getty Images)*

Geographically transient serial killers (examples include Ted Bundy and Henry Lee Lucas), in contrast, move from place to place in search of victims and bury the bodies in areas that are distant from the killing sites. These killers travel to confuse law-enforcement authorities, and they are much less vulnerable to capture than geographically stable serial killers. Another categorization scheme differentiates among four types: visionary serial killers, who have serious mental illnesses and select victims by listening to auditory command hallucinations; mission serial killers, who are driven to murder certain types of people; hedonistic serial killers, who murder for sexual gratification; and power/control serial killers, who achieve sexual pleasure from dominating and controlling their victims.

One of the most widely known criminal profiling methods was developed by FBI agents John Douglas and Robert K. Ressler; their system categorizes serial killers on the basis of whether their crime scenes are organized or disorganized. Organized offenders are likely to be average or above average in intelligence, engaged in skilled occupations, married or living with partners, and interested in the media's coverage of their crimes. In contrast, disorganized offenders are likely to be below average in intelligence, socially awkward, living alone, and uninterested in the media's coverage of their crimes.

Caveats and Ethical Issues

Criminal personality profiling is more an art than a science. Profilers use a few general approaches that can be readily adapted to fit specific types of crimes, but no tried-and-true profiling techniques have been developed that work in every case. Instead, the formulas that profilers use are based largely on the particular circumstances of each case and the evidence at hand; these yield educated guesses derived from knowledge, practical experience, and clinical acumen.

Despite the fact that profiling has often been glamorized or sensationalized in novels, films, and television programs, it is only one component in a wide range of strategies used by law-enforcement agencies to apprehend serial offenders. Profiling is an adjunctive tool that supplements and complements the investigatory activities of experienced law-enforcement officers. Profilers are consultants to the police; they are generally summoned after officers have failed in their attempts to identify or question suspects. Profilers must be careful not to oversell their capabilities.

Many experienced homicide investigators regard criminal personality profiling with skepticism and disdain. The field is without a sound scientific basis and relies on weak standards of proof, although psychologists have begun to conduct more research on the validity of profiling techniques. The field of profiling is also lacking in professional standards and minimal educational requirements, and no credentialing bodies exist to govern and oversee the conduct of practitioners. Profilers have an ethical obligation to be unbiased and impartial in their collection and interpretation of evidence, to restrict their opinions to the specific facts of the case, to present their qualifications honestly and openly, and never to use a profile to assert the guilt or innocence of any suspect.

Arthur J. Lurigio

Further Reading

Brussel, James. *Casebook of a Crime Psychiatrist*. New York: Bernard Geis, 1968. Classic volume presents case studies drawn directly from Brussel's files. A must-read for profiling enthusiasts.

Hickey, Eric. *Serial Murderers and Their Victims*. Belmont, Calif.: Wadsworth, 2002. Offers an extensive account of serial murder that is grounded in social science research. Examines the lives of four hundred serial murderers and attempts to explain their behaviors from biological, psychological, and sociological perspectives.

Holmes, Ronald, and Stephen Holmes. *Profiling Violent Crime: An Investigative Tool*. Thousand Oaks, Calif.: Sage, 1996. Solid introductory text on profiling presents the principles and techniques that investigators employ in developing the profiles of violent criminals.

Petherick, Wayne. *Serial Crime: Theoretical and Practical Issues in Behavioral Profiling*. Burlington, Mass.: Academic Press, 2006.

Text designed for advanced students is divided into two sections, one on behavioral profiling—including its theoretical foundations and history as well as discussion of media depictions—and one on specific serial crimes, including arson, murder, rape, and stalking.

Turvey, Brent E. *Criminal Profiling: An Introduction to Behavioral Evidence Analysis*. San Diego, Calif.: Academic Press, 2002. A definitive source of information on deductive profiling methods. Describes crime scene reconstruction techniques as well as procedures for the collection and analysis of evidence.

See also: Bite-mark analysis; Crime scene investigation; Criminology; *Diagnostic and Statistical Manual of Mental Disorders*; Federal Bureau of Investigation Forensic Science Research and Training Center; Forensic psychiatry; Forensic psychology; Geographic profiling; Minnesota Multiphasic Personality Inventory; Police psychology; Psychopathic personality disorder; Questioned document analysis; *Silence of the Lambs, The*; Unabomber case.

Criminalistics

Definition: Use of scientific principles in the evaluation of physical evidence to detect, analyze, and solve crimes.

Significance: Criminalists work in various professional settings, but they have a common goal: To use the evidence from crime scenes to tell the stories of what happened there in order to link offenders with crime victims and scenes. Criminalists analyze and interpret various forms of physical evidence and then disseminate their findings in reports that can be used by law-enforcement officers, lawyers, judges, and juries.

The term "criminalistics" is often used interchangeably with "forensic science," and criminalistics may be broadly interpreted as the science of policing or the profession of forensic science. A narrower definition of criminalistics, however, focuses on the use of scientific principles in the evaluation of physical evidence of crimes. Science has an important role to play in the criminal justice system, and this role continues to develop and change as technology advances and improves the techniques available for investigating crimes. Criminalistics is a broad field that incorporates the use of the scientific method in the processing of evidence and the investigation of crimes.

The practitioners of criminalistics, known as criminalists, work in many different settings and in a variety of professions. Some work in crime labs as medical professionals, dentists (forensic odontologists), chemists, toxicologists, biologists, geneticists, physicists, geologists, or anthropologists, whereas others work as researchers in university settings. Generally, criminalists have some specialized training in science as it is applied to the recognition, collection, analysis, and preservation of physical evidence from crime scenes. Criminalists may also be found in courtrooms as expert witnesses, providing testimony to help juries understand the science behind particular findings concerning evidence.

Work of Criminalists and Criminologists

The discipline of criminalistics is often confused with the discipline of criminology, but the two differ in several ways. Although both criminalists and criminologists seek to understand the patterns and truth behind criminal activities, they use different approaches and ultimately have different goals. Criminalists seek to examine evidence in order to detect class and individual characteristics. The ultimate goal of a criminalist is to link three things: a victim, a crime scene, and an offender. The physical evidence that may be found at a crime scene may be invisible to the naked eye, such as fingerprints; it may be minute trace evidence, such as fibers from the clothing or the environment of the offender; or it may be as obvious as a body and a pool of blood. The job of the criminalist is to uncover the story that the evidence has to tell.

The investigative tasks in which criminalists are involved are widely varied. For example, a criminalist in a crime lab may examine the chemistry of inks in a threatening letter to identify the types of materials used in an effort to determine the origin of the letter. Another criminalist may apply techniques of forensic chemistry to understand the use of drugs in a homicide investigation. Yet another may examine fragments of a broken taillight from a hit-and-run accident, with the goal of identifying class characteristics that can be used to identify the type of vehicle from which the taillight came. In such a case, the criminalist's next job may be to look for individual characteristics in the evidence that could link it to a specific vehicle.

Criminologists are also interested in understanding why and how crime occurs, but they do not usually examine and evaluate the physical evidence left at crime scenes to try to link crimes to specific persons or specific groups. Rather, criminologists examine psychological and sociological causes of crime, such as mental illness, low cognitive abilities, certain personality traits, socioeconomic disadvantage, poor neighborhood conditions, and dysfunctional families. Criminologists often try to understand why crime occurs and attempt to predict who is at risk to engage in criminal endeavors by finding patterns in offending. They use various methods to achieve these ends, including survey research methods and statistical analyses.

Criminalists ask questions, examine patterns, and analyze evidence to answer legal questions. In other words, the starting point for the criminalist is to translate legal questions into scientific research questions. The goal is to use the evidence to formulate hypotheses and test the research questions. The evidence and the questions vary depending on the crime scene, but the goal remains the same: to disseminate the findings in reports that can be used by law-enforcement officers, lawyers, judges, and juries.

Stephanie K. Ellis

Further Reading

Barnett, Peter D. *Ethics in Forensic Science: Professional Standards for the Practice of Criminalistics*. Boca Raton, Fla.: CRC Press, 2001. Examines various ethical scenarios in light of the codes of ethics of the most prominent professional organizations for criminalists in the United States.

Eckert, William G., ed. *Introduction to Forensic Sciences*. 2d ed. Boca Raton, Fla.: CRC Press, 1997. Textbook intended for students considering careers in the forensic sciences includes discussion of all aspects of criminalistics.

Fisher, Barry A. J. *Techniques of Crime Scene Investigation*. 7th ed. Boca Raton, Fla.: CRC Press, 2004. Comprehensive work provides an overview of the uses of the forensic sciences, particularly in criminal investigations.

Gaensslen, R. E., Howard A. Harris, and Henry C. Lee. *Introduction to Forensic Science and Criminalistics*. New York: McGraw-Hill, 2008. Covers the types of forensic science techniques used in crime laboratories as well as those employed by private examiners in civil cases. Discusses various crime scene procedures and analyses.

Girard, James E. *Criminalistics: Forensic Science and Crime*. Sudbury, Mass.: Jones & Bartlett, 2008. Examines the procedures that criminalists undertake at crime scenes and in laboratories. Explains scientific concepts clearly for readers with no background in chemistry or biology.

Inman, Keith, and Norah Rudin. *Principles and Practice of Criminalistics: The Profession of Forensic Science*. Boca Raton, Fla.: CRC Press, 2001. Addresses the interpretation of various kinds of evidence, with a focus on best practices in the forensic science profession.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007. Comprehensive introductory textbook provides in-depth discussion of the activities carried out by criminalists.

See also: American Academy of Forensic Sciences; Crime laboratories; Crime scene investigation; Criminology; Forensic anthropology; Forensic entomology; Forensic geoscience; Forensic nursing; Forensic odontology; Forensic pathology; Forensic photography; Forensic toxicology; Living forensics; Locard's exchange principle; Medicine.

Criminology

Definition: Scientific study of crime and criminal behavior.

Significance: Criminologists examine how people interact with the criminal justice system. They also study crime victims to understand why offenders target them and what risk factors increase the likelihood of victimization. The research that criminologists conduct into the causes of crime and social deviance assists with the classification and treatment of offenders as well as the identification of forensic evidence in relation to crime.

More than two hundred years ago, two utilitarian philosophers, Cesare Beccaria (1738-1794) and Jeremy Bentham (1748-1832), studied human behavior. They asserted that human beings conduct cost-benefit analyses regarding their future behavior and then act out of greed and personal need. The theory now known as classical criminology is based on these premises: Potential criminal offenders have the free will to choose to act, and in making their decisions they compare risks to possible gains.

Although this theory lost popularity to newer theories over time, it has seen a resurgence in recent decades. Routine activities theory, for example, is a perspective in criminology that attempts to use deterrence theory to explain crime (and the treatment of criminal behavior). According to routine activities theory, in order for a crime to occur, three elements must be in place at the same time: someone who is motivated to commit that crime, a target worthy of victimizing, and the lack of a capable person to protect that target.

A potential criminal is less likely to victimize someone who has no money or material goods, or to victimize a person who is walking with a group of other people. Such circumstances should deter someone from committing a crime because they decrease the offender's chances of financial gain and increase the offender's chances of being caught, hurt, or identified. To design successful punishments based on deterrence theory, however, criminologists would need to prove that all criminals are rational human beings, that they think about the consequences of their actions, and that they actually believe they could be caught.

Challenges to Classical Criminology

Several criticisms have been directed toward classical criminology and deterrence theory. First, many offenders commit crimes under conditions that make it likely for them to be caught (that is, witnesses or victims can identify them). Second, most offenders know the risks involved (arrest, jail time, loss of the respect of friends and family) when they commit crimes. Further, some criminals do know the difference between right and wrong, but they nevertheless cannot stop themselves from committing crimes; mental illness or very low IQ, for example, might prevent some from understanding the consequences of certain behaviors.

Given the shortcomings of classical criminology and deterrence theory, some criminologists have suggested other explanations for criminality. For example, some theorists believe that the behavior of offenders is not something that can be controlled. Instead, factors beyond these individuals explain why they would commit crimes under less-than-ideal circumstances. These theories are part of the positivist school of criminology.

Positivist Criminology and Other Theories

In the nineteenth century, Cesare Lombroso (1836-1909), known as the father of positivist criminology, developed a theory of criminal behavior related to his medical research. As a doctor, he had noted similar physical characteristics among delinquents. He asserted that criminals exhibited apelike physical traits and that they were biologically and physiologically similar to the primitive ancestors of humans. Some criminologists and other theorists postulated that psychological problems (such as personality disorders) caused criminal behavior. Sigmund Freud (1856-1939), the founder of psychoanalysis, believed that human behavior was controlled by unconscious processes.

Criminologists have also examined how environmental factors play a role in predicting criminality. Sociological explanations of crime focus on social structure, culture, poverty rates, racial disparities, and neighborhood instability in relation to criminal behavior. They also examine community changes, the strength and weakness of social controls, and the role of the family, school, peers, and religion in explaining behavior. All of these theories blame criminality on factors outside of offenders' control.

Criminologists have developed many competing theories that attempt to explain why crime happens and what the relationships are among offenders, victims, and the criminal justice system. Each theory has merit, yet a single explanation is insufficient, in part because each criminal is unique—an individual with a particular past and a person who may or may not have a conscience. Just as experts continue to debate the role of nature versus nurture in shaping human behavior, arguments continue between classical and positivist theorists in criminology. At the same time, some criminologists are attempting to develop integrated theories that combine some of the characteristics of both to explain criminal behavior.

Gina M. Robertiello

Cesare Lombroso, known as the father of positivist criminology, developed a theory that related criminal behavior to physical traits. (The Granger Collection, New York)

Further Reading

Cohen, Albert K. *Delinquent Boys: The Culture of the Gang*. New York: Free Press, 1955. Early study explains class differences in expectations of boys and asserts that lower-class boys have less ability to defer gratification than do middle-class boys.

Cohen, Lawrence E., and Marcus Felson. "Social Change and Crime Rate Trends: A Routine Activity Approach." *American Sociological Review* 44 (1979): 588-608. Explains how people's everyday behaviors can increase their likelihood of becoming crime victims.

Cullen, Francis T., and Robert Agnew, eds. *Criminological Theory: Past to Present—Essential Readings*. 3d ed. Los Angeles: Roxbury, 2006. Collection of writings brings together past theories on crime and criminology and reports of more recent research in this field.

Merton, Robert K. "Social Structure and Anomie." *American Sociological Review* 3 (1938): 672-682. Classic article on strain theory as an explanation of criminal behavior provides a sociological viewpoint. Asserts that criminal offenders develop adaptations to the strain of their lack of opportunity to reach universal norms.

Shaw, Clifford R., and Henry D. McKay. *Juvenile Delinquency and Urban Areas: A Study of Rates of Delinquency in Relation to Differential Characteristics of Local Communities in American Cities*. Rev. ed. Chicago: University of Chicago Press, 1969. Addresses the ecology of crime, specifically focusing on the geographic locations of cities' central business districts in relation to where crime occurs.

Vito, Gennaro F., Jeffrey R. Maahs, and Ronald M. Holmes. *Criminology: Theory, Research, and Policy*. 2d ed. Sudbury, Mass.: Jones & Bartlett, 2007. Comprehensive text discusses the criminological theories of the past as well as modern theories and reviews the research conducted on these theories.

Winslow, Robert W., and Sheldon X. Zhang.

Criminology: A Global Perspective. Upper Saddle River, N.J.: Pearson Prentice Hall, 2008. Provides in-depth information on the field of criminology across the United States and internationally.

See also: Criminal personality profiling; Criminalistics; Drug abuse and dependence; Federal Bureau of Investigation; Forensic psychiatry; Forensic psychology; Geographic profiling; Insanity defense; Irresistible impulse rule; *Mens rea*; Police psychology; Psychopathic personality disorder; Racial profiling; Victimology.

Croatian and Bosnian war victim identification

Date: Began in 1996

The Event: Forensic scientists have been involved in ongoing efforts to identify the bodies of victims of genocide recovered from mass graves in Croatia and Bosnia and Herzegovina.

Significance: The deaths of thousands of individuals in the former Yugoslavia during the 1990's presented a daunting victim identification task for forensic scientists. Despite a number of factors hindering identification efforts, progress has been made, in large part owing to the work of the International Commission on Missing Persons, which established a program to collect DNA samples from living relatives of the missing.

The wars that took place in the former Yugoslavia in the period 1991-1995 resulted in the disappearance of an estimated forty thousand individuals from Croatia and Bosnia and Herzegovina alone. Many of those who disappeared were executed in acts of genocide and buried in mass graves throughout the countryside. In 1996, forensic scientists began the task of locating these clandestine grave sites and identifying the victims. Since that time, thousands of individuals have been excavated from

Forensic experts work on the collection of human remains at the site of a mass grave in a Bosnian village in July, 2006. This site is considered to be a secondary grave in which more than two hundred bodies that had been initially buried elsewhere were later dumped. *(AP/Wide World Photos)*

mass graves and their remains have been examined for purposes of identification and determination of the cause and manner of death. Law-enforcement investigators, pathologists, anthropologists, archaeologists, odontologists, radiologists, and database technicians have worked collaboratively in the identification process.

Identification

A number of agencies have played important roles in the efforts to identify genocide victims from Bosnia and Herzegovina and Croatia, including Physicians for Human Rights (PHR), the United Nations International Criminal Tribunal for the former Yugoslavia (UN-ICTY), the Bosnia State Commission on Missing Persons, and the International Commission on Missing Persons (ICMP). Much of the effort of the UN-ICTY has involved the documentation of genocide and has focused on the use of forensic evidence from mass graves in the prosecution of war criminals. Other agencies have placed greater emphasis on identification of remains and the return of those remains to living relatives.

A number of factors have hindered efforts to identify the bodies found in the mass graves of the former Yugoslavia. For one thing, antemortem (before death) medical and dental records for comparison to the bodies are nonexistent or difficult to find for most of the missing, unlike in the United States and Western Europe, where such records, along with fingerprints, are commonly used in the positive identification of remains. The unidentified population is also relatively homogeneous—the majority of the victims are young to middle-aged adult males. Further, methods for estimating age at death and stature from skeletal remains are often based on North American standards, which are inappropriate for Balkan populations; forensic anthropological assessments are thus limited.

For some time, the teams working on identifying the genocide victims relied heavily on clothing and personal effects (such as identification cards and religious items) found with the bodies in making presumptive identifications. It became increasingly apparent, however, that this method could lead to misidentifications, as the clothing and personal effects associated with remains may not have belonged to the deceased. Another hindrance to identification of remains has been the fact that many mass graves have been disturbed by human scavengers; as these grave robbers attempted to hide some remains in secondary locations, they created large-scale commingling of remains of individuals and also separated some intact bodies into multiple body parts.

International Commission on Missing Persons

In 1996, the ICMP was established to develop an antemortem database of missing persons that could be compared against postmortem records of unidentified remains. This effort, which is ongoing, requires that the ICMP develop close working relationships with the families of the missing; since 1999, this has included the widespread collection of DNA (deoxyribonucleic acid) samples from living relatives of missing persons. Because nuclear DNA is often degraded in the decomposed remains taken from mass graves, mitochondrial DNA (mtDNA), which is more abundant in the cell and less susceptible to degradation, is often used for identification. This type of DNA is inherited along the maternal line, so samples taken from unidentified remains can be matched only to relatives who share the same maternal mtDNA as the victim. DNA analysis has been essential in the identification of victims of the massacre that took place in the Bosnia and Herzegovina town of Srebrenica in July of 1995, in which approximately eight thousand Bosniak (Bosnian Muslim) men died.

The ICMP considers DNA testing the gold standard for positive identification; over time, the organization has placed decreasing emphasis on presumptive methods of identification. After the ICMP began its DNA program, the numbers of persons identified increased dramatically; in 2002 alone, approximately twelve hundred individuals were identified, more than a tenfold increase over the numbers identified in all the previous years combined. New developments in DNA technology continue to provide the best avenue for identification of remains in Bosnia and Herzegovina and Croatia, where traditional methods have had limited success. However, forensic archaeologists, anthropologists, and pathologists continue to play pivotal roles in the meticulous excavation of remains recovered from mass graves, in the sorting of commingled remains from primary and secondary grave sites, and in the assessment of the circumstances surrounding death.

Eric J. Bartelink

Further Reading

Haglund, William D. "Recent Mass Graves: An Introduction." In *Advances in Forensic Taphonomy: Method, Theory, and Archaeological Perspectives*, edited by William D. Haglund and Marcella H. Sorg. Boca Raton, Fla.: CRC Press, 2002. Comprehensive overview for forensic professionals addresses the issues involved in body identification in cases of mass graves and war crimes investigations; focuses on the former Yugoslavia.

Komar, Debra A. "Lessons from Srebrenica: The Contributions and Limitations of Physical Anthropology in Identifying Victims of War Crimes." *Journal of Forensic Sciences* 48, no. 4 (2003): 1-4. Offers an illuminating discussion of the prospects and challenges of the use of anthropological methods in the identification of victims from Srebrenica, Bosnia.

Simmons, Tal. "Taphonomy of a Karstic Cave Execution Site at Hrgar, Bosnia-Herzegovina." In *Advances in Forensic Taphonomy: Method, Theory, and Archaeological Perspectives*, edited by William D. Haglund and Marcella H. Sorg. Boca Raton, Fla.: CRC Press, 2002. Penetrating discussion for forensic professionals addresses the investigation of execution and disposal sites of genocide victims in Bosnia-Herzegovina.

Skinner, Mark F., and Jon Sterenberg. "Turf Wars: Authority and Responsibility for the Investigation of Mass Graves." *Forensic Science International* 151 (2005): 221-232. Discusses the ethics, professionalism, and responsibility of forensic scientists in relation to human rights investigations. Also addresses the challenges faced by forensic teams composed of individuals from a wide variety of backgrounds.

Skinner, Mark F., Heather P. York, and Melissa A. Connor. "Postburial Disturbance of Graves in Bosnia-Herzegovina." In *Advances in Forensic Taphonomy: Method, Theory, and Archaeological Perspectives*, edited by William D. Haglund and Marcella H. Sorg. Boca Raton, Fla.: CRC Press, 2002. Discussion aimed at forensic professionals focuses on the challenges associated with the investigation of primary and secondary mass graves in Bosnia-Herzegovina.

Williams, Erin D., and John D. Crews. "From Dust to Dust: Ethical and Practical Issues Involved in the Location, Exhumation, and Identification of Bodies from Mass Graves." *Croatian Medical Journal* 44, no. 3 (2003): 251-258. Discusses the ethics and responsibility of forensic professionals working on human rights investigations. Addresses forensic, cultural, and psychological aspects related to genocide investigations.

See also: Argentine disappeared children; Asian tsunami victim identification; Beslan hostage crisis victim identification; Buried body locating; Ethics; Expert witnesses; Forensic anthropology; Forensic archaeology; Genocide; Mass graves; Skeletal analysis; Taphonomy.

Cross-contamination of evidence

Definition: Failure to preserve the purity or exclusivity of physical evidence related to a crime scene through the introduction of transferred materials from other sections of the crime scene, various related crime scenes, or other sources.

Significance: Crime scenes yield evidence that can link suspects, victims, and the actions of persons present when the crimes occurred. The collection and preservation of evidential materials without cross-contamination is thus crucial, as incorrect conclusions may be drawn from contaminated evidence.

Forensic investigation of a crime scene relies on Locard's exchange principle, which states that when two objects come in contact, they exchange trace evidence. A crime scene thus contains evidence that may place a suspect at the scene, and analysis of that evidence may reveal the associations between perpetrator and crime that are necessary for a prosecutor to obtain a conviction in a court of law. Evidence may also refute theories that link a suspect to a crime and thus may exonerate the innocent.

The methods used in the collection and preservation of evidence are intended to ensure that the preserved materials did originate from the crime scene, that the materials are pertinent to the crime, and that the materials can be analyzed in a comparable state to the way they were found at the scene. Cross-contamination of evidence results from the failure to protect an evidence sample from the transfer of other material onto or into it. Evidence may become cross-contaminated at the crime scene during collection and packaging of evidential materials, during transportation to laboratories or other facilities, during storage, or while it is undergoing analysis.

At the crime scene, cross-contamination of evidence is most likely to occur when the actions of first responders and others moves materials such as hairs, fibers, and fluids around the scene. Evidence may also be compromised by cross-contamination when investigators do not use crime scene protective gear or use such gear improperly, resulting in their leaving their own fingerprints, hair, and fluids at the scene. Also, when investigators leave the crime scene to search related areas (such as a suspect's car), evidence may be transferred from one scene to the other, resulting in cross-contamination.

Materials other than the evidential materials gathered at the crime scene may cause cross-contamination if the evidence samples are not properly packaged and safeguarded during transportation to labs or other locations. In addition, evidence must be stored properly and protected while it is being analyzed or tested to prevent cross-contamination.

Taylor Shaw

Further Reading

Genge, N. E. *The Forensic Casebook: The Science of Crime Scene Investigation*. New York: Ballantine, 2002.

Pentland, Peter, and Pennie Stoyles. *Forensic Science*. Philadelphia: Chelsea House, 2003.

Platt, Richard. *Crime Scene: The Ultimate Guide to Forensic Science*. New York: Dorling Kindersley, 2003.

See also: Accident investigation and reconstruction; Crime scene investigation; Crime scene protective gear; Disturbed evidence; DNA extraction from hair, bodily fluids, and tissues; Evidence processing; First responders; Locard's exchange principle; Physical evidence; Quality control of evidence; Trace and transfer evidence.

Cryptology and number theory

Definitions: Cryptology is the scientific study of the hiding, disguising, or encryption of messages. Number theory is the branch of mathematics that is concerned with the properties of the positive integers.

Significance: Computer security experts use public-key cryptography to ensure the confidentiality of electronically transmitted messages through encryption and the integrity of messages with digital signatures. Cryptology is an important part of investigations regarding attempts by computer hackers to decrypt messages or modify digital signatures. Hackers sometimes use public-key encryption to hide attacks, such as Trojan horses, and forensic analysis techniques have been developed to detect such attempts.

Cryptology encompasses both cryptography, the hiding of messages, and cryptanalysis, the revealing of hidden messages. Number theory is involved in cryptography in many ways, but its most important use is in public-key encryption.

A number of computationally intensive algorithms exist in number theory, one of which is factoring the product of two large prime numbers. In 1978, Ron Rivest, Adi Shamir, and Leonard Adleman published a public-key encryption algorithm named RSA (from the initials of the inventors' last names) that uses the difficulty of factoring large numbers to protect the value of a private key. RSA has been used to encrypt electronic files to ensure their confidentiality and to create digital signatures for e-mail to ensure its integrity.

When computer hackers want to see encrypted files, they often devise attacks to steal the receivers' private keys, which will allow them to decrypt the files. When such attacks occur, forensic experts can use tools designed to detect the attacks; similar tools are available to defend against such attacks. Hackers recognize that digital signatures can be used to guarantee the integrity of e-mail. They often intercept e-mail messages, modify the contents, and then attach invalid signatures. The hackers then have to ensure that the receivers use fake public keys to check the signatures. One way hackers could do this would be by replacing certificate authorities' public keys in the recipients' e-mails. Antivirus software can protect against this kind of attack by performing its usual checks of e-mail.

Encryption and Number Theory

Encryption is the process of using a key to transform a readable plaintext message into an unreadable ciphertext message. Decryption reverses encryption to recover the plaintext message. When the encryption and decryption key are the same, the encryption is described as algorithm-symmetric. Although symmetric algorithms are complex, they do not use much number theory.

Public-key encryption algorithms, which are often based on number theory, use different keys for encryption and decryption. The most famous public-key encryption algorithm, RSA, selects two large prime numbers (a prime number is divisible only by one and by itself) and forms a modulus, n, as their product. The modulus n is too large to be factored. The ciphertext message, C, is created by raising the integer value of the plaintext message, M, to the power e modulo n, and the plaintext message is recovered from C by raising C to the power d modulo n. The public key is the pair (e, n) and the private key is the pair (d, n).

RSA is widely used for encrypting files and signing messages. It has proven to be very resistant to brute-force attacks on the private keys. A major part of the RSA scheme involves creation of the private keys and the safe distribution of the corresponding public keys. Usually, the private key is safely transmitted to its owner by a trusted public-key infrastructure (PKI) vendor who then uses digital certificates, which contain the owner's public key and are signed by the PKI vendor, to distribute the public key.

Computer Hacking and Encryption

In 1976, Whitfield Diffie and Martin Hellman developed an algorithm that allowed two people to create a shared symmetric key. The algorithm is similar to the RSA public-key algorithm and makes considerable use of modular exponential arithmetic. To create the shared symmetric key, each person involved uses a secret number that never leaves his or her computer but generates the shared secret key as the result of several data exchanges. If a hacker knows that a purchaser and an online store are generating a symmetric key with the Diffie-Hillman key exchange, the hacker could drop a Trojan horse into the purchaser's computer, capture the secret information, and then masquerade as the purchaser to buy items for personal gain. In investigating such an attack, a forensic expert could log into the purchaser's computer and check to see if the Trojan horse is still there; if it is, it might provide information on the location of the hacker.

Hackers can gain access to other people's computers in a number of ways, not the least of which is through Web browsers. When they gain access, they often try to leave files that con-

Early Cryptographers

Julius Caesar is generally recognized as the earliest military leader to utilize ciphers to encrypt and decode messages. His ciphering system became the basis for many more advanced ciphers in later centuries. Eventually, mechanical devices were invented to make encryption and decryption faster and easier. In the late eighteenth century, Thomas Jefferson invented a drumlike device that was used to encode and decode messages. During World War II, the Enigma machine, a brilliant conception of the German military, was used to add complexity to codes. Enigma's scheme was eventually broken, first by Polish mathematicians suspicious of the intentions of Germany's Nazi rulers. The Polish then shared their knowledge with the French and British. None of these early pioneers in cryptology could have envisioned the impacts that computers would have on the necessity for systems of covert communication to be used not only in wars and by spies but also by average people in daily life.

Heidi V. Schumacher

tain worms, Trojan horses, or viruses. Given these threats, computers have become increasingly well equipped with antivirus software that is designed to protect users from such attacks. One of the most important techniques used by antivirus software is to check all files and quarantine any files that look suspicious. A clever trick used by modern hackers is to encrypt attack files with private RSA keys so that the files are not detected by antivirus software. This allows the hackers to return later, decrypt the files, and carry out their intended attacks. Web browser helper objects are especially susceptible to this kind of delayed attack. Increasingly sophisticated forensic software has been developed to catch multilevel attacks of this type.

George M. Whitson III

Further Reading

Hellman, Martin. "An Overview of Public Key Cryptography." *IEEE Communications Magazine*, May, 2002, 42-49. Very good survey article provides basic information. Written by one of the founders of the field of public key encryption.

Mandia, Kevin, Chris Prosise, and Matt Pepe. *Incident Response and Computer Forensics*. 2d ed. Emeryville, Calif.: McGraw-Hill/Osborne, 2003. Includes several chapters on incident response to cryptology attacks.

Shieneier, Bruce. "Inside Risks: The Uses and Abuses of Biometrics." *Communications of the ACM* 42 (November, 1999): 136. Brief but informative article describes methods of defeating encryption by subversion.

Shinder, Debra Littlejohn. *Scene of the Cybercrime: Computer Forensics Handbook*. Rockland, Mass.: Syngress, 2002. Bridges the gap between the computer professionals who provide the technology for cybercrime investigations and the law-enforcement professionals who investigate the crimes.

Vacca, John R. *Computer Forensics: Computer Crime Scene Investigation*. 2d ed. Hingham, Mass.: Charles River Media, 2005. Provides a good introduction to computer forensics. Devotes several chapters to cryptology forensics.

Yan, Song Y. *Cryptanalytic Attacks on RSA*. New York: Springer, 2008. Covers most of the known cryptanalytic attacks and defenses of the RSA cryptographic system. Also provides a good introduction to the use of number theory in the RSA encryption algorithm.

See also: Computer crimes; Computer forensics; Computer hacking; Computer viruses and worms; Crime scene search patterns; Electronic voice alteration; Internet tracking and tracing; Steganography.

CSI: Crime Scene Investigation

Date: First aired on October 6, 2000

Identification: Popular television series involving a team of crime scene investigators who solve unusual crimes through the collection of physical evidence and analysis of this evidence using technologically advanced forensic procedures.

Significance: The original *CSI: Crime Scene Investigation* television series and its two spin-offs (*CSI: Miami* and *CSI: NY*) are very popular both within and outside the United States. Some criminal justice authorities and legal scholars have voiced concern that exposure to these shows has generated unrealistic expectations in the general public about the collection and forensic analysis of crime-related evidence. This phenomenon is commonly referred to as the "*CSI* effect." Although the existence of such an effect has not been confirmed by systematic research, anecdotal evidence of the *CSI* effect has been widely shared among legal authorities, and concerns regarding the television programs' negative impact continue to be a topic for discussion and debate.

CSI: Crime Scene Investigation is a television crime drama that depicts how a team of crimi-

Crime scene investigators Catherine Willows (Marg Helgenberger) and Gil Grissom (William Petersen) examine evidence in an episode of *CSI: Crime Scene Investigation. (Ron Jaffe/CBS/Landov)*

nal investigators solve crimes by gathering and examining forensic evidence using technically advanced methods and tools. Created by Anthony E. Zuiker, the original *CSI* debuted in 2000 and soon became one of the most-watched crime dramas on television. The show's popularity can be attributed to its fresh and modern portrayal of criminal investigation. What made *CSI* different from traditional police shows of the past was its story lines, which focus more on the "how" of crime than on the "who." The popularity of *CSI* eventually led to two spin-off series, *CSI: Miami* began airing in 2002 and *CSI: NY* in 2004. Both of these programs follow the same premise: a team of crime scene investigators solve crimes through the collection and examination of forensic evidence. By 2007, the original *CSI* was being aired in two hundred countries and was watched by an estimated two billion viewers. In addition to the two spin-off television series, *CSI* spawned comic books, novels, and computer games.

Examples of Forensic Evidence

CSI episodes depict many different types of physical evidence that can be collected at crime scenes as well as the various tools and procedures that can be used to analyze such evidence. The types of physical evidence that can be collected from crime scenes vary greatly and depend heavily on location and type of crime. For example, the physical evidence available for collection at the scene of a robbery is quite different from that available at a murder scene. Physical evidence might include marks on a victim's body, such as abrasions or bite marks. Fingerprints on a door or a window frame also constitute physical evidence, as does blood left behind by a likely perpetrator. Trace evidence is a type of physical evidence that can be collected and forensically examined; this kind of evidence is commonly depicted in *CSI* episodes. Trace evidence is found when a small amount of material has transferred from either one location or person to another location or person. Examples of trace evidence include gunshot residue and fibers from clothing or carpeting.

Just as many types of physical evidence can be found at crime scenes, forensic scientists use many different tools and procedures to examine and test physical evidence. The tools of crime scene investigators may range from the brushes used to apply powder to fingerprint areas to the zNose, an "electronic nose" that has the ability to detect and identify different types of gases and vapors. Crime scene investigators use a number of different tools to collect blood samples, fiber samples, tire impressions, shoe impressions, and bite marks. These and many other types of tools allow for the identification and collection of potentially important samples of physical evidence. By collecting and testing samples from crime scenes, forensic scientists help to piece together the events that took place there, which can lead to the identification of the perpetrators.

The Impact of *CSI*

In the television world, crime scene investigators have a variety of responsibilities in addition to the collection and analysis of the physical evidence found at crime scenes. On *CSI* they also interview witnesses, victims, and suspects. If the forensic evidence reveals an individual's guilt, the crime scene investigators are involved in tracking down, confronting, and arresting the perpetrator. These dramatic embellishments of the role of crime scene investigators and their use of forensic evidence have generated a great deal of concern and debate among legal authorities. This concern is directed at the possibility that *CSI* and similar shows have created unrealistic expectations among viewers and the general public regarding how forensic evidence is used in the criminal justice system, and these expectations may have repercussions in the courts. For example, when *CSI* viewers serve on juries, they may expect all types of forensic evidence, specifically DNA evidence, to be presented during trial, and they may expect this evidence to be conclusive in revealing the guilt or innocence of defendants. This potential problem is popularly referred to as the *CSI* effect.

Although this topic has received a great deal of attention, the existence of the *CSI* effect has yet to be confirmed. Despite many anecdotal reports from prosecuting attorneys and other legal authorities, no systematic empirical research has proven that the *CSI* effect has had any real impact on legal proceedings. In another way, however, *CSI* and similar television programs have had a clear impact: After they began to air, forensic science programs across the United States experienced noticeable increases in applications.

Erin J. Farley

Further Reading

Cather, Karin H. "The *CSI* Effect: Fake TV and Its Impact on Jurors in Criminal Cases." *The Prosecutor* (National District Attorneys Association), March/April, 2004, 9-15. Presents interviews with attorneys to show support for the seriousness of the concept of the *CSI* effect.

Genge, N. E. *The Forensic Casebook: The Science of Crime Scene Investigation*. New York: Ballantine, 2002. Good source for an overall description of different kinds of crime scene investigators and their job responsibilities.

Marrinan, Corinne, and Steve Parker. *Ultimate "CSI: Crime Scene Investigation."* New York: Dorling Kindersley, 2006. Discussion of *CSI* focuses on how forensic evidence and techniques have been used on the program.

Podlas, Kimberlianne. "'The *CSI* Effect': Exposing the Media Myth." *Fordham Intellectual Property, Media, and Entertainment Law Journal* 16 (Winter, 2006): 429-465. Presents findings of a research study that call into question the existence of the *CSI* effect.

Ramsland, Katherine. *The "C.S.I." Effect*. New

York: Berkley Books, 2006. Not a critical discussion of the so-called *CSI* effect but rather a discussion of how various types of forensic evidence are used in real criminal investigations, with a focus on demystifying forensic processes and technologies. Features examples from the *CSI* program throughout.

_______. *The Forensic Science of "C.S.I."* New York: Berkley Books, 2001. Uses the television show to discuss how various types of forensic evidence are employed in real-world cases. Attempts to demystify the process of forensic investigation.

Tyler, Tom R. "Viewing *CSI* and the Threshold of Guilt: Managing Truth and Justice in Reality and Fiction." *Yale Law Journal* 115, no. 5 (2006): 1050-1085. Offers a relatively complex discussion of the *CSI* effect, with a review of prior research findings that support or refute the existence of the effect.

See also: Celebrity cases; *Cold Case*; Composite drawing; Crime laboratories; Crime scene documentation; Crime scene investigation; Crime scene measurement; Crime scene reconstruction and staging; *Forensic Files*; Journalism; Literature and forensic science; Misconceptions fostered by media.

Cyanoacrylate fuming. *See* Superglue fuming

Cybercrime. *See* Computer crimes

Cyberstalking

Definition: Electronic communication in which perpetrators repeatedly contact victims with the intent of abusing, exploiting, annoying, threatening, slandering, terrifying, or embarrassing them.

Significance: Cyberstalkers use the anonymity allowed by electronic communications technologies to disguise their true identities while they harass and threaten their victims. Depending on its severity, cyberstalking can be a misdemeanor or a crime punishable by jail time. Investigating cyberstalking is difficult for several reasons, not least of which is the lack of physical evidence in many cases. To find and prosecute cyberstalkers and authenticate the electronic evidence in these cases, law-enforcement personnel must typically use computer forensics investigative methods.

Rather than engaging in physical confrontation, cyberstalkers take advantage of the impersonal, nonconfrontational, and anonymous nature of the Internet and e-mail to harass or threaten their victims. This makes it difficult for authorities to measure the full extent of the crime of cyberstalking. Perpetrators can use various Internet-based technologies from any location; they may live next door to their victims or on the other side of the world.

In cases where cyberstalkers know their victims, the most common motive is revenge. Cyberstalking frequently occurs in workplace settings, perpetrated by employees who are angry with management or fellow workers. Pedophiles also sometime engage in cyberstalking, using social network Web sites, such as MySpace, to find potential victims. Law-enforcement investigations of cyberstalking may be valuable to defend against child sexual exploitation and other physical crimes, as many cyberstalking attacks have the potential to escalate to violent criminal acts. Some law-enforcement agencies are able to respond aggressively to cases of cyberstalking by following trails of digital evidence and seizing computers of suspects, but others lack the expertise and resources to pursue such cases.

Legal Defenses Against Cyberstalking

The incidence of cyberstalking has increased over the years as growing numbers of people around the world have gained access to the Internet. In response to this trend, nations have enacted increasingly strict legislation to deal with cyberstalking. The first antistalking legislation in the United States went into effect in 1990. Since 1999, federal and state jurisdictions have amended existing general antistalking and antiharassment statutes to include instances of cyberstalking or have enacted new statues to protect victims of cyberstalking.

By mid-2007, forty-five U.S. states had laws against cyberstalking. The federal antistalking law prohibits anonymous Internet communications "with intent to annoy, abuse, threaten or harass." Laws to combat cyberstalking include federal statute 18 U.S.C. 875(c), which makes it a federal crime, "punishable by up to five years in prison and a fine of up to $250,000, to transmit any communication in interstate or foreign commerce containing a threat to injure the person or another." Because most states have also enacted their own specific legislation, investigators as well as victims of cyberstalking in the United States may face complicated sets of laws offering varying definitions, protections, and penalties.

A growing number of law-enforcement agencies have recognized the serious nature and extent of cyberstalking and have responded by providing training in computer forensic techniques and software. In large cities, such as New York and Los Angeles, police departments and district attorneys' offices have developed specialized units to investigate cyberstalking cases. The Federal Bureau of Investigation (FBI) has established Computer Crime Squads throughout the country; these units investigate all kinds of computer crime, including cyberstalking.

Nature of Cyberstalking

Cyberstalking is similar to traditional forms of stalking in several ways. Many stalkers, both online and off, are motivated by a desire to control their victims, and both kinds of stalkers engage in behaviors aimed at gaining control. Online forums such as chat rooms, blogs, and social network sites make it easy for cyberstalkers to trick third parties into harassing or threatening the cyberstalkers' intended victims. To carry out such ruses, cyberstalkers post inflammatory or salacious messages in online forums while impersonating their victims, causing viewers of the messages to send unwelcome or threatening messages to the victims. Cyberstalkers with knowledge of their victims' screen names may use software that advises them when their victims are online; the stalkers then send their victims lewd or threatening instant messages.

Cyberstalking is different from other types of stalking in that it may not involve any physical contact at all. As with other types of stalking, the majority of perpetrators are men and the majority of victims are women, although cases of women cyberstalking men and same-sex cyberstalking have been reported.

Tracking Down Cyberstalkers

In cyberstalking cases, computers and the Internet are the weapons. Experienced cyberstalkers often use anonymous remailers, which can make it impossible for investigators to determine the true sources of e-mail and instant

Contentious Legislation Versus Legal Recourse

In the United States, laws concerning cyberstalking have generated controversy because many civil libertarians maintain that prohibiting anonymous communication that merely annoys others is a restraint on free speech online. They assert that the right of free speech extends to the Internet and even includes anonymous free speech. In contrast, many of the victims of cyberstalking have argued that legislation is necessary to provide victims of this behavior with legal recourse.

messages, Internet Relay Chat (IRC), or other electronic communication. Anonymity gives cyberstalkers an advantage over investigators. Anonymous services on the Internet allow individuals to create free Web-based e-mail accounts, and most Internet service providers (ISPs) provide their services without authenticating or confirming users' identities. The investigation of cyberstalking thus requires the use of sophisticated computer and e-mail forensics methods to trace cyberstalkers' activities through their phone records. Investigators usually need subpoenas to obtain such records, whether from telephone companies or ISPs.

After investigators have identified suspects in cyberstalking cases, or the addresses of suspects' computers, they generally obtain search warrants that allow them to seize the computers, any electronic storage equipment, and digital devices. Because of the fragile nature of such equipment, these are usually transported to computer forensics labs, where experts make copies of the electronic evidence to investigate further.

Law-enforcement officers are sometimes frustrated by jurisdictional limitations in cyberstalking cases, as when they find that stalkers are located in other cities or states, making further investigation difficult or impossible. Officers who travel to other legal jurisdictions to continue their investigations may have trouble obtaining assistance from other agencies. It is likely that such limitations on law enforcement will diminish in the future, as cybercrimes, including cyberstalking, become increasingly widespread.

Statutes that require a showing of a "credible threat" may hinder prosecution in some cyberstalking cases. Cyberstalkers often do not threaten their victims overtly or in person, although they engage in conduct that would cause reasonable persons to fear violence. In the context of cyberstalking, the legal requirement of the existence of a credible threat is especially problematic because cyberstalkers may in fact be located far away from their victims (although their victims do not know that), and so the threats they pose might not be considered credible.

Preserving Evidence

Connecting suspects to the crime of cyberstalking is a challenge without some evidence in addition to the electronic evidence, such as a former romantic or work-related link between the stalker and victim. With or without such other evidence, the key to successful prosecution in cyberstalking cases is the preservation of the full electronic trail of evidence. Tracking down cyberstalkers and convicting them depends a great deal on the cooperation of the victims. Victims of cyberstalking should save all communications from their harassers as evidence; these should not be altered or edited in any way. Victims should also keep logs of the times and dates of their Internet activity and when they received communications from the stalkers.

The requirements for the preservation of electronic evidence for legal purposes differ from the requirements for other types of evidence. The admissibility of electronic evidence in court depends on the existence of a reliable record of chain of custody for that evidence. Investigators must be able to demonstrate that they have not added to or otherwise altered the data or communications presented as evidence. They can help to satisfy this requirement by write protecting and virus checking all the media used. Investigators must be able to demonstrate to the court that what is purported to be a complete forensics copy of a suspect's hard drive or storage medium is indeed such a copy.

Linda Volonino

Further Reading

Bocij, Paul. *Cyberstalking: Harassment in the Internet Age and How to Protect Your Family*. Westport, Conn.: Praeger, 2004. Discusses how Internet and communication technologies are used to harass and what individuals can do to prevent technological harassment.

D'Ovidio, Robert, and James Doyle. "A Study on Cyberstalking: Understanding Investigative Hurdles." *FBI Law Enforcement Bulletin* 72 (March, 2003): 10-17. Bulletin for law-enforcement personnel focuses on the challenges of tracking the digital trails of cyberstalkers.

Proctor, Mike. *How to Stop a Stalker*. Amherst, N.Y.: Prometheus Books, 2003. Provides information on various types of stalkers and their methods of stalking and discusses the courses of action people can take when they are being stalked. Presents many examples taken from actual cases.

Smith, Russell G., Peter Grabosky, and Gregor Urbas. *Cyber Criminals on Trial*. New York: Cambridge University Press, 2004. Discusses the results of an international study of the ways in which cybercriminals are handled by different nations' judicial systems.

Willard, Nancy E. *Cyberbullying and Cyberthreats: Responding to the Challenge of Online Social Aggression, Threats, and Distress*. 2d ed. Champaign, Ill.: Research Press. 2007. Discusses cyberstalking and other cyberbullying against students and offers advice regarding how victims can prevent and respond to those threats.

See also: Computer crimes; Computer forensics; Computer Fraud and Abuse Act of 1984; Computer hacking; Electronic voice alteration; Internet tracking and tracing; Rape.

D

Daubert v. Merrell Dow Pharmaceuticals

Date: Ruling issued on June 28, 1993
Court: U.S. Supreme Court
Significance: In *Daubert v. Merrell Dow Pharmaceuticals*, the U.S. Supreme Court held that under the Federal Rules of Evidence, a judge is required to make an independent reliability and relevance determination before allowing expert testimony to be admissible.

Daubert v. Merrell Dow Pharmaceuticals was a suit brought by two minor children who were born with serious birth defects, which they alleged were the result of their mothers' ingestion during pregnancy of Benedectin, a prescription antinausea drug marketed by Merrell Dow Pharmaceuticals. A U.S. district court granted summary judgment in favor of Merrell Dow because a great deal of scientific evidence demonstrated that Benedectin did not cause birth defects and because the scientific evidence offered by the plaintiffs was found to be inadmissible, as the evidence lacked general acceptance in the scientific community. The court of appeals agreed, stating that expert opinion is inadmissible unless the scientific technique on which the opinion is based is generally accepted by the relevant scientific community.

The U.S. Supreme Court disagreed and remanded the case for a new determination of the admissibility of the scientific evidence in question. The Court explained that the Federal Rules of Evidence (FRE) govern the admissibility of evidence in federal court, thus the rule stated in *Frye v. United States* (1923) requiring general acceptance of a scientific technique is no longer an absolute requirement and has been superseded by Federal Rule of Evidence 702. Under the governing rule of FRE 702, judges should examine the reliability and relevance of proffered expert scientific evidence in determining the admissibility of that evidence.

Specific Requirements of *Daubert* and FRE 702

To determine the reliability of scientific evidence, judges should assess whether the methodology is scientifically valid and whether the methodology offers scientific knowledge that will assist the trier of fact (the jury in a jury trial, the judge in a bench trial) in determining the outcome of the case. Specifically, the four factors that judges should consider are whether the methodology and scientific evidence being offered can be and has been tested for validity, whether the scientific theory or technique has been peer-reviewed and published, what the known or potential rate of error is of the technique and the existence and maintenance of standards that control the technique's operation and use, and whether the methodology is generally accepted by the relevant scientific community.

In using the consideration of these four factors as a guide for evaluating scientific evidence, trial judges have great latitude in determining the reliability of evidence. The Supreme Court thus concluded in *Daubert v. Merrell Dow* that general acceptance of scientific evidence is no longer a precondition of admissibility under the Federal Rules of Evidence, but that factor may still have some bearing. In *Kumho Tire Company v. Carmichael* (1999), the Supreme Court later extended the requirements of *Daubert* in a loosened form to all experts, regardless of whether or not the experts are testifying as to scientific evidence.

Applications of the *Daubert* Standard

Because forensic scientific evidence is often presented in the courtroom through the use of expert testimony, the *Daubert* standard greatly affects the admissibility of such evidence. For example, evidence that was previously rejected under *Frye* as not being generally accepted has been reexamined by courts to see if the evidence does embody good science. Polygraph results were viewed as inadmissible under *Frye*, but under *Daubert*, this form of evidence is no longer subject to a per se ban. Although polygraph evidence is still rarely admitted, judges at least give its admissibility minimal consideration.

In some cases, courts have reevaluated the validity and applicability of evidence that many would previously have accepted automatically as being valid under *Frye*. For instance, court decisions allowing handwriting comparisons and fingerprint identification date back to before the 1920's, but no empirical studies were conducted on the validity of handwriting comparisons or fingerprint identification because empirical scientific foundations for these methods were not required under *Frye*.

Some commentators have questioned the tacit acceptance by courts of forensic fingerprint identification evidence because they believe that such evidence is not as reliable as previously assumed, as indicated by erroneous convictions and inconsistencies in protocols. It is extremely difficult to make accurate comparisons of poor-quality latent fingerprints left at a crime scene with rolled fingerprints taken directly from a defendant, and such comparisons often require fingerprint analysts to make subjective assessments. The scientific bases underlying fingerprint identification have yet to be tested fully under *Daubert*, but this form of evidence may one day be found to be unreliable and inadmissible. No appellate court has held that such evidence is definitively inadmissible, but in 2003 the U.S. Court of Appeals for the Fourth Circuit, in *United States v. Crisp*, became the first appellate court to hold that expert testimony on handwriting comparisons and fingerprint identification is admissible under *Daubert*.

The *Daubert* decision thus created a gatekeeper role for judges, who became responsible for assessing the reliability of the opinions of expert witnesses. This new role might result in previously accepted expert testimony being found inadmissible at the same time modern techniques of forensic science may have greater opportunities to alter the outcomes of cases as they are deemed admissible by more courts.

Vivian Bodey

From the Court's Decision in *Daubert v. Merrell Dow*

Respondent expresses apprehension that abandonment of "general acceptance" as the exclusive requirement for admission will result in a "free-for-all" in which befuddled juries are confounded by absurd and irrational pseudoscientific assertions. In this regard, respondent seems to us to be overly pessimistic about the capabilities of the jury and of the adversary system generally. Vigorous cross-examination, presentation of contrary evidence, and careful instruction on the burden of proof are the traditional and appropriate means of attacking shaky but admissible evidence. . . . Additionally, in the event the trial court concludes that the scintilla of evidence presented supporting a position is insufficient to allow a reasonable juror to conclude that the position more likely than not is true, the court remains free to direct a judgment, . . . and likewise to grant summary judgment. . . . These conventional devices, rather than wholesale exclusion under an uncompromising "general acceptance" test, are the appropriate safeguards where the basis of scientific testimony meets the standards of Rule 702.

Further Reading

Benedict, Nathan. "Fingerprints and the *Daubert* Standard for Admission of Scientific Evidence: Why Fingerprints Fails and a Proposed Remedy." *Arizona Law Review* 46 (Fall, 2004): 519-549. Explores the history behind the *Daubert* standard and its possible application to fingerprint identification evidence.

Judicial Gatekeeping Project, ed. *The Judge's Role as Gatekeeper: Responsibilities and Power*. Cambridge, Mass.: Berkman Center for Internet and Society, Harvard Law School, 1999. Collection of essays, written for a general audience, provides detailed discussion of *Daubert* and the case's ramifications.

Klein, Daniel A. "Reliability of Scientific Technique and Its Acceptance Within Scientific Community as Affecting Admissibility, at

Federal Trial, of Expert Testimony as to Result of Test or Study Based on Such Technique: Modern Cases." In *American Law Reports, Federal*. St. Paul, Minn.: Thomson/West, 2007. Offers analysis of court cases dealing with the admissibility of expert testimony involving a wide range of scientific and technical areas and techniques.

National Research Council. *The Polygraph and Lie Detection*. Washington, D.C.: National Academies Press, 2003. Provides interesting discussion of the polygraph and concludes that use of the polygraph for legal purposes is not likely to increase.

Rothstein, Paul F., Myrna S. Raeder, and David Crump. *Evidence*. St. Paul, Minn.: Thomson/West, 2003. Presents a broad discussion of the Federal Rules of Evidence as well as a detailed description of the history and current analysis of the admissibility of expert testimony and scientific evidence.

See also: Cognitive interview techniques; Courts and forensic evidence; DNA fingerprinting; Drug and alcohol evidence rules; Ethics; Expert witnesses; Federal Rules of Evidence; *Frye v. United States*; Polygraph analysis; Pseudoscience in forensic practice; Toxic torts.

Decomposition of bodies

Definition: Process by which cadavers become skeletons through the destruction of the body's soft tissue.

Significance: Understanding the processes that take place during decomposition of a human body can help investigators determine a number of important pieces of information, including approximate time of death and whether the body was moved after death. Sometimes, the decomposition of remains can contribute to the determination of cause and manner of death. Investigators need to remember that because of the number of variables involved in decomposition, it is rare to find two instances that share identical processes.

Decomposition begins at the moment of death, when all of the internal functions that work together to maintain the body's homeostasis cease. At this stage, decomposition manifests as the result of two processes: autolysis, which is the breaking down of tissues by the body's own internal chemicals and enzymes; and putrefaction, which is the breaking down of tissues by bacteria. These processes release gases that are the chief source of the distinctive odor of dead bodies. A great many factors affect the progression of decomposition, accelerating, hampering, or otherwise changing the process; these factors vary from body to body .

Knowledge of the decomposition process can help investigators and forensic pathologists to estimate time of death and to determine whether the body has been moved. Although often on popular television shows and in movies, characters portraying forensic experts make impressive specific statements about time of death, estimating using intervals of thirty or sixty minutes, in reality, forensic investigators are grateful if the time of death can be narrowed to a twelve-hour window. In contrast, analyis of decomposition manifestations makes the determination that a body has been moved more clear-cut. The fact that a body has been repositioned provides investigators with a very important piece of information—someone was on the scene before their arrival.

Initial Body Changes

Immediately upon the discovery of a body, investigators look for four initial body changes. All of these changes begin at the moment of death; thus the presence or absence of manifestations of these changes can be used in the determination of an estimate of time of death. The four all have Latin names ending in *mortis*, the Latin word for death: pallor (paleness, fading) mortis, algor (cold or cooling) mortis, rigor (stiffening) mortis, and livor (black and blue mark, bruise) mortis.

Pallor mortis is the paleness that is associated with death; it results from the fact that the blood is no longer at the skin's surface because circulation has ceased. Full paleness happens in the first three hours after death. It is difficult to quantify the progression of this process, however, so this change generally is of little value in determining the time of death.

Algor mortis is the cooling of the body's temperature following death as it falls from the static 98.6 degrees to the ambient temperature. A body's temperature—usually measured using a rectal thermometer—provides some information that is useful in estimating the time of death, but bodies do not all cool at a consistent rate, so a somewhat complex equation must be used. Many factors can influence the rate of a body's cooling, including the presence of excessive humidity, lack of humidity, and the body's position near a heat source (such as a radiator), so any estimation has a wide margin of error.

Rigor mortis is the stiffening of the body's muscles after death. The muscles become so stiff that they are nearly impossible to move or manipulate. If the entire body is moved from its position at death while rigor mortis is fully established, the body's limbs will maintain their original pose, appearing to defy gravity. The cause of rigor mortis is a chemical reaction in which water reacts with the body's adenosine triphosphate (commonly referred to as ATP) and converts it to another compound. ATP is the chemical energy source required for movement in living tissue.

Rigor mortis follows what is typically referred to as the "rule of twelves." It normally takes the first twelve hours after death for rigor mortis to set fully and the body to become completely rigid. The body stays in full rigor for the next twelve hours (twelve to twenty-four hours after death), and then rigor begins to release during the third twelve hours (twenty-four to thirty-six hours after death). After thirty-six hours, the rigor mortis is fully released and the body is once again limp. Knowing what stage of rigor mortis a body is in can help in the determi-

Employees of the District of Columbia medical examiner's office remove one of four decomposing bodies of youths found in a house in early 2008. The ability of forensic scientists to estimate how long bodies have been decomposing plays an important role in the determination of what took place at crime scenes. *(AP/Wide World Photos)* nation of time of death, but many factors—such as ambient temperature, antemortem physical condition, and humidity—can vary the rigor schedule by hours.

A body's stage of rigor mortis can be very helpful in the determination of whether the body has been moved. If a body's limbs appear to be defying gravity or the body is in a position that does not make sense given the circumstances (leaning against a wall instead of crumpled on the floor, for example), investigators can conclude with certainty that the body was moved several hours after death.

Livor mortis occurs when the blood, no longer in circulation, passes through the capillaries to settle in the gravity-dependent areas of the body. The blood stains the skin a dark red color in those areas. Lividity, as this process is also called, begins within the first hour of death and continues until full staining occurs at approximately twelve hours after death. An estimation of time of death can be made based on how deeply the skin is stained, but such an estimation is not specific and cannot be made until after full lividity is reached.

If the body is moved before full lividity is reached, the blood will shift and settle in the new gravity-dependent areas of the body. Partial staining may have already occurred in the original position, meaning the body has dual lividity. The only way dual lividity can occur is if the body is moved after death and prior to full livor mortis. Another sure indication that a body was moved after death is that it has reached full livor mortis, but the staining is not in the gravity-dependent areas of the body. In other words, if a body has full lividity of the chest but is found found lying on the back, the body must have been flipped over after full lividity was reached while the body was facedown.

Autolysis and Putrefaction

Autolysis is the destruction of a cell after its death by the action of its own enzymes, which break down its structural molecules. Human cells have an organelle known as the lysosome, which is a membrane containing up to forty digestive enzymes that are made by the endoplasmic reticulum and Golgi apparatus (sometimes called the Golgi complex). The lysosomes are responsible for digesting nucleic acids, polysaccharides, fats, and proteins within the cell. They are active in recycling the cell's organic material and in the intracellular digestion of macromolecules. At the point of a person's death, the digestive enzymes are released from the lysosomes' membranes and begin destroying the cell.

Putrefaction usually begins concurrent with autolysis in the first stages of decomposition. Putrefaction is the breaking down of flesh and tissue caused by bacteria, which creates the strong, unpleasant odor associated with decomposition. The stages of putrefaction vary, as do the times within each stage, depending on environmental conditions. Some of the factors that influence the speed of putrefaction include the atmospheric temperature and humidity level, the movement of air, the state of hydration of the tissues and the nutritional state of the body before death, the age of the deceased, and the cause of death. Low temperatures, which inhibit the growth of bacteria, retard the process considerably.

One of the earliest signs of putrefaction in human decomposition is the discoloration of the lower abdominal wall near the right hip bone because of the proximity of the cecum and large intestine to the skin's surface there. Human bodies house many bacteria that assist in the digestion process. After death, as intestinal bacteria begin the putrefaction process, the lower-right abdomen turns a greenish to black color. The gases produced by the bacteria are also responsible for swelling of the face and neck. This swelling may cause the eyes and tongue to protrude and may make visual identification of the decedent difficult. Other effects produced by the gases include a marked increase in the volume of the abdomen, which is under tension, and of the scrotum and penis, which may become larger than normal.

The intestinal bacteria begin colonizing the entire body, utilizing the venous system as pathways. The discoloration of the abdomen eventually spreads as the bacteria migrate, changing the veins and arteries of the rest of the abdomen, the thighs, the chest, and the shoulders to the same green and black. The discolored venous system makes visible lines across the body; this is referred to as marbling.

A few days to a week after death, as the bacteria continue to devour tissue, the skin begins to blister in the sloping regions of the body. Eventually the blisters, which contain a thick reddish liquid, erupt, making the epidermis (the outer layer of skin) fragile. Ultimately, the epidermis becomes so delicate that it tears easily and may come off in large areas, leaving the red dermis below visible. This phenomenon is referred to as skin slippage. At times, the epidermis of an entire hand may detach, creating a glove of skin. If the skin of the fingertips detaches, identification of the body through fingerprints may be difficult, but as long as the fingertip skin is still available, fingerprints may be retrievable; forensic scientists have had success in placing such skin over their own latex-gloved fingers to retrieve the fingerprints.

As the body enters the second week following death, the increased pressure on the abdomen produced by putrefactive gases leads to the ejection of feces and urine. This pressure also leads to the expulsion of liquids from other body orifices, particularly from the mouth and nostrils. Because this liquid is often bloody, its presence sometimes leads to a misdiagnosis of injury. At this stage, the orifices as well as the organs may take on a foamy appearance as the gases mix with liquids internally.

In the following weeks, the skin begins to darken to black, making identification even more difficult. The face becomes even more bloated and blackens as well, so that racial characteristics may be masked. The cadaver continues to bloat with internal gases, giving the impression that the deceased was a very heavy individual.

Internal decomposition of the organs tends to occur at a slower pace than that of the rest of the body. The capsules of the kidney, spleen, and liver resist putrefaction more than do other tissues, but eventually they become sacs containing a thick reddish liquid. These sacs will ultimately burst. The viscera and soft tissues disintegrate, whereas organs such as the uterus, heart, and prostate last longer, as do tendon tissues and ligaments attached to the bones. These different rates of decay of the organs may be proportional to the amounts of muscular and conjunctive tissue they contain.

Saponification

Decomposition tends to be slower in water than in air because of the usually lower temperature of water, which retards bacterial growth. Water also protects the body from insects and predatory animals, with certain birds and fish as notable exceptions. A body typically floats head down, because the head does not develop gas formation as easily as the abdomen; this causes fluids to gravitate to the head. Putrefaction of a body that has been decomposing in water is thus more visible on the face and front of the neck, making visual identification particularly difficult. Identification is further hampered by saponification, which is a chemical process in which water converts the body's fatty acids into a different compound called adipocere. A grayish-white or tan spongy substance that adheres to the body, adipocere can act as a preservative, counteracting the effects of decomposition.

Saponification requires at least partial immersion of the body in an aquatic environment with warm temperatures. It normally presents as peeling, blanched skin. Adipocere has been found on bodies in bathtubs, ponds, lakes, and oceans. It has also been discovered on bodies inside caskets, on bodies found in caves, and on remains wrapped in plastic.

Mummification

Mummification is the process of drying out the tissues of a body. It is characterized by dryness and brittle, torn skin, especially on the protruding areas of the body, which is generally brown in color. It is possible for slight adipocere to form in mummified bodies, as the hydration needed to create the fats contributes to the drying of the body. Mummification is found in dry, ventilated environments and generally in warm places where bodies lose fluids through evaporation. Mummification is often found in desert environments, but it can also occur in dry, closed spaces, such as attics and closets. Dehydration before death may contribute to the process of mummification.

Mummified bodies are often found in a state of preservation, so that it is usually much easier to investigate the identities of the deceased than it is in cases of saponification. Performing autopsies on mummified remains is very difficult because the skin is extremely brittle and disintegrates easily. A variety of methods have been developed to rehydrate mummified bodies for better autopsy results. This rehydration is often referred to as tissue building.

Skeletonization

Skeletonization, or the removal of all soft tissue from the bone, is generally considered the last stage of decomposition. Skeletonization may be complete, meaning the entire body has no flesh, or partial, with areas of the body in different stages of decomposition.

Under normal conditions, skeletonization occurs only after a considerable amount of time has passed. An unembalmed adult body buried six feet deep in ordinary soil without a coffin normally takes ten to twelve years to decompose fully to a skeleton, given a temperate climate. Immerse the body in water, and skeletonization occurs approximately four times faster; expose it to air, and it occurs eight times faster. The intervention of predatory insects or animals can greatly speed up this timetable, however.

Insect and Predator Activity

Predatory insects and animals can accelerate decomposition by eating the flesh of a cadaver, separating the body into parts, or using the body as a repository for their eggs. The involvement of insect predators in particular can be beneficial to investigators in that it can help in the determination of an estimate of time of death. Insects are the first organisms to arrive on a body after death. They colonize the remains in a predictable sequence, as each stage of decomposition, from fresh body to skeletonization, is attractive to a different group of insects.

When remains are found weeks or months after death, the examination of insect evidence is often the only method available that can help investigators to determine an approximate time of death. Forensic entomologists study what insects are present in and on the body and pinpoint the development stages of those insects. They also take note of the species that are not present. Every group of insects that has inhabited the body will have left evidence of having been there, even the groups that have moved on as the body progressed through successive decomposition stages. Blowflies, which can detect death from great distances, are the first to colonize a body.

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Further Reading

Catanese, Gerard, and Tamara Bloom. "Recovery of a Mummified Pregnant Woman from a Fifty-five-Gallon Drum More Than Thirty Years After Her Death." *American Journal of Forensic Medicine and Pathology* 23, no. 3 (2002): 245-247. Interesting article on mummification discusses the case of a twenty-eight-year-old woman whose mummified remains were found in steel drum in a crawl space under a house.

DiMaio, Vincent J., and Dominick DiMaio. *Forensic Pathology*. 2d ed. Boca Raton, Fla.: CRC Press, 2001. One of the best reference sources available in the field of forensic pathology. Includes a very informative section on human decomposition.

Mann, Robert, William Bass, and Lee Meadows. "Time Since Death and Decomposition of the Human Body: Variables and Observations in Case and Experimental Field Studies." *Journal of Forensic Sciences* 35, no. 1 (1990): 103-111. Excellent comprehensive study of the decomposition of a body includes discussion of determination of time of death.

O'Brien, Tyler G., and Amy C. Kuehner. "Waxing Grave About Adipocere: Soft Tissue Change in an Aquatic Context." *Journal of Forensic Sciences* 52, no. 2 (2007): 294-301. Presents the results of a study of the saponification process on submerged bodies. Excellent source for further information on this phenomenon.

Rodriguez, William, and William Bass. "Decomposition of Buried Bodies and Methods That May Aid in Their Location." *Journal of Forensic Sciences* 30, no. 3 (1985): 836-852. Interesting article coauthored by one of the foremost forensic anthropologists in the United States; Rodriguez has conducted extensive research on the decomposition of human bodies.

Spennemann, Dirk H. R., and Bernd Franke. "Decomposition of Buried Human Bodies and

Associated Death Scene Materials on Coral Atolls in the Tropical Pacific." *Journal of Forensic Sciences* 40, no. 3 (1995): 356-367. Informative, penetrating study of decomposition focuses on the effects of tropical conditions.

Spitz, Werner U., ed. *Spitz and Fisher's Medicolegal Investigation of Death: Guidelines for the Application of Pathology to Crime Investigation*. 4th ed. Springfield, Ill.: Charles C Thomas, 2006. Indispensable volume for those conducting forensic investigations and forensic pathology. Includes comprehensive sections on specific cases along with their pathological findings.

See also: Adipocere; Algor mortis; Autopsies; Bacteria; Body farms; Coffin birth; Forensic anthropology; Forensic archaeology; Forensic entomology; Livor mortis; Mummification; Rigor mortis; Taphonomy; University of Tennessee Anthropological Research Facility.

Decontamination methods

Definition: Chemical and physical methods of eradicating, inactivating, or cleaning potentially dangerous biological, chemical, or radiological agents that are present on persons or objects, including surfaces and building structures.

Significance: Exposure to certain kinds of biological, chemical, and radiological agents can be detrimental to human beings. Forensic scientists as well as members of the general public may find themselves in situations where they may be exposed to such agents, thus decontamination procedures need to be in place. Such procedures include removal of contaminants, prevention of infectious transmission from biological hazards, reduction of contaminant levels to ensure protection from harm, and provision of decontaminated objects or surfaces that are safe for use, handling, storage, or disposal.

Exposure to various hazardous agents can take place in the home, in the workplace, or in other environments. For example, workers in health care institutions and in laboratories of many kinds (forensic, clinical and research) are often exposed to bloodborne pathogens and other potentially infectious materials. Individuals who work in manufacturing industries are also often exposed to potentially toxic chemicals specific to their work environments. In addition to such everyday exposure, public concern has risen regarding the prospect of the use of chemical and biological agents as weapons. A radiological (nuclear) agent was last used as a weapon in World War II, but such agents are also present in nuclear power plants, in some weapons manufacturing plants, and in small quantities in forensic, clinical, and research laboratories when particular experiments require them. Forensic scientists may be exposed to biological, chemical, or radiological agents in the course of their work.

Because of the dangers of exposure to hazardous agents, the issue of decontamination is increasingly important. Decontamination methods include two broad categories: chemical and physical. Specific cleaning and decontamination procedures apply to different situations. For example, different methods of cleaning and decontamination would be used for a crime scene, for an operating room in a hospital, for a patient examination room in an outpatient clinic, for a blood bank, for a research laboratory, and for a facility exposed to a biological or chemical war agent, such as the anthrax-laden letters that contaminated the Hart Senate Office Building and the associated U.S. Postal Service mail-handling and -sorting centers in the fall of 2001. Moreover, specific protocols are in place in the United States for decontaminating civilians as opposed to military personnel in military settings, where quick and efficient strategies need to be employed. The choice of decontamination methods depends also on the severity and consequences of the exposure and on the nature of the item that will be decontaminated, including the material of which it is made.

General Methods

The U.S. Occupational Safety and Health Administration (OSHA) recommends several gen-

Members of special weapons and tactics (SWAT) and hazardous-materials teams outside a tent set up for decontamination showers. *(© iStockphoto.com/Loren Rodgers)*

eral measures of decontamination. Hand decontamination by completely washing hands with soap and water, rinsing, and drying with a clean towel or air-drying can help prevent transmission of disease. This method is useful in many different settings, including food-related industries, health care institutions, and forensic laboratories.

Clothing, tools, and appropriate equipment should be washed completely using soap and clean water. A solution of chlorine bleach (sodium hypochlorite) and water (one-fourth cup of bleach per gallon of water) should be used to wipe down surfaces; gloves, eye protection, and appropriate clothing should be worn by those using bleach solutions for decontamination.

Chemical Methods

Chemical disinfectants that are often used in medical, surgical, and research facilities include alcohols (isopropyl and ethyl alcohol, usually 70 percent solutions, are used to inactivate biological hazards, including adenoviruses, murine retroviruses, and human immunodeficiency virus, or HIV); halogen-containing compounds such as iodophors (iodine combined with an organic substance); oxidizing chlorine solutions such as bleach (a 10 percent chlorine solution made fresh daily is recommended); phenolic compounds such as chlorhexidine; strong bases such as calcium, sodium, and potassium hydroxides; mild acids such as vinegar; surface-active compounds such as soaps and detergents (quaternary ammonium compounds commonly known as quats); and aldehyde compounds such as glutaraldehyde and formaldehyde.

The necessary length of exposure to these chemical decontaminating agents depends on the level of disinfection required (low, medium, or high) as well as the limitations of each situation (for example, the nature of the item being disinfected is a factor, whether it is a sample containing bloodborne pathogens or other potentially infectious materials, the surface of a laboratory workbench, or a soft surface such as a carpeted area). One type of chemical decontamination used in forensic science involves dichloromethane. Forensic investigators often obtain samples of DNA (deoxyribonucleic acid) from hair, teeth, body fluids, and fingernails. Hair is usually decontaminated with dichloromethane for two minutes before extraction of DNA. In addition to the chemical decontamination, most of these objects are placed in specially designed biohazard bags or containers for disposal; these are then sterilized using an autoclave, a device that employs heat, steam, and pressure to destroy biological pathogens.

Chemical disinfectants that may be used for decontamination of building structures in cases of toxic industrial events or biological or chemical attacks include three broad categories: liquid-based topical agents (such as bleach and aqueous chlorine dioxide), foams and gels (such as the L-Gel System and a decontamination foam created by Sandia National Laboratories), and gaseous and vapor technologies, or fumigants (such as chlorine dioxide gas, vapor-phase hydrogen peroxide, and paraformaldehyde).

The L-Gel System is an innovative decontaminant of biological hazards as well as of chemical and biological warfare agents, such as the spores of *Bacillus anthracis*, the bacterium that causes anthrax. L-Gel, which was developed at the Lawrence Livermore National Laboratory in California, is based on a Du Pont Corporation product called Oxone, a commercial oxidizer that uses potassium peroxymonosulfate as its active ingredient. L-Gel incorporates Oxone solution and a silica gelling agent, which allows it to cling to walls, ceilings, and other surfaces.

The decontamination foam developed at the Sandia National Laboratories in New Mexico, known as Sandia foam, uses aqueous-based hydrogen peroxide as its active ingredient. Sandia foam can also eradicate bacterial spores through its surfactant and oxidizer properties.

Radioactive material contaminants, especially from water-cooled nuclear reactors, are decontaminated with chemical reagents. For example, alkaline permanganate is used for pretreatment, citrate-oxalate solution for treatment, acidified hydrogen peroxide solution for posttreatment, and demineralized water for rinsing in between steps.

Radioactive contamination from spills that occur in laboratories is usually minor and easily contained. Exposed personnel are decontaminated using the protocols in place for such events. Chemical decontamination methods include using soaps or detergents with chelating compounds and special decontaminants for radioactivity, such as Decon90, Count-Off, and Radiacwash. For personnel decontamination, hydrogen peroxide, potassium permanganate, and sodium metabisulfite can be used for decontamination of exposed skin, provided there are no wounds and the skin does not become inflamed or irritated. If radioactive material is ingested, vomiting is induced and copious amounts of water are given to dilute the radioactivity. Most institutions where radioactive materials are present have environmental health and safety officers and radiation safety officers who are responsible for reporting radioactive contamination incidents and for more extensive decontamination per institutional protocols.

Most of the decontamination technologies developed in the United States for use in case of biological, chemical, and radiological attacks have been developed for military purposes, but these technologies and their potential uses have been expanded to include civilian purposes since the events of fall, 2001, when the United States experienced terrorism on a scale that it had never before seen.

Physical Methods

Physical methods of decontamination range from simply scrubbing off microbes with an antimicrobial chemical agent to more sophisticated methods, such as the use of ultraviolet (UV) light, ionizing radiation, microwave irradiation, absorbents, filtration, dry heat, and moist heat (steam). UV light is often used to cause mutation experimentally; its main application as a decontaminant is in laboratories that use hazardous microbes and in irradiation of air near important surgical sites. Ionizing radiation includes electron beams, X rays, cathode rays, and gamma rays; these have greater energy than UV light. Ionizing radiation is often used in industrial processes such as the sterilization of disposable medical and surgical supplies. Microwave irradiation has been used to sterilize items such as sponges and scrub pads.

Absorbents are natural materials, such as fuller's earth, that can take up liquid contaminants or impurities. An absorbent used by the military is M291, a dried resin used for rapid decontamination of the skin. Filtration is a method of sterilizing large volumes of liquid to remove contaminants by passing the liquid through one or more filters. Dry-heat sterilizers are often used to disinfect instruments that can withstand high temperatures. Moist heat (steam) is used in autoclaves to sterilize equipment, liquids, and other objects. Some bacteria that form spores (such as those that belong to the genera *Bacillus* and *Clostridium*), however, cannot be completely eradicated by autoclaving because the spores can survive extremely high pressures and temperatures.

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Further Reading

Boss, Martha J., and Dennis W. Day, eds. *Biological Risk Engineering Handbook: Infection Control and Decontamination*. Boca Raton, Fla.: CRC Press, 2003. Provides extensive coverage of biological contaminants in relation to industrial hygiene, including methods for measuring, controlling, and containing human exposure.

Environmental Protection Agency. *Compilation of Available Data on Building Decontamination Alternatives*. Washington, D.C.: Author, 2005. Presents information on the technologies that could be used for decontaminating buildings in the event of chemical or biological attacks in the United States.

Johansson, I., and P. Somasundaran, eds. *Handbook for Cleaning/Decontamination of Surfaces*. 2 vols. New York: Elsevier, 2007. Comprehensive reference resource includes up-to-date discussion of the physicochemical features of the cleaning process, different materials used for decontamination, effects of cleaning on the environment, and other related matters.

Occupational Safety and Health Administration. *Bloodborne Pathogens Fact Sheet*. Washington, D.C.: Government Printing Office, 2002. One of a series of brief informational publications that highlight OSHA standards.

O'Neal, Jon T. *The Bloodborne Pathogens Standard: A Pragmatic Approach*. New York: Van Nostrand Reinhold, 1996. Provides practical information to help employers interpret and implement the OSHA standard and discusses what to do if exposure to pathogens occurs.

Raber, E., et al. *Universal Oxidation for CBW Decontamination: L-Gel System Development and Deployment*. Springfield, Va.: National Technical Information Service, 2000. Presents a comprehensive discussion of the L-Gel System, which is used for decontamination of chemical and biological agents.

Ryan, Kenneth J., and C. George Ray. *Sherris Medical Microbiology: An Introduction to Infectious Diseases*. New York: McGraw-Hill Medical, 2003. Textbook on microorganisms includes discussion of the spread and control of infections.

See also: Air and water purity; Anthrax; Biohazard bags; Biological terrorism; Brockovich-PG&E case; Chemical agents; Chemical Biological Incident Response Force, U.S.; Chemical terrorism; Chemical warfare; Crime scene cleaning; Crime scene protective gear; Radiation damage to tissues; U.S. Army Medical Research Institute of Infectious Diseases.

Defensive wounds

Definition: Injuries received by victims as the result of trying to defend themselves during physical attacks.

Significance: Defensive wounds can provide key pieces of evidence during investigations of criminal acts. Because they are inflicted on victims while the crimes are being committed, they can reveal a great deal about the crimes themselves.

Defensive wounds often occur during crimes of violence, such as homicides, rapes, and other assaults. Most such wounds are found on victims' forearms and palms of hands, but they can also be found on other parts, such as the lower legs and feet of victims who attempt to kick their attackers. Defensive wounds are typically inflicted by knives or other sharp instruments or result from blunt force trauma from objects such as baseball bats and hammers. Less commonly, defensive wounds are inflicted by firearms.

Defensive wounds can reveal where perpetrators were in relation to their victims, what types of weapons they used, and the amount of force they used. Such wounds can also be important in reconstructing the time lines of crime scenes, and they may produce other kinds of evidence. For example, blood from wounds may leave smears or spatters. When victims scratch their attackers—as they often do in physical struggles—traces of the attackers' skin cells can almost always be found under the victims' fingernails. These traces can be scraped, and the DNA (deoxyribonucleic acid) they contain can be analyzed. At the same time, considerable amounts of trace and transfer evidence can be transferred between victims and their attackers.

A popular misconception about defensive wounds is that if they are not found on victims' bodies, the victims must not have chosen to fight back or were compliant. This is often untrue, especially in cases of sexual assault. An absence of defensive injuries may indicate several possible sequences of events. For example, victims may fight back without sustaining any injuries. More frequently, however, victims simply cannot fight back, usually because they are quickly overpowered or are incapacitated during the attacks. Victims may be asleep or rendered unconscious through the use of drugs or alcohol during their attacks. Victims might also be caught unaware by their attackers and thus not have time to fight back. When the body of a victim has many fresh wounds, none of which seems to be defensive in nature, it may mean that the victim was already dead or unconscious when the wounds were inflicted. The victim may also have been restrained to prevent defensive movements.

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Further Reading

Hopping, Lorraine Jean. *The Body as Evidence*. Milwaukee: Gareth Stevens, 2007.

Houck, Max M. *Forensic Science: Modern Methods of Solving Crime*. Westport, Conn.: Praeger, 2007.

_______, ed. *Mute Witnesses: Trace Evidence Analysis*. San Diego, Calif.: Academic Press, 2001.

See also: Antemortem injuries; Bite-mark analysis; Blood residue and bloodstains; Blood spatter analysis; Blood volume testing; Blunt force trauma; DNA extraction from hair, bodily fluids, and tissues; Gunshot wounds; Hesitation wounds and suicide; Homicide; Knife wounds; Puncture wounds; Rape; Strangulation; Trace and transfer evidence.

Deoxyribonucleic acid. *See* DNA

Diagnostic and Statistical Manual of Mental Disorders

Date: First published in 1952; fourth edition, text revision (*DSM-IV-TR*), published 2000

Identification: The text-revised fourth edition of the *Diagnostic and Statistical Manual of Mental Disorders*, commonly called the *DSM-IV-TR*, provides an authoritative scheme that mental health professionals use to classify psychological disorders.

Significance: The *Diagnostic and Statistical Manual of Mental Disorders*, published by the American Psychiatric Association, provides detailed information about mental disorders for mental health professionals, including, for each disorder, key diagnostic features, associated features and

> disorders, specific age and gender features, familial pattern, and differential diagnosis. Mental health professionals use the *DSM-IV-TR* in treatment and when serving as forensic experts, such as when they must determine defendants' competency to stand trial.

In the United States, the *DSM-IV-TR* provides the most widely used classification system for mental disorders. This comprehensive manual lists approximately four hundred psychological disorders, including mental retardation, simple phobia, and paranoid schizophrenia. The manual was developed in coordination with the tenth edition of the World Health Organization's *International Classification of Diseases* (*ICD-10*), which covers both medical and psychological disorders.

Structure

The *DSM-IV-TR* is structured to require the diagnostician to evaluate a person's condition along five axes, or separate branches, of information. First, the diagnostician must determine whether the person displays one or more clinical disorders from an extensive list. These include disorders usually first diagnosed in infancy, childhood, and adolescence, such as enuresis (bedwetting); delirium, dementia, amnesia, and other cognitive disorders; mental disorders due to a general medical condition; substance-related disorders; schizophrenia and other psychotic disorders; mood disorders; anxiety disorders; somatoform disorders; factitious (intentionally feigned) disorders; dissociative disorders (such as what was formerly called multiple personality disorder); eating disorders (such as bulimia); sexual disorders and gender identity disorder; sleep disorders; impulse-control disorders; and adjustment disorders. Some of the most frequently diagnosed disorders are anxiety disorders and mood disorders (depression).

Second, the diagnostician must decide whether the person is displaying long-standing problems including retardation and personality disorders, which can be overlooked because of the first set of clinical disorders. Mental retardation involves significantly below-average intellectual functioning plus impairments in present adaptive functioning and usually occurs before age eighteen. Personality disorders are rigid, maladaptive patterns that deviate markedly from cultural expectations, are pervasive and inflexible, start in adolescence or early adulthood, are stable over time, and lead to distress or impairment. For example, antisocial personality disorder involves persistent disregard for and violation of the rights of others, and narcissistic personality disorder involves a pattern of grandiosity, need for admiration, and lack of empathy.

Third, the diagnostician must ascertain whether the person has any relevant general medical conditions. For example, many people who have recently experienced open heart surgery report clinical depression afterward, and people with diabetes may experience problems with sexual functioning. Fourth, the diagnostician must determine whether the person faces any special psychosocial or environmental problems, such as school or housing problems. Fifth, the diagnostician must rate the person's overall functioning on a scale from zero to one hundred.

It is possible for a person to have more than one diagnosis. For example, a person could have anorexia, an eating disorder that involves self-starvation, and bipolar disorder, a mood disorder that involves periods of depression that last at least two weeks and periods of mania that last at least a week.

Strengths and Weaknesses

Two issues with any kind of diagnostic system are reliability (that is, different people agree on the diagnosis) and validity (that is, the diagnosis is accurate). The people who developed the *DSM-IV-TR* conducted extensive reviews of research to pinpoint which categories in past versions of the *DSM* had been too vague. They next developed some new diagnostic criteria and categories and conducted field trials in which many professionals and researchers used the new criteria in their work. It was found that, most of the time, the same clients or kinds of clients were receiving the same diagnoses, although some problems occurred. One problem was that practitioners had some trouble distinguishing one kind of anxiety disorder from another. Thus, although not totally reliable or valid, the most recently published version of the manual represents the best information available about diagnosis.

The *DSM-IV-TR* is designed to be primarily descriptive, so it avoids suggesting underlying causes for a person's behavior. Instead, it paints a picture of the behavior itself. Also, it provides precise information so that researchers can explore causes of a problem, and two persons diagnosing the same person will arrive at the same diagnosis. This emphasis on behavior could be considered a strength or a weakness of the manual's approach.

A potential problem with the *DSM-IV-TR* is that it compartmentalizes people into inflexible, all-or-nothing categories rather than considering the degree to which individuals display disordered behavior. In addition, some mental health professionals have expressed concern that attaching the label of "abnormal" to a person imparts a dehumanizing, lifelong stigma. Further, a particular diagnosis might cause professionals who deal with that person to concentrate on the problem diagnosed and neglect others. Despite such drawbacks, which are inherent in any labeling system, the *DSM-IV-TR* offers a logical way to organize the major types of mental disturbance.

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Further Reading

American Psychiatric Association. *Desk Reference to the Diagnostic Criteria from DSM-IV-TR*. Washington, D.C.: Author, 2000. Abridged version of the *DSM-IV-TR* is designed to be more portable and easier to use than the full 943-page edition. Includes the *DSM-IV-TR* classification chart, a differential diagnosis decision tree, and a list of the appendixes that appear in the unabridged edition.

Durand, V. Mark, and David H. Barlow. *Essentials of Abnormal Psychology*. 4th ed. Belmont, Calif.: Wadsworth, 2006. Presents thorough descriptions of the different diagnostic groups and includes examples of interviews with individuals who have specific disorders.

First, Michael B., and Allan Tasman. *Clinical Guide to the Diagnosis and Treatment of Mental Disorders*. Hoboken, N.J.: John Wiley & Sons, 2006. Provides clear, concise, and practical diagnostic and therapeutic advice to all practitioners involved in the treatment of mental disorders, covering all *DSM-IV-TR* diagnostic categories in a reader-friendly way.

Klott, Jack, and Arthur E. Jongsma, Jr. *The Co-occurring Disorders Treatment Planner*. Hoboken, N.J.: John Wiley & Sons, 2006. Contains the elements practitioners need to develop formal treatment plans quickly and easily, with a focus on treating adults and adolescents with alcohol, drug, or nicotine addictions and co-occurring disorders such as depression, post-traumatic stress disorder, eating disorders, and attention-deficit/hyperactivity disorder.

Kupfer, David J., Michael B. First, and Darrel A. Regier, eds. *A Research Agenda for "DSM-V."* Washington, D.C.: American Psychiatric Association, 2002. Presents attempts to stimulate research and discussion in the field in preparation for the eventual start of the revision process for the fifth edition of the *DSM*.

See also: Borderline personality disorder; Competency evaluation and assessment instruments; Drug abuse and dependence; Forensic psychiatry; Guilty but mentally ill plea; Hallucinogens; Minnesota Multiphasic Personality Inventory; Psychopathic personality disorder; Victimology.

Dial tone decoder

Definition: Device that deciphers all numbers dialed from a particular telephone and sends the information to an external recorder.

Significance: During criminal and foreign intelligence investigations, information about what telephone numbers have been called from specific telephones can be important for establishing connections among individuals.

When a number key is pressed on a touch-tone telephone, two tones are generated. Each vertical column on the keypad generates a high-frequency tone, and each horizontal row produces a low-frequency tone. When the high- and low-frequency tones of any key are mixed, they produce a tone of unique frequency associated with that specific keypad number. A dial tone recorder deciphers these unique frequencies on an outgoing telephone line and uses the information to route the call to the correct receiving telephone.

When a dial tone decoder is connected to an external device, information about the number called can be recorded, so that a third party can tell what number has been dialed. This is called a pen register tap. The telephone conversation is not accessible to the third party, only the number called. A modern pen register tap usually sends the information to a computer with an infrared port (an infrared data association, or IRDA) that can communicate wirelessly with the dial tone decoder in the same way a remote control turns on a television. The presence of a pen register tap on a telephone line is difficult to detect.

Historically, wiretap laws in the United States were designed to protect the content of telephone conversations. Initiating a telephone wiretap required a court order and a high level of proof that the wiretap was essential to an investigation. Because pen register taps (or the reverse, trap and trace taps, which decipher the numbers of the telephones that originate incoming calls) do not allow access to the contents of calls, it has historically been much easier for investigators to obtain court orders for these types of taps. The Patriot Act, which was passed following the 2001 terrorist attacks on the Pentagon and the World Trade Center in New York City, made it even easier for law-enforcement agencies to place pen register taps. All the act requires is that the requesting agency certify that information likely to be obtained from the tap is relevant to an investigation.

In the twenty-first century, telecommunication companies routinely record originating and receiving telephone numbers of all calls for billing purposes, so pen register taps are not as useful as they once were. Law-enforcement agencies can get the same information by obtaining court orders that require telecommunication companies to release the calling information for particular individuals or telephones.

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Further Reading

Diffie, Whitfield, and Susan Landau. *Privacy on the Line: The Politics of Wiretapping and Encryption*. Cambridge, Mass.: MIT Press, 2007.

Olejniczak, Stephen P. *Telecom for Dummies*. Indianapolis, Ind.: Wiley, 2006.

See also: Computer crimes; Crime laboratories; Electronic voice alteration; Internet tracking and tracing; Telephone tap detector.

Direct versus circumstantial evidence

Definitions: Evidence that links directly to material facts is direct evidence; evidence that requires inferences to link it to material facts is circumstantial evidence.

Significance: Most forensic evidence collected from crime scenes is circumstantial evidence in its relationship to the material issue of whether suspects are guilty of the crimes charged, although such evidence may be direct evidence of lesser material facts of the crimes.

Direct and circumstantial evidence of a series of material facts related to a crime builds the case and leads to an outcome of guilt or innocence. In obtaining evidence, forensic scientists rely on Locard's exchange principle, which states that every contact of an individual with another person, place, or object results in an exchange of materials. The work of forensic science applies scientific disciplines to the law and encompasses the discovery, gathering, investigation, preservation, examination, comparison, documentation, and quality control of materials found at the scenes of crimes. The work of forensic science enables investigators to use the physical evidence or the absence of particular physical evidence at crime scenes to develop associations that prove or disprove material facts as those facts relate to the crimes.

Direct evidence is evidence that links directly to material issues in a case; it may take the form of witness testimony, video or audio recordings of the events that took place, or confession of the suspect. Fingerprints also may be direct evidence of material facts. The fact finder (judge or jury) does not have to infer anything from this evidence, as the evidence is considered to speak for itself. For example, a witness testifies that he saw the suspect strike the victim. The eyewitness testimony relates directly to the material fact that the suspect struck the victim. A video surveillance tape showing that the suspect struck the victim would also be direct evidence relating to the material issue of the suspect's guilt or innocence.

Direct evidence may link directly to a lesser material fact but not directly to the material issue of guilt or innocence. For example, a fingerprint found at a crime scene is direct evidence that a particular person was at the crime scene at some point in time. However, it is not direct evidence that the person was at the crime scene at the time the crime was committed or that the person committed the crime. The fingerprint evidence does not directly prove guilt or innocence. A photograph taken by a passenger on a passing tourist bus that shows a suspect entering a bank that was robbed may be direct evidence that the suspect was at the crime scene, but the same evidence would be circumstantial evidence that the suspect robbed the bank.

Circumstantial evidence does not establish proof in a direct sense. It requires the drawing of inferences between the evidence and a material issue before a conclusion is reached. For example, the material issue may be that the suspect struck the victim with a baseball bat. A date-stamped credit card receipt for the purchase of a baseball bat may be direct evidence that the suspect bought the bat, but it is indirect, or circumstantial, evidence that the suspect struck the victim with the bat. The receipt directly proves one fact (the purchase), but it does not directly prove the other fact (the suspect struck the victim with a baseball bat). With circumstantial evidence, the fact finder must infer any number of things to link the suspect to the material issue of guilt or innocence. The majority of forensic evidence found at crime scenes is circumstantial evidence as it relates to the material issue of suspect guilt or innocence because inferences must be made to link the evidence to guilt or innocence.

Direct and circumstantial evidence may also be found at secondary scenes of crimes—other locations where evidence connected to crimes are discovered. For example, a piece of jewelry found on a body in a shallow grave may contain a fingerprint that can be direct evidence that a suspect handled the jewelry of the deceased, but it is circumstantial evidence that the suspect had involvement with the victim's death. A fiber from a victim's clothing found in the home of a suspect may be direct evidence that the suspect had contact with the victim's clothing, but it would be circumstantial evidence that the suspect killed the victim. In each of these examples,

Case Example: Direct and Circumstantial Evidence

If valuable assets have been stolen from a company safe that was opened without the use of force at a time when no company employees had any business on the premises, evidence for the crime would fall into two categories. Direct evidence might include fingerprints on the safe, trace evidence inside the safe, a video surveillance camera tape showing the thief opening the safe, an eyewitness sighting of the thief entering or leaving the premises, or discovery of the stolen assets in someone's possession.

If no such evidence is available, investigators would turn their attention more closely to circumstantial evidence. Suspicion might then fall on a company employee who knows the combination to the safe, who shortly after the robbery quit his job and left the area, and who cannot account for his whereabouts at the time of the theft. None of these facts would directly link the employee to the crime, but in combination such circumstantial evidence could be used to build a case against him.

one must infer other actions from the indirect evidence to reach a conclusion of guilt or innocence.

Courts in the United States make no distinction between direct and circumstantial evidence in terms of importance toward proving guilt or innocence. In most of the fifty states, evidence in court cases falls under the guidelines of the Federal Rules of Evidence, which specify all instances in which evidence is relevant (pertaining to the case at hand), probative (likely to aid a fact finder in determining truth), and admissible (obtained under proper legal sanctions) to establish the facts of a case. Relevance is important in terms of whether or not a piece of evidence will be seen or heard by the court and in terms of how the evidence relates to the material issues of the case, but a determination of whether evidence is direct or circumstantial is not pertinent to the determination that the evidence is relevant and admissible at trial.

Direct evidence and circumstantial evidence hold equal weight in a court of law. Likewise, from a forensics point of view, evidence is evidence. Each piece of evidence serves to build the associations that prove or disprove material facts related to a crime.

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Further Reading

Best, Arthur. *Evidence: Examples and Explanations*. 6th ed. New York: Aspen, 2007. Uses the Federal Rules of Evidence to organize examples and explanations of types of evidence, relevance requirements, and exclusionary rules.

Genge, N. E. *The Forensic Casebook: The Science of Crime Scene Investigation*. New York: Ballantine, 2002. Presents examples of evidence sleuthing from real cases to illustrate the work involved in forensics.

Giannelli, Paul C., Albert J. Weatherhead III, and Richard W. Weatherhead. *Understanding Evidence*. 2d ed. Albany, N.Y.: LexisNexis/Mathew Bender, 2006. Provides an informative summary of the basic concepts of evidence law.

Pentland, Peter, and Pennie Stoyles. *Forensic Science*. Philadelphia: Chelsea House, 2003. Discusses the scientific methods used to investigate crime scenes. Intended for young adult readers.

Platt, Richard. *Crime Scene: The Ultimate Guide to Forensic Science*. New York: Dorling Kindersley, 2003. Explains concepts in forensic science using well-known cases and easy-to-understand examples.

Sapse, Danielle S. *Legal Aspects of Forensics*. New York: Chelsea House, 2006. Provides an overview of the legal issues relating to forensic science techniques and their uses in trials.

See also: Accident investigation and reconstruction; Class versus individual evidence; Courts and forensic evidence; Crime scene documentation; Crime scene investigation; Criminal personality profiling; Evidence processing; Eyewitness testimony; Federal Rules of Evidence; Locard's exchange principle; Physical evidence; Quality control of evidence.

Disturbed evidence

Definition: Materials that have been altered, moved, or destroyed at the scene of a crime after the crime has occurred.

Significance: An undisturbed crime scene yields the most reliable physical evidence to support the investigative process. When evidence is disturbed, the truth of what happened at the crime scene may be compromised or impossible to determine and may be impossible to prove in a court of law.

The objective of crime scene investigation is to gather evidence that supports or refutes theories surrounding the crime. Toward this end, investigators carefully choose and employ procedures that will maximize the likelihood of the discovery of pertinent evidence and minimize actions that could disturb that evidence. Taking into account Locard's exchange principle (which states that every contact of an individual with another person, place, or object results in an exchange of materials), it is implausible that all evidence at a crime scene will remain undisturbed throughout the duration of the investigation.

Although investigators may make every effort to maintain evidence in an undisturbed state, it is not unusual for evidence to be disturbed in many different ways. Frequently, evidence is disturbed in the period between discovery of the crime and securing of the scene, when numerous individuals may be present. Evidence such as blood trails, footprints, fingerprints, and pertinent biological fluids may be smeared or inadvertently erased by first responders, and materials not pertinent to the crime (such as fibers from blankets) may be introduced to the scene. Moving a living person or a dead body from the scene without taking precautionary steps to preserve surrounding evidence may result in disturbed evidence.

Evidence may be disturbed when individuals at the scene move objects, break objects, spill liquids, wipe up spills, remove clothing, cover victims, or otherwise introduce materials onto the scene that are not pertinent to the crime. Natural occurrences can also disturb evidence, such as when a crime victim dies in an outdoor setting and is exposed to weather conditions that alter or wash away materials. Evidence may also be disturbed by inappropriate or careless investigative techniques, such as when a technician pours casting material into a depression on a surface before checking the surface for fingerprints.

Investigators minimize or prevent the disturbance of evidence by securing the crime scene, by choosing an appropriate crime scene search pattern, and by following an effective sequence of evidence collection. Securing the crime scene entails controlling who is allowed onto the crime scene, designating the entrance and exit paths for responders administering to any victims, and establishing the search methods that will be used. An appropriate crime scene search pattern guides a methodical search that maximizes evidence discovery efforts while minimizing disturbance of the scene. In an effective sequence of evidence collection, pertinent materials are gathered before other investigative actions are taken that could disturb those materials. Through these actions and methods, investigators attempt to ensure that crime scene evidence is not disturbed; when these methods are followed and evidence is nevertheless somehow disturbed, investigators make note of any reasonable explanation for the disturbance so that it does not jeopardize the utilization of pertinent evidence in a court of law.

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Further Reading

Genge, N. E. *The Forensic Casebook: The Science of Crime Scene Investigation*. New York: Ballantine, 2002.

Pentland, Peter, and Pennie Stoyles. *Forensic Science*. Philadelphia: Chelsea House, 2003.

Platt, Richard. *Crime Scene: The Ultimate Guide to Forensic Science*. New York: Dorling Kindersley, 2003.

See also: Chain of custody; Crime scene investigation; Crime scene search patterns; Cross-contamination of evidence; Evidence processing; First responders; Locard's exchange principle; Physical evidence; Quality control of evidence.

DNA analysis

Definition: Process in which DNA is obtained from biological materials—such as saliva, blood, semen, sweat, urine, hair, tissue, or bone—for use in typing that can reveal information on individual identities or genetic relationships between individuals.

Significance: After crime scene investigators identify and collect evidence samples consisting of biological materials, forensic scientists extract DNA from the samples so that the sources of the samples can be determined. This work allows further analysis that can link suspects to crimes and exclude innocent persons as suspects.

DNA (deoxyribonucleic acid) is a small biological molecule that contains the genetic material that dictates individual traits. It is contained in every cell in the human body except mature red blood cells. Because DNA is the basic unit of all life, the cells of nonhuman living organisms, such as plants, microbes, and animals, also contain it.

In addition to identifying potential suspects, the results of DNA analysis have been used to exonerate innocent persons who have been wrongly convicted, to establish paternity, and to identify the victims of mass murder and natural catastrophes. In some cases, DNA analysis of canine samples has been used when dogs have been involved in crimes or to establish the presence of persons at crime scenes through the matching of canine hairs on their clothing or other personal belongings. DNA analysis has also been performed on microbial samples, to trace the origins of deadly pathogens, and on botanical samples, to gather information about the origins of certain plants (such as marijuana) and about plant specimens found at crime scenes.

Biological evidence obtained at crime scenes can provide investigators with little or no information unless the DNA contained within the evidence samples is analyzed. A forensic scientist cannot compare a sample of saliva, for example, with a sample of a suspect's blood or a sample of the suspect's saliva just by looking at the swab on which the saliva was collected, nor can the scientist compare such samples simply by looking at them under a microscope. To compare and contrast samples of biological evidence and determine whether two samples could have originated from a particular individual, the scientist needs to extract the DNA from the evidence samples. The process of DNA analysis consists of a series of steps that lead to samples that can be separated into distinct DNA fragments, or sequenced, to obtain profiles for comparison to the DNA profiles of known persons, thereby establishing individual identities.

Ohio's Cuyahoga County coroner examines the remains of a body found buried in Cleveland in 1938. During the late 1930's, bones from five women and seven men believed to be the victims of a serial-killing spree known as the Torso Murders were uncovered in and around Cleveland. Using the forensic techniques available at that time, investigators could identify only three of the victims. In 2003, a documentary filmmaker proposed using DNA analysis to identify the remaining victims. However, investigators still faced the monumental problem of finding control samples with which to match DNA samples from the bodies. *(AP/Wide World Photos)*

DNA Extraction

After biological evidence samples are submitted to the laboratory, DNA analysts carefully obtain subsamples from the original samples and then use one of the available extraction (also known as isolation) methods to isolate the DNA in the subsamples. Just as there are different biological sources from which scientists must obtain DNA samples, different methods have been developed for this purpose. The methods vary in complexity and the amounts of time they take as well as in quality and sample throughput, but the same principles underlie all of these extraction technologies.

The sample is first subjected to a lysis (dissolution) step, which can be mechanical, chemical, or a combination of both, depending on the material. During this step, the cells are broken open to allow their contents to be released. Following this, the DNA in solution is bound to a membrane or magnetic beads and the remaining of the cell's contents are subsequently subjected to a series of washes that usually contain ethanol. Because DNA is insoluble in ethanol, it remains attached to the membrane or it is pelleted during centrifugation while the remaining components are either dislodged from the membrane or stay in solution (the supernatant) and are discarded. In the last step of the extraction, the DNA is resuspended in distilled water or an elution buffer.

The process of obtaining high-molecular-weight DNA from known mixed samples, as is often necessary in cases of rape, or from degraded samples or samples that have been exposed to harsh environmental conditions is usually more complicated, as the forensic scientist must take special care either to separate the fractions corresponding to the potential mixture or to remove environmental contaminants. When potential DNA inhibitors (such as dyes, humic acids, or heme) are present, a DNA purification step must be performed before the analysis can proceed.

DNA Quantification

After the DNA has been isolated, the analyst needs to quantify the DNA and dilute it to a predetermined amount in order to amplify it. An analyst can estimate DNA concentrations using agarose gels, fluorometry, or spectrophotometry, but the most accurate means of determining the DNA concentration of a particular sample is through real-time polymerase chain reaction (qPCR). This process follows the same principle as the traditional PCR, but it quantifies the sample as it is amplified using fluorescence. Specific primers are added so that only the type of DNA of interest is quantified.

The technology of qPCR works with fluorescent dyes that are introduced into the double strands of the DNA and emit a signal or with gene-specific probes that fluoresce when they find a complementary DNA strand with which to bind. The emitted signals are recorded and transferred to a computer, which provides the output and transforms it into a numerical value. After the DNA is quantified, it is diluted to the required concentration for that type of sample and the corresponding PCR amplification "recipe."

DNA Amplification

The final step of the analysis is the amplification of the DNA sample. Amplification is the exponential copying of a gene fragment or fragments of interest. The sample is subjected to cyclic increases and decreases in temperature while in a mixture of (fluorescent) primers that demarcate the fragments of interest, an enzyme that extends the newly created fragments, and other reagents that provide the optimal conditions for in vitro replication of the specific genetic marker or markers of interest.

The steps described above are only the first portion of a series of procedures performed on a biological evidence sample. When DNA analysis is complete, the forensic scientist can begin the task of DNA typing, which allows the comparison of an evidence DNA sample to a known DNA standard.

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Further Reading

Budowle, Bruce. "Genetics and Attribution Issues That Confront the Microbial Forensics Field." *Forensic Science International* 146 (Fall, 2004): S185-S188. Discusses the potential for using microbial DNA as a means of attribution in forensic scenarios.

Gehrig, Christian, and Anne Teyssier. "Forensic DNA Analysis." *CHIMIA International Journal for Chemistry* 56 (March, 2002): 71-73. Describes the various techniques available for DNA analysis of human samples.

Hunter, William. *DNA Analysis*. Philadelphia: Mason Crest, 2006. Presents an interesting discussion of the different applications of DNA analysis in crime scene investigations.

Miller, Heather. *Nonhuman DNA Typing*. Boca Raton, Fla.: CRC Press, 2007. Introduces the field of nonhuman DNA typing and its applications to forensics. Includes interesting case examples with information on legal decisions.

Rudin, Norah, and Keith Inman. *An Introduction to Forensic DNA Analysis*. 2d ed. Boca Raton, Fla.: CRC Press, 2002. Uses very simple language to describe all the basic principles of DNA analysis in the forensic sciences. Includes a useful glossary.

See also: CODIS; DNA extraction from hair, bodily fluids, and tissues; DNA fingerprinting; DNA isolation methods; DNA profiling; DNA sequencing; DNA typing; Ethics of DNA analysis; Federal Bureau of Investigation DNA Analysis Units; Mitochondrial DNA analysis and typing; National DNA Index System; Polymerase chain reaction; Postconviction DNA analysis; Y chromosome analysis.

DNA banks for endangered animals

Definition: Facilities that preserve genetic materials from and information about endangered animal species.

Significance: Building on the advances being made in DNA-related technologies in forensic science and the knowledge being accumulated in the related field of wildlife forensics, some organizations have undertaken to collect and store the genetic materials of endangered animal species in the hope that someday technological advancements will enable scientists to use these materials to restore the species.

Organizations that are concerned with the loss of animal species to extinction have established banks to preserve the DNA (deoxyribonucleic acid) of endangered animals. In addition to collecting and storing biological samples from endangered species (sperm, embryos, and body tissues), preserving them in liquid nitrogen at nearly –400 degrees Fahrenheit, these organizations store information on the species' natural habitats and maintain databases to keep track of the materials that have been collected. Organizations devoted to preserving animal DNA have been established in the United States, Great Britain, China, India, and Australia; among the most widely known animal DNA banks are those maintained by the Frozen Ark Project in England and the Frozen Zoo Project in San Diego, California.

Several factors have come together to fuel the animal DNA bank movement, including advances in DNA technology and growing environmental activism. The banking of animal DNA is a conscience-driven effort by people who also want to increase awareness of the threats posed to existing species by human advancement. Estimates of potential extinctions in the twenty-first century are ominous, with some researchers asserting that the world is in the midst of a mass extinction period. Many species considered to be endangered or threatened in the early twenty-first century may someday benefit from DNA banks, including the California condor, the Florida panther, the polar bear, the killer whale, the black rhino, the panda, and the yellow seahorse.

Critics of the organizations that maintain DNA banks for endangered animals have asserted that these organizations may inadver-

The keeper of zoology at the Natural History Museum in London, England, holds a test tube on which rests a Polynesian tree snail, one of the endangered species whose DNA is stored at the museum. The museum is part of the Frozen Ark Consortium. *(AP/Wide World Photos)* tently create an underground market for the animals they mean to protect; the stored genetic materials could potentially have high monetary value. Moreover, many scientists believe that species extinction is a natural part of the planet's life cycle, one that humans should not tamper with, at least until they have had much more time to observe the interactions between species and Earth's environment. The animal DNA banks, however, enjoy widespread support among scientists, if only for the value they provide as historical databases.

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Further Reading

McGavin, George. *Endangered: Wildlife on the Brink of Extinction*. Richmond Hill, Ont.: Firefly Books, 2006.

Stone, Richard. *Mammoth: The Resurrection of an Ice Age Giant*. New York: Basic Books, 2002.

See also: Animal evidence; DNA extraction from hair, bodily fluids, and tissues; DNA isolation methods; DNA typing; Forensic botany; Polymerase chain reaction; Wildlife forensics.

DNA database controversies

Definition: Debates on social, ethical, and legal issues that surround the existence of databases containing the individual DNA profiles of large numbers of persons.

Significance: DNA databases constitute extremely important tools for law enforcement, but the existence of such repositories raises social, ethical, and legal issues, particularly concerning privacy rights and confidentiality. Because of the potential for misuse of the information stored in DNA databases, issues of public safety need to be balanced with the protection of civil liberties.

Each person has a unique DNA (deoxyribonucleic acid) profile that may be used to identify that individual. DNA samples, however, may also be used for other purposes; a person's DNA can reveal susceptibility to certain diseases, for example, or predisposition to certain behaviors. The establishment of DNA databases has helped law-enforcement agencies greatly in identifying suspects, but many observers have expressed concerns regarding the potential for misuse of the information stored in these databases.

DNA Dragnets and Fourth Amendment Issues

After serious crimes have been committed, law-enforcement agencies sometimes conduct so-called DNA dragnets to attempt to identify suspects; that is, they obtain DNA samples from all persons in selected groups of individuals to compare with DNA found at the crime scenes. In these cases, the people involved are generally pressured to "volunteer" DNA samples or the samples are taken without due process. In one case, all men in Truro, Massachusetts (a town with a population of approximately eighteen hundred), were requested to volunteer DNA samples after a murder. In Baton Rouge, Louisiana, samples were collected from about twelve hundred men during a hunt for a serial killer. The Fourth Amendment to the U.S. Constitution protects against unreasonable searches and seizures, and it has been argued that such collection of DNA samples without probable cause (a reasonable belief that the individuals have some involvement with the crimes) may constitute "unreasonable search"

Fourth Amendment to the U.S. Constitution

The right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures, shall not be violated, and no Warrants shall issue, but upon probable cause, supported by Oath or affirmation, and particularly describing the place to be searched, and the persons or things to be seized.

under the Fourth Amendment. It is likely that this issue will ultimately be decided by the U.S. Supreme Court.

The DNA profiles produced as a result of DNA dragnets are usually entered into state criminal databases. In most cases, removal of a profile from such a database requires a court order. In some states, including Virginia and Louisiana, the DNA profiles of any individuals who are arrested, even if they are not convicted, are also retained in databases. Some critics have argued that the inclusion of unconvicted individuals in DNA databases may be viewed as a violation of the concept of presumption of innocence.

A forensic scientist at the Virginia Division of Forensic Science prepares a DNA sample found at a crime scene for testing. As of 2001, the state's database of DNA from felons was averaging one "cold hit" per day, where DNA found at a crime scene was matched to DNA on file in the database. The American Civil Liberties Union has expressed opposition to this use of the technology, saying that it violates the rights of felons, who, by law, must give blood samples to the state for inclusion in the database. *(AP/Wide World Photos)*

The national DNA database maintained by the Federal Bureau of Investigation (FBI), known as CODIS (Combined DNA Index System), does not permit the entering of "volunteer" DNA profiles. The U.S. Congress, however, has made it legal for federal agencies to collect DNA samples from suspected illegal immigrants, and those profiles are entered into CODIS.

Familial Issues

People who are related by blood have similar, but not identical, DNA profiles. Given this fact, law-enforcement agencies sometimes search DNA databases for less-than-perfect matches to their suspects' DNA profiles; this is known as familial searching. By finding first-degree relatives, the police may identify suspects. Such searches have been criticized as violating the privacy rights of the parties involved; they have yet to be tested in the courts. Familial searching has also been criticized as racially discriminatory. For instance, because African Americans are disproportionately represented in CODIS, they are approximately four times more likely than Caucasians to be "findable" through familial searching.

In addition to the use of DNA databases by law-enforcement agencies, the storage of DNA profiles in such repositories raises many other issues, particularly in the areas of privacy and confidentiality. Information on adoption and sperm and egg donation, for example, can be very sensitive, with many parties wishing to remain anonymous. Such anonymity is threatened by the placement of DNA profiles in searchable databases.

Universal Databases and Discrimination

By 2007, nine countries had established population-based DNA databases as resources for the study of genealogy and gene-disease relationships. In some nations, initiatives have been undertaken to include DNA profiles of all newborns in these databases. The storage of this information may be useful to scientists who seek to understand the genetic components of disease, but it raises issues of privacy and confidentiality. Of particular importance is the question of who has the right to access the data. In the United States, the courts have yet to decide whether DNA database information falls under the security and privacy provisions of the Health Insurance Portability and Accountability Act (HIPAA) of 1996.

It has been argued that universal DNA databases and disease gene databases have great potential for abuse. Disease genes are being identified at an increasing rate, and screening for many such genes is becoming easier and cheaper. In addition to government databases, private DNA databases are being established, and these pose additional issues of confidentiality because they contain more detailed information than that found in the government databases and so will be less likely to protect individuals' anonymity. As critics have pointed out, the availability of information on individuals' genetic characteristics has the potential to lead to discrimination by insurance carriers, employers, educational institutions, and government agencies.

Retention of DNA samples

A DNA profile only identifies the individual. The genetic markers used are short tandem repeat (STR) regions of the genome where there are variable numbers of certain DNA segments. These regions do not encode functional genes, so a person's DNA profile does not contain information on the individual's genetic makeup. In contrast, the DNA sample from which the profile was created contains all of that person's genetic information. Most U.S. states do not have laws that require the destruction of DNA samples after DNA profiling is complete.

Moreover, hospitals, clinics, and doctors' offices store tissue samples taken for biopsies or retained for research from which DNA may be extracted and analyzed. No set policy exists among forensic laboratories regarding destruction of DNA samples, and many preserve such samples in case additional testing is deemed necessary or the results of previous tests need to be confirmed. It has been argued that government agencies have not adequately regulated the retention and future potential uses of such DNA samples.

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Further Reading

Greeley, Henry T. "The Uneasy Ethical and Legal Underpinnings of Large-Scale Genomic Biobanks." *Annual Review of Genomics and Human Genetics* 7 (2007): 343-364. Discusses the various issues related to the existence of private databases that contain genetic information on individuals.

Lazer, David, ed. *DNA and the Criminal Justice System: The Technology of Justice*. Cambridge, Mass.: MIT Press, 2004. Collection of essays explores the ethical and procedural issues related to DNA evidence. Includes a chapter by Associate Justice Stephen G. Breyer of the U.S. Supreme Court.

Moulton, Benjamin W. "DNA Fingerprinting and Civil Liberties." *Journal of Law, Medicine and Ethics* 34 (Summer, 2006): 147-148. Presents an overview of the issues addressed at a symposium on the topic of DNA fingerprinting and civil liberties. Contributions to the symposium appear as articles in the same issue of the journal.

Swede, Helen, Carol L. Stone, and Alyssa R. Norwood. "National Population-Based Biobanks for Genetic Research." *Genetics in Medicine* 9, no. 3 (2007): 141-149. Focuses on the ethics issues related to the establishment of national genetic databases.

Weiss, Marcia J. "Beware! Uncle Sam Has Your DNA: Legal Fallout from Its Use and Misuse in the U.S." *Ethics and Information Technology* 6, no. 1 (2004): 55-63. Discusses the constitutionality of DNA profiling.

See also: Argentine disappeared children; CODIS; DNA analysis; DNA fingerprinting; DNA typing; Ethics of DNA analysis; Federal Bureau of Investigation DNA Analysis Units; Jefferson paternity dispute; National DNA Index System; Paternity testing; Short tandem repeat analysis.

DNA extraction from hair, bodily fluids, and tissues

Definition: Techniques used to obtain DNA from different kinds of biological materials so that the DNA can be analyzed.

Significance: DNA comparison has become a critical tool for identifying victims and suspects in a variety of crimes, and biological evidence such as hairs, bodily fluids, and tissues can provide the DNA needed for comparisons.

When biological materials that have been found at crime scenes—such as hairs, bodily fluids, and tissues—are submitted for DNA (deoxyribonucleic acid) analysis, the samples must first undergo DNA extraction procedures. The most common methods for extracting DNA from such materials are organic extraction, Chelex extraction, extraction using preservation paper, and extraction using silica-based columns. The common organic extraction uses detergent and proteinase to break open (lyse) cells, followed by introduction of an organic solvent to separate proteins and other cellular debris away from the DNA. Chelex extraction is a quick and easy procedure, but the purity of the DNA extracted is low. Chelex binds metal ions that could otherwise lead to poor DNA typing results, but little other purification is done. Preservation papers provide another quick method for extracting DNA. Bodily fluids are applied directly to the paper, where the cells are immediately lysed. Once the sample is dried, a small portion can be punched out, washed briefly, and then moved directly to DNA amplification. Silica-based columns bind DNA following cell lysis, allowing cellular debris to be washed through. The DNA is then eluted in relatively pure form.

Hair

Given their ubiquity, hairs are often found at crime scenes. Hairs with root tags attached are excellent sources of DNA, whereas hairs without their roots are not good sources of nuclear DNA for short tandem repeat (STR) testing. Shed hairs, which are the kind most often found at crime scenes, generally do not have root tags and so require mitochondrial DNA testing.

Hair roots are processed like other tissues. A questioned shed hair is first cleaned to remove any exogenous DNA; an enzymatic detergent such as Terg-A-Zyme is often used for this purpose. The keratin (protein) of the hair is broken down with proteinase, detergent, and dithiothreitol, releasing any trapped DNA. Prior to this, the hair may be ground or homogenized, which further helps to free DNA.

An alternative method for extracting DNA from hair is alkaline extraction. The hair is washed and then is exposed to a strong basic solution (such as sodium hydroxide), which destroys the protein without harming the DNA. The solution is neutralized and filtered, leaving the DNA ready for analysis.

Bodily Fluids

The bodily fluids most commonly processed in crime laboratories (generally in dried form) are semen and blood; these are followed in frequency by saliva and urine. Other fluids, including vaginal secretions and perspiration, are also sources of DNA. In blood, the abundant red blood cells do not have nuclei and therefore do not contain DNA. In contrast, white blood cells, which make up less than 1 percent of cells present in blood, harbor a full DNA component. This means that blood is a valuable source of DNA, although not an ideal one.

Semen, which contains huge numbers of spermatozoa, each containing its complement of DNA, is considered one of the richest sources of genetic material. Owing to the strength of sperm cell walls, isolation of DNA from semen requires treatment similar to that of hair shafts. The other bodily fluids contain DNA somewhat by chance, in that epithelial cells are shed into them, such as from the mouth (saliva) or urinary tract (urine). DNA from these sources can be isolated from bodily fluids using several of the procedures noted above.

Skin, Bone, and Other Tissues

Shed skin cells are a viable source of DNA and may potentially be collected from any item that has come into contact with skin, such as clothing, keys, or backpacks. Generally, organic extraction of such DNA is performed after a cutting or swab is collected from the item that has had skin contact. It should be noted that individuals can shed cells at very different rates; thus two pieces of evidence that seem similar may produce variable levels of DNA typing success.

Bones are frequently included in forensic investigations, in general owing to their relative longevity. Fresh skeletal material is a rich source of DNA, but the longer bones are in contact with the environment, the more degraded the DNA becomes. Likewise, inhibitory chemicals such humic acids can leach from soil into bone, making DNA analysis difficult. This is particularly true of spongy bones, where rain, soil, and microorganisms easily enter and destroy DNA. In contrast, skeletal materials with more cortical (compact) bone (such as the femur, or thighbone) resist DNA degradation. The DNA is extracted as described above after the bone is cleaned and then ground or drilled to create a powder. In some instances, bone may be decalcified using EDTA (ethylenediaminetetraacetic acid), which helps to augment its breakdown.

Other tissues are also potential sources of DNA. Generally, tissues that do not harbor degradative enzymes (as does the digestive tract, for instance) are favored. Small pieces of tissue may be homogenized to disrupt cells before the tissue is incubated in detergent and proteinase. Organic extraction is the most common method of DNA purification, but DNA has

Forensic scientists work in the DNA extraction laboratory of the New Jersey State Police Forensic Science Center in Hamilton, New Jersey, where about ninety forensic specialists were employed in 2004. *(AP/Wide World Photos)* been extracted successfully using the Chelex and silica-based column methods.

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Further Reading

Belgrader, P., et al. "Automated DNA Purification and Amplification from Blood-Stained Cards Using a Robotic Workstation." *BioTechniques* 19 (September, 1995): 426-432. Describes the automated isolation of DNA from paper matrices.

Butler, John M. *Forensic DNA Typing: Biology, Technology, and Genetics of STR Markers*. 2d ed. Burlington, Mass.: Elsevier Academic Press, 2005. Provides a detailed overview of DNA methodologies used by forensic scientists.

Deedrick, Douglas W. "Hairs, Fibers, Crime, and Evidence: Part 1—Hair Evidence." *Forensic Science Communications* 2 (July, 2000). Presents an overview of the uses of hairs as forensic evidence.

Graffy, Elizabeth A., and David R. Foran. "A Simplified Method for Mitochondrial DNA Extraction from Head Hair Shafts." *Journal of Forensic Sciences* 50 (September, 2005): 1119-1122. Describes the alkaline method for DNA extraction from head hairs.

Nagy, M., et al. "Optimization and Validation of a Fully Automated Silica-Coated Magnetic Beads Purification Technology in Forensics." *Forensic Science International* 152, no. 1 (2005): 13-22. Discusses the automated isolation of DNA using silica.

Walsh, P. S., D. A. Metzger, and R. Higuchi. "Chelex 100 as a Medium for Simple Extraction of DNA for PCR-Based Typing from Forensic Material." *BioTechniques* 10 (April, 1991): 506-513. Reports on the first detailed application of the Chelex technique for DNA isolation.

See also: Blood residue and bloodstains; Control samples; Cross-contamination of evidence; DNA isolation methods; Mitochondrial DNA analysis and typing; Physical evidence; Polymerase chain reaction; Rape kit; Saliva; Semen and sperm; Sex determination of remains; Short tandem repeat analysis; Y chromosome analysis.

DNA fingerprinting

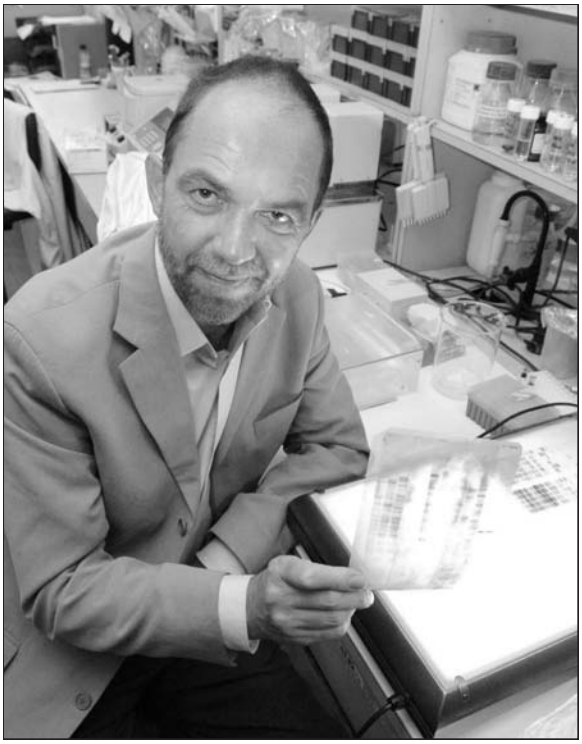
Definition: Laboratory procedure for analyzing patterns of sequence variation in DNA samples for the purpose of identifying evidence in forensic investigations.

Significance: The development of DNA fingerprinting represents one of the major breakthroughs in forensic science. Using techniques from molecular biology and increasingly detailed databases, investigators are able to examine the DNA contained within biological evidence obtained from crime scenes and compare their findings with known samples, resulting in a high degree of probability that particular pieces of evidence can be associated with individual suspects or victims.

In 1985, the English geneticist Alec Jeffreys proposed that newly discovered repetitive sequences in DNA (deoxyribonucleic acid) could be used as a form of genetic fingerprint to identify individuals. DNA fingerprinting represents a combination of both molecular biology and population genetics in that in this process, pieces of DNA are examined for the presence of specific markers and the findings are compared against known samples in a database to establish the prevalence of those markers in the general population.

Types of Genetic Markers

The human genome comprises more than 3.2 billion nucleotides, the letters that are responsible for coding for the proteins that make up and carry out bodily functions. The sequences of the human genome that code for these proteins are called genes. Humans are believed to have approximately twenty-five thousand genes. Between these genes are vast stretches of DNA that do not code for proteins. Within these areas are repetitive sequences called variable number of tandem repeats, or VNTRs. One class of VNTRs is made up of the minisatellites, sequences of up to one hundred nucleotides that may be repeated in tandem up to one thousand times. In addition to the minisatellites, microsatellites have been identified. These are also



Alec Jeffreys, the English geneticist who pioneered the use of DNA markers for personal identification, holds a copy of the first DNA fingerprint profile at the University of Leicester. *(AP/Wide World Photos)*

known as short tandem repeats (STRs) or simple sequence repeats (SSRs). Microsatellites are sequences of two to seven nucleotides that may be repeated hundreds of times. An example is the CA repeat (CACACACA) that occurs on average every thirty-thousand base pairs in the human genome.

Every human being has two copies of genetic information in each cell. This represents the genetic information contributed by each of the individual's parents. Each STR thus exists in two copies. Often, the number of repeats within a specific STR differs in the parents. These differences are called alleles. In a population, a given STR may be polymorphic, meaning that many different forms (or alleles) of the STR exist in the population. For each allele used in forensic analysis, population geneticists have determined the percentage of the population at large that contains that given allele. This information forms the basis of DNA fingerprinting.

Analysis of DNA Fingerprints

When DNA fingerprinting was initially developed, analysts examined DNA patterns using a procedure called the Southern blot. In a Southern blot, DNA is extracted from cells and then cut with a special enzyme called a restriction endonuclease. Restriction endonucleases recognize specific sequences of nucleotides in the DNA. When the sequence has been identified, the enzyme makes a cut in the DNA, generating short fragments that may be separated by size through gel electrophoresis. A radioactive probe is then used to identify specific fragments that contain sequences of nucleotides of interest. Initially, analysts accomplished this task by using minisatellites and restriction fragment length polymorphisms (RFLPs). When exposed to photographic film, the radioactive probes revealed patterns in the DNA that could be used to identify evidence.

Soon after DNA fingerprinting began, the entire process was greatly simplified by the invention of the polymerase chain reaction (PCR). Instead of cutting the DNA with restriction enzymes, the analyst copies specific sections of the genome, in this case the area containing the microsatellite repeats, millions of times. The amplified sections are then separated by gel electrophoresis, stained, and photographed. Because the fragments are much smaller than those generated during a Southern blot, the results may be ready in just a few hours of time. As with a Southern blot, the length of the fragment is determined by the number of repeats. The larger the number of repeats in the amplified section of DNA, the slower its movement during gel electrophoresis. This allows the analyst to discriminate among STRs that differ in the numbers of repeats within the amplified sequence.

In the United States, thirteen STRs have been identified for use during forensic and criminal investigations. Most investigative laboratories also include an additional test for amelogenin, a gene associated with dental pulp, which allows an investigator to determine whether a sample comes from a male or a female subject. For each of the STRs, researchers have determined the prevalence of that allele in the general population. Although the allele for one

STR may be shared by a large percentage of the population, the power of discrimination becomes much greater as the number of STRs being analyzed is increased. For example, when three STRs (A, B, and C) are used, the probability of a certain combination (A_1, B_3, C_2) is equal to the product of the frequency of that allele in the population ($A \times B \times C$). As the number of STRs increases, the chances that two individuals will share the same identical pattern decrease.

When coupled with additional evidence found at a crime scene, DNA fingerprinting can be a powerful tool for proving the guilt or innocence of a suspect. DNA fingerprinting is also used to identify human remains that have degraded over time or that have been badly damaged by exposure to chemicals or fire.

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Further Reading

Butler, John M. *Forensic DNA Typing: Biology, Technology, and Genetics of STR Markers*. 2d ed. Burlington, Mass.: Elsevier Academic Press, 2005. Provides a detailed examination of DNA fingerprinting analysis using STR markers. Intended for readers with background in the sciences.

Jeffreys, A. J., V. Wilson, and S. L. Thein. "Individual-Specific 'Fingerprints' of Human DNA." *Nature* 316 (1985): 76-79. Landmark paper that introduced the concept of DNA fingerprinting as a method of identification.

Kobilinsky, Lawrence F., Louis Levine, and Henrietta Margolis-Nunno. *Forensic DNA Analysis*. New York: Chelsea House, 2007. Presents a comprehensive introduction to the use of STRs in DNA fingerprinting. Includes discussion of future directions, including mitochondrial and Y chromosome analyses.

Rudin, Norah, and Keith Inman. *An Introduction to Forensic DNA Analysis*. 2d ed. Boca Raton, Fla.: CRC Press, 2002. Provides a good introduction to the use of biological evidence in forensics as well as the history and application of DNA fingerprinting in forensic investigations.

See also: CODIS; DNA analysis; DNA database controversies; DNA isolation methods; DNA profiling; DNA typing; Electrophoresis; Ethics of DNA analysis; Mitochondrial DNA analysis and typing; National DNA Index System; Polymerase chain reaction; Postconviction DNA analysis; Restriction fragment length polymorphisms; September 11, 2001, victim identification; Short tandem repeat analysis.

DNA isolation methods

Definition: Techniques used to obtain DNA specimens from biological materials.

Significance: DNA obtained from forensic samples can be used to link suspects to crime scenes, associate suspects and victims, identify the remains of missing individuals, or determine parentage. Numerous techniques are available for isolating DNA from cellular material; the choice of the most appropriate helps to ensure that a DNA profile will be obtained successfully.

The isolation of DNA (deoxyribonucleic acid) from biological material can be relatively straightforward, but forensic scientists must consider several factors before commencing. The first of these is the planned subsequent DNA analysis, including whether the DNA can be single-stranded, as for polymerase chain reaction (PCR) analyses, or must be double-stranded, as for restriction fragment length polymorphism (RFLP) testing. The source of the sample (whether blood, semen, hair, or bone) will influence processing choices and may mean that a tissue must be processed in advance (for example, skeletal material may need to be ground). Other considerations include the desired level of DNA cleanliness, the maximization of yield, the minimization of processing steps, the number of samples, the presence of mixtures, and the presence of potential PCR inhibitors (such as iron in blood or humic acid in soil).

Commonly used methods of DNA isolation in forensic laboratories include organic extraction, differential extraction, Chelex, the use of preservative papers, the use of isolation kits, and the use of robotics. All of these involve breaking open cells (lysis) to release DNA, purification to remove unwanted material, and harvesting the DNA for analysis.

Once an extraction method is chosen, the analyst must take steps to prevent contamination. Proper training of laboratory personnel is imperative; disposable gloves and protective clothing should be worn, and equipment must be cleaned regularly. A reagent blank control, containing no tissue but undergoing the same extraction process, should be included to ensure that reagents are not contaminated.

Organic Extraction

Organic extractions are widely used in forensic laboratories owing to their general applicability and the purity of the resultant DNA. Following cell lysis (with a proteinase and detergent), undesired materials (such as fats and proteins) are solubilized into an organic solvent such as phenol or chloroform.

Organic extractions can be time-consuming, but the DNA collected is relatively clean, can be used for any type of subsequent analysis, and is amenable to any tissue type. Disadvantages of these methods include lengthy time expenditure and exposure to hazardous chemicals.

Differential Extraction

An expanded organic method is the differential extraction, which is used on samples from sexual assaults, particularly vaginal swabs, which can contain epithelial cells from the victim and sperm from the perpetrator. Differential extractions take advantage of the dissimilar nature of sperm and epithelial cell walls. The sample is first placed in a mild lysis buffer that releases epithelial cell DNA while sperm remain intact. The sperm are pelleted by centrifugation, and the liquid containing epithelial DNA (the nonsperm fraction) is removed and purified organically. The sperm are then lysed under stronger conditions, and this male/sperm fraction is purified. Differential extraction allows enrichment of each fraction by upward of 90 percent, helping to clarify mixture results.

Chelex Extraction

DNA preparation using Chelex (iminodiacetic acid bound to polystyrene beads) has two positive attributes: It is fast and it is easy. The entire procedure is carried out in a single tube and is generally performed on blood and saliva, although other tissues may be considered. The major objective of a Chelex extraction is to bind (chelate) unwanted metals that can inhibit PCR, notably polyvalent cations (such as iron and calcium). The sample is boiled, and upon centrifugation the beads are forced to the bottom of the tube, leaving the DNA in solution ready for quantification and amplification. Because minimal purification steps are involved in this method, the DNA is not pristine (hence it may not amplify or store well). Also, owing to the boiling step, the DNA is single-stranded.

Preservative Papers

One of the simplest methods for extracting DNA is through the use of special papers chemically treated to lyse cells and denature proteins on contact. A liquid sample (blood, saliva) is applied to the paper and dried, then stored at room temperature or used immediately. A small punch of the stained paper is collected, washed, and subjected directly to PCR. Extended sample stability is the major advantage of the use of preservative papers; disadvantages include possible difficulty in manipulating the papers and the fact that this method produces no DNA quantification.

Commercial DNA Isolation Kits

Several companies have developed commercial kits for DNA purification. These tend to be quick (as little as thirty minutes) and easy to use, but they are often expensive. Kits can allow for a large number of samples to be processed simultaneously, and manufacturers provide necessary solutions as well as other materials, such as tubes and columns. Generally, cells are lysed and the DNA is bound in place (for example, to silica on a column), followed by washing and DNA release. The DNA isolated tends to be pure, but sample digestion is short, and thus yield may be sacrificed; yield can particularly suffer when limited amounts of DNA exist.

A forensic scientist tests a shirt for blood in the DNA section of the Seattle crime laboratory of the Washington State Patrol. *(AP/Wide World Photos)*

Automation

The use of robotic means of DNA preparation allows the processing of large numbers of samples in short amounts of time while eliminating the human factor. Automated DNA isolation is most desirable for work with high-quality material, such as database samples. Material involved in law-enforcement investigations is less often processed in this manner. In automated methods, the DNA isolation procedures are similar to those detailed above (particularly those for kits), with reagent transfer being automated. The robots involved are expensive, as are the proprietary reagents required, but the savings in technician time can be substantial.

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Further Reading

Belgrader, P., et al. "Automated DNA Purification and Amplification from Blood-Stained Cards Using a Robotic Workstation." *BioTechniques* 19 (September, 1995): 426-432. Discusses the automated isolation of DNA from paper matrices.

Butler, John M. *Forensic DNA Typing: Biology, Technology, and Genetics of STR Markers*. 2d ed. Burlington, Mass.: Elsevier Academic Press, 2005. Provides a detailed overview of the basic biology of DNA and forensic DNA methodologies.

Greenspoon, S. A., et al. "Application of the BioMek 2000 Laboratory Automation Workstation and the DNA IQ System to the Extraction of Forensic Casework Samples." *Journal of Forensic Sciences* 49 (2004): 29-39. Reports on the automated isolation of DNA through the use of a commercial kit.

Nagy, M., et al. "Optimization and Validation of a Fully Automated Silica-Coated Magnetic Beads Purification Technology in Forensics." *Forensic Science International* 152, no. 1

(2005): 13-22. Describes the automated isolation of DNA using silica.

Walsh, P. S., D. A. Metzger, and R. Higuchi. "Chelex 100 as a Medium for Simple Extraction of DNA for PCR-Based Typing from Forensic Material." *BioTechniques* 10 (April, 1991): 506-513. Reports on the first detailed application of the Chelex technique for DNA isolation.

See also: Blood residue and bloodstains; Cross-contamination of evidence; DNA analysis; DNA extraction from hair, bodily fluids, and tissues; Mitochondrial DNA analysis and typing; National DNA Index System; Polymerase chain reaction; Rape kit; Saliva; Semen and sperm; Short tandem repeat analysis.

DNA postconviction analysis. *See* Postconviction DNA analysis

DNA profiling

Definition: Process of statistically analyzing the output of DNA typing results to determine the probability that another nonrelated individual in the general population might share the same exact DNA fingerprint as the one obtained in the evidence sample.

Significance: When DNA is analyzed and typed, a graph (called an electropherogram) containing peaks representing the different alleles (different forms of a gene) inherent to that particular sample is obtained. These data must be statistically interpreted by a forensic scientist, who calculates the frequency of that "fingerprint" combination in the general population, before they are presented and accepted in a court of law. Without statistical value, DNA processing serves no practical purpose in criminal investigations.

In legal cases involving DNA (deoxyribonucleic acid) evidence, statistical analysis provides investigators with a tool that can potentially exclude innocent individuals from suspect lists. In forensic science, DNA samples are used not only to establish similarities between evidence and suspects or victims but also to identify victims of mass murders and catastrophes and to determine parentage of children. The statistical analyses employed vary depending on the situation.

Because 99 percent of the bases that form the human genome are identical among all individuals, analysts need to use several different DNA markers to encounter differences in the remaining 1 percent. Most crime laboratories in the United States use the thirteen short tandem repeat (STR) markers used by the national DNA database, the Combined DNA Index System (CODIS), to compare DNA samples. Of these thirteen markers, only one needs to differ to exclude a particular individual (except identical twins) from being the source of an evidence sample. In that case, no statistical analysis is necessary. The inclusion of individuals, however, is somewhat more complicated.

Allele frequencies for each STR marker (the number of occurrences of a particular allele) have been determined by scientists working for the Federal Bureau of Investigation (FBI), a project funded by the National Science Foundation (NSF), and the National Institute of Science and Technology for various geographic regions and ethnic populations. These databases were created through the collection of DNA results from many (at least two hundred) individuals and the calculation of a percentage frequency of allele X in the total population surveyed for a specific marker. Individual crime laboratories determine which of the databases they use for frequency calculations, but the end results are similar in that they have either a very low or very high probability.

Statistical Approach

Each human being is made up of thousands of genes, each of which is inherited from the parents. Most individuals possess two copies (alleles) of a gene, one donated by the mother and one donated by the father. These copies can have either the same form (for example, two alleles for black hair) or different forms (one allele for black hair, one allele for blond hair). If the occurrence of inheriting one marker has no effect on the occurrence of the other, statisticians and analysts are able to multiply the frequencies of the individual alleles to establish the overall frequency of the DNA profile.

In criminal investigations, the races or geographic origins of the perpetrators are often not known; thus, a forensic scientist cannot place a suspect into an ethnic category (with any degree of certainty high enough to stand up in court) when determining which allele frequencies to use. Therefore, the most conservative approach is commonly used. For example, if given an allelic frequency database that has African American, Caucasian, and Asian populations, and the frequency of allele A of marker B is to be determined, the analyst will probably select the population in which allele A is more common or has the highest percentage. In doing this for each allele in question, the analyst will obtain a final number that is the highest possible for that specific profile. This approach ultimately favors the suspect and removes any biases that might compromise the investigation. Once all the allelic frequencies corresponding to the sample are obtained, the Hardy-Weinberg probabilistic principle is used to calculate the occurrence of that DNA fingerprint.

The Hardy-Weinberg principle is based on the assumption that the probability of two independent events occurring at the same time is the product of the probability of them occurring separately. The equilibrium formula for the Hardy-Weinberg principle is $p^2 + 2pq + q^2$, in which p and q represent the two possible forms of a particular gene. Thus, when an individual is homozygous (has two identical copies of the allele) for a particular allele, the frequency of that allele is squared (p^2 or q^2) to obtain the overall frequency for that marker in that particular individual. If the individual is heterozygous (has two different copies of the allele), then the frequency of the first allele is multiplied by the frequency of the second allele and the product is multiplied by two ($2pq$). Once all marker frequencies are obtained, the individual frequencies are multiplied to obtain the rarity of the overall DNA fingerprint.

Interpretation

When attempting to establish biological relationships, such as paternity, analysts do not attempt to find the probabilistic nature of randomly finding other individuals in the general population with matching profiles. Instead, they take into account the increased probability of similarity between samples (because there is a chance that they are related) to prevent under- or overestimation of the likelihood ratio. Take, for example, a paternity dispute in which the DNA of a child's alleged father is analyzed. It is known that the child has a father, and because there is only one alleged father, a fifty-fifty chance exists that he is the father. When the calculation is done, a paternity likelihood probability will be obtained, and the known 50 percent default probability will increase this likelihood by a certain factor, thus making the results stronger.

Forensic scientists performing DNA analysis must be cautious, however, when profiles are incomplete or the DNA is degraded, given that markers that are actually heterozygous could be interpreted as homozygous because only one allele was amplified from the damaged DNA. Additionally, scientists need to perform more thorough and complicated analyses when they are dealing with mixed profiles or when there is suspicion of contamination of the DNA evidence.

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Further Reading

Barbaro, Anna, Patrizia Cormaci, and Aldo Barbaro. "DNA Analysis from Mixed Biological Materials." *Forensic Science International* 146, supp. 1 (Fall, 2004): S123-S125. Discusses the difficulties of interpreting mixed DNA profiles and possible solutions.

Buckleton, John, Christopher M. Triggs, and Simon J. Walsh, eds. *Forensic DNA Evidence*

Interpretation. Boca Raton, Fla.: CRC Press, 2005. Collection compiled by experts in the field provides complete information on the basic background and tools necessary for forensic statistical analysis.

Butler, John M., et al. "Allele Frequencies for Fifteen Autosomal STR Loci on U.S. Caucasian, African American, and Hispanic Populations." *Journal of Forensic Sciences* 48 (Summer, 2003): 908-911. Reports on research regarding the allelic frequencies for three ethnic populations.

Fung, Wing K. "User-Friendly Programs for Easy Calculations in Paternity Testing and Kinship Determinations." *Forensic Science International* 136 (Fall, 2003): 22-34. Describes the problems forensic scientists face in trying to calculate likelihood ratios to establish relationship and proposes an easy way to overcome them.

Lucy, David. *Introduction to Statistics for Forensic Scientists*. Hoboken, N.J.: John Wiley & Sons, 2005. Provides information on the basics of DNA profiling and interpretation for law-enforcement personnel. Very easy to understand, with helpful self-study questions and reviews.

See also: CODIS; DNA analysis; DNA database controversies; DNA fingerprinting; DNA typing; Federal Bureau of Investigation DNA Analysis Units; Interpol; Paternity testing; Postconviction DNA analysis; Restriction fragment length polymorphisms.

DNA recognition instruments

Definition: Instruments used by crime scene investigators to detect the presence of biological materials from which DNA may be isolated for analysis.

Significance: The use of biological evidence, specifically DNA, to prove the guilt or innocence of suspects is an important component in modern criminal investigations. By using DNA recognition instruments at crime scenes to identify the presence of materials from which DNA evidence may be isolated—such as hair, saliva, or semen from suspects or victims—investigators increase the efficiency of evidence gathering.

The detection of DNA (deoxyribonucleic acid) at a crime scene begins with the identification and isolation of biological evidence such as blood, semen, saliva, or hair. Historically, such evidence has been found through physical searches of crime scenes, but the search process has been expedited by the development of specialized light sources and chemical tests.

Most commonly, the detection of biological samples has been aided by the use of ultraviolet (UV) light sources. UV lights belong to a class of instruments known as alternate light source (ALS) instruments. Unlike light sources that emit wavelengths of light across a broad spectrum, ALS lights use filters or special bulbs to emit a much narrower range of wavelengths. For example, UV lights emit wavelengths in the 400-200 nanometer range. The most common UV light is called a "black light," which emits wavelengths in the 400-320 nanometer range, also known as UVA. These wavelengths are invisible to the human eye but may cause certain chemicals, mainly proteins, to fluoresce. UV lights are useful in the detection of blood, semen, and saliva. Other ALS instruments include copper and argon lasers and modified arc lamps. The use of lasers in DNA detection is becoming increasingly popular because lasers do not damage DNA strands and can emit very specific wavelengths of light.

ALS instruments can indicate fluorescing molecules, but upon finding such samples, investigators must confirm the presence of specific forms of biological evidence by using certain chemicals to perform presumptive tests. These are usually colometric tests, meaning that the reagents used in the tests change colors when exposed to specific compounds. For example, the presumptive test for semen is specific for acid phosphatase, an enzyme that is more abundant in semen than in other body fluids. The presumptive tests for blood use human-specific antibodies that allow investigators to distinguish between human blood sources and the blood of other animals.

In addition to light sources and chemical tests, several commercially produced detection kits are available to forensic investigators. Among these are kits that can detect the proteins present in semen and kits that can detect the presence of DNA. Kits are also available that can disregard female DNA and indicate the presence of male DNA only, making them especially useful in rape and sexual assault cases.

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Further Reading

Butler, John M. *Forensic DNA Typing: Biology, Technology, and Genetics of STR Markers*. 2d ed. Burlington, Mass.: Elsevier Academic Press, 2005

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005.

See also: Blood residue and bloodstains; Crime scene investigation; DNA extraction from hair, bodily fluids, and tissues; National DNA Index System; National Institute of Justice; Presumptive tests for blood; Semen and sperm.

DNA sequencing

Definition: Process in which the nitrogenous bases that make up a DNA molecule (adenine, guanine, cytosine, and thymine) are "read" to determine their order and sequence in a given genome.

Significance: Biological specimens obtained at scenes of crimes are not always intact; some have been exposed to harsh environmental conditions and others do not possess the necessary amount of nuclear DNA for standard analysis. When analysts encounter these types of specimens, they can use the alternative method of DNA sequencing to discriminate between samples.

In some instances, biological samples are not suitable for performing the relatively fast and standard nuclear analysis and typing of DNA (deoxyribonucleic acid). On occasion, the copy number of nucleated cells is too low, and the analyst cannot obtain enough nuclear DNA to acquire a strong enough signal to interpret after typing the DNA. DNA sequencing, although more time-consuming and complicated than the standard analysis, may provide the necessary clues when other methods to obtain a good profile using conventional typing methods are exhausted.

The first step in sequencing a DNA sample is to determine what fraction of the genome is to be read (usually between three hundred and one thousand base pairs) and perform an amplification reaction using unlabeled primers that target the region of choice. After the DNA is amplified, the polymerase chain reaction (PCR) product is cleaned to remove any unbound nucleotides and residual, nonincorporated primers. This purified product is subsequently quantified and diluted to a predetermined concentration that is dependent on the length of the fragment of DNA being sequenced. The sequencing template is amplified with a single primer (forward or reverse) so that the end products are single-stranded DNA molecules. Unlike in the more common PCR reactions, a pair of primers cannot be used because the end product would result in a double-stranded molecule that could not be interpreted. This would be analogous to attempting to read two lines of text when one is superimposed on the other, a task that is difficult to perform.

In the sequencing reaction, fluorescently tagged modified nucleotides called dideoxyribonucleic acids (ddNTPs) are present. Each is labeled with a different color fluor and is randomly incorporated into the newly synthesized DNA strand. Because ddNTPs lack the hydroxyl group normally involved in the elongation step, the synthesis of the new strand terminates with the labeled ddNTP. The cycle-sequencing product is then cleaned to remove any unbound nucleotides and dried.

The samples are now ready to be "read," or separated. The dried samples are resuspended in formamide, a denaturant, before they are loaded onto high-throughput genetic analyzers. The sample is electrokinetically injected into a capillary filled with a gel polymer that is able to provide the one-base-pair resolution needed to determine the order of nucleotides in a particular DNA fragment. Because each nucleotide is labeled with fluors that will emit at different wavelengths, color distinction can be used to determine the sequence of the sample. The fluorescence is captured by a camera and transferred to the computer's software, which makes the data available to the analyst for further interpretation.

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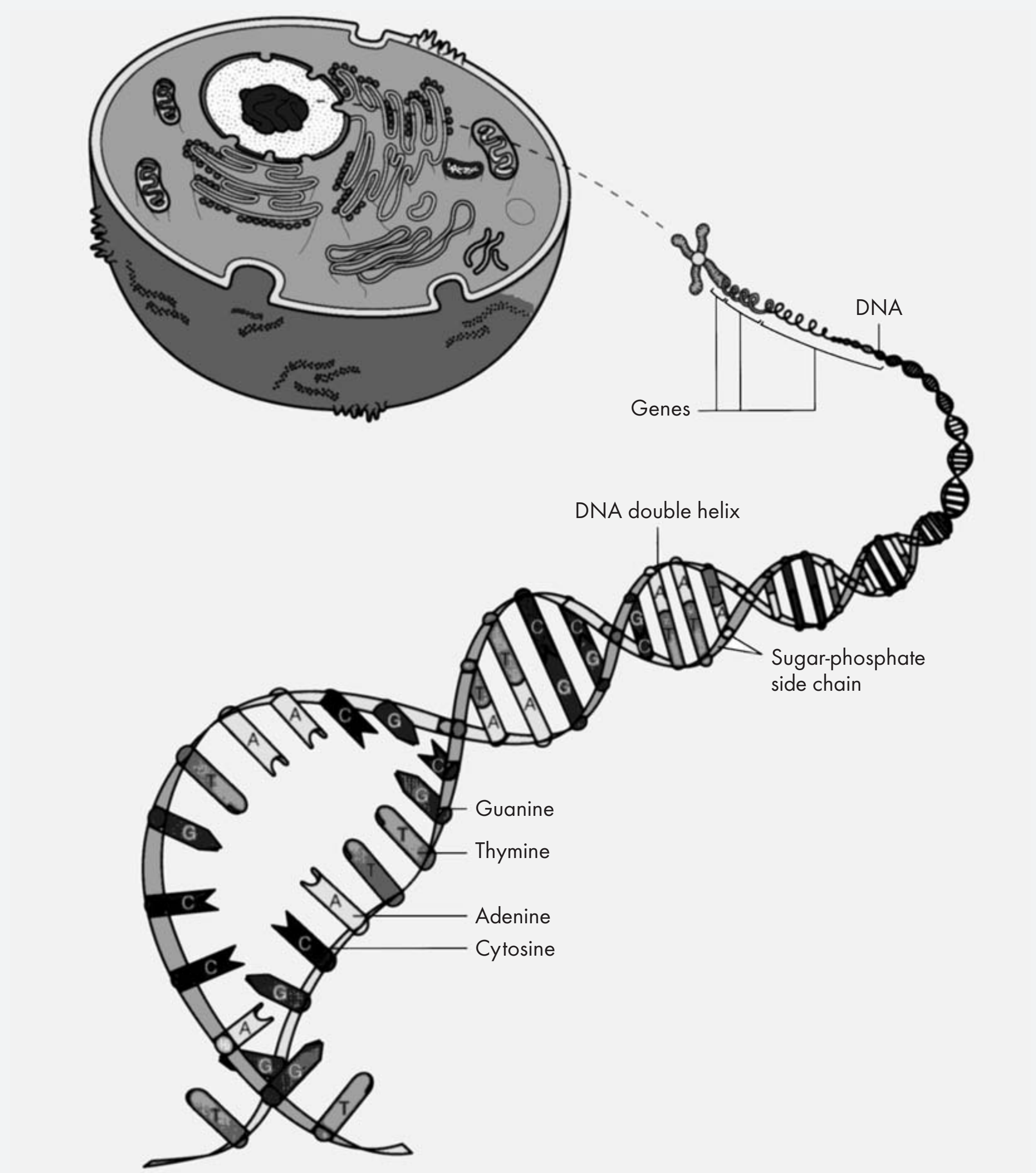
The Structure of DNA



Further Reading

Kieleczawa, Jan. *DNA Sequencing: Optimizing the Process and Analysis*. Sudbury, Mass.: Jones & Bartlett, 2005.

Nunnally, Brian K. *Analytical Techniques in DNA Sequencing*. New York: Taylor & Francis, 2005.

See also: Anastasia remains identification; DNA analysis; DNA typing; Electrophoresis; Hair analysis; Jefferson paternity dispute; Mitochondrial DNA analysis and typing; National DNA Index System; Paternity evidence; Pathogen genomic sequencing; Polymerase chain reaction; September 11, 2001, victim identification.

DNA typing

Definition: Process of separating amplified DNA fragments in order to obtain profiles that can be compared with known persons' profiles to establish similarities or differences that will include or exclude those persons as possible sample donors.

Significance: In forensics, the collection and processing of evidence are steps in crime scene investigations that are expected ultimately to aid in the process of conviction or exoneration of potential suspects. DNA typing can provide a unique "picture" that can identify an individual. If the DNA found in a crime scene sample is a perfect match for that of a known sample, this constitutes a powerful piece of evidence that can often help in the conviction of the guilty; lack of an exact match can potentially exonerate an individual.

The human genome comprises approximately three billion nitrogenous bases, of which 99 percent are identical across the human population, leaving only 1 percent that makes each person's DNA (deoxyribonucleic acid) unique; the only exception is identical twins, who have identical DNA. When DNA is amplified, an analyst uses a set of primers to target locations in the molecule that are known to vary between individuals. Within these varying regions, however, possible similarities still exist; for example, at locus A, person X and person Y are both heterozygous with alleles named 13, 15. In locus C, these same individuals are homozygous for allele 12, but the fact that they share the same alleles for these two markers does not indicate that they are the same person. The power of DNA discrimination is evident when a combination of markers (usually thirteen) gives at least one nonmatching allele between the samples being typed, indicating that the samples did not come from the same individual.

Among the different human DNA typing techniques are restriction fragment length polymorphisms (RFLPs; often referred to as variable number of tandem repeats, or VNTRs), single nucleotide polymorphisms (SNPs), short tandem repeats (STRs), mitochondrial (mtDNA), and Y chromosome. The technique selected depends on the source of the sample and the degree of separation needed. Some of the products of the techniques noted above are often visualized on agarose or polyacrylamide slab gels, whereas others can be loaded into genetic analyzers. Although gels separate DNA, the resolution obtained is much less exact than that required for DNA typing in criminal cases and often more complicated to analyze. Genetic analyzers are instruments based on capillary electrophoresis technology. They use a capillary loaded with a gel polymer that acts like a sieve and is able to separate amplified DNA fragments based on size and charge. The DNA is electrokinetically injected into the capillary and kept at a constant heat to keep the DNA traveling through it in a denatured (single-stranded) form. The shorter fragments travel faster and elute first out of the capillary; the longer fragments move more slowly and are retained longer in the capillary. As the fragments are eluted, the fluorescent tag associated with each fragment is detected and recorded by a camera, and the data are transferred to a computer. When all the fragments present have traveled through the capillary, a unique DNA fingerprint is obtained. This DNA fingerprint is now ready to be profiled.

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Further Reading
Butler, John M. *Forensic DNA Typing: Biology, Technology, and Genetics of STR Markers*. 2d ed. Burlington, Mass.: Elsevier Academic Press, 2005
Carracedo, Angel. *Forensic DNA Typing Protocols*. Totowa, N.J.: Humana Press, 2005.
Moreno, Lilliana I., and Bruce McCord. "Separation of DNA for Forensic Applications Using Capillary Electrophoresis." In *Handbook of Capillary and Microchip Electrophoresis and Associated Microtechniques*, edited by James P. Landers. 3d ed. Boca Raton, Fla.: CRC Press, 2008.

See also: Bacterial biology; DNA analysis; DNA extraction from hair, bodily fluids, and tissues; DNA fingerprinting; DNA profiling; DNA sequencing; Electrophoresis; Mitochondrial DNA analysis and typing; Paternity testing; Postconviction DNA analysis; Restriction fragment length polymorphisms; Semen and sperm; Short tandem repeat analysis; Y chromosome analysis.

Document examination

Definition: Application of analytical techniques to questions of the authenticity or origins of materials that bear marks, signs, or symbols that have meaning or convey messages.

Significance: An important component of forensic science is the investigation of questioned documents, which may be anything from written death threats to ransom notes to suicide notes to adulterated wills. The analysis of documents can help to connect suspects to such crimes as kidnapping, bank robbery, and forgery.

In the forensic science field of document examination, anything that bears marks, signs, or symbols that have meaning or convey messages is considered to be a document. Document examiners establish the authenticity or inauthenticity of contested materials, detect alterations in documents, and trace documents to their places of origin. Among the tasks performed by document examiners are handwriting comparisons, comparisons of type styles, ink analyses, and comparisons of documents created using typewriters, fax machines, and computer printers.

Handwriting Identification

Handwriting analysis is conducted in many types of investigations, including cases of fraud, homicide, suicide, drug trafficking, sexual offenses, threats, extortion, blackmail, arson, and robbery. No two individuals have the same handwriting style; each person's handwriting displays unique features that distinguish it from the writing of all other persons. Among the features of handwriting that differ from person to person are the use of margins; the spacing, crowding, alignment, and slope of letters; the pressure applied to the writing instrument; and the speed with which the writing is done. In addition, document analysts look at related matters such as spelling, punctuation, phraseology, and grammar.

Handwriting analysts compare the handwriting on questioned documents with the handwriting of any identified suspects using authenticated handwriting samples (writing exemplars) obtained from those individuals. Ideally, writing exemplars are produced in a manner that makes them as close as possible to the questioned documents under examination; that is, the size and type of paper and the kind of writing instrument used should be the same, and the same text should be written. The text to be written is dictated to the suspect, and no instructions are given concerning the spelling, punctuation, or arrangement of the requested writing sample.

The writing of several pages of dictation yields exemplars that best represent a suspect's subconscious style and characteristics. As the amount of writing that a suspect is asked to produce increases, it becomes more difficult for the suspect to conceal his or her own writing style and to imitate the writing style of another. The suspect is also required to provide writing samples from both the right and left hands. In addition, when possible, the analyst compares the requested exemplars and the questioned document against writing examples from the suspect that were produced before that person was officially contacted by law enforcement. Such examples might include business records, personal correspondence, and canceled checks.

Indented Writing

Forensic document examiners are sometimes able to connect suspects to crimes by examining the indentations left on sheets of paper when other sheets that rested above them have been written on, such as on notepads. For example, a bank robbery note may be connected to a writing pad recovered from a suspect's residence.

The clarity of such impressions is influenced by the amount of pressure that was used by the writer and the thickness of the paper. If the indentations are deep (from heavy pen pressure, for instance), they may be visible to the naked eye. If the indentations are too shallow to be seen clearly, the analyst may enhance them by using the Electrostatic Detection Apparatus (ESDA). This instrument uses a vacuum to seal a thin plastic film over the sheet of paper with the suspected indentations. The plastic film is then given an electrostatic charge, and black toner is applied to it. The toner adheres to any indentations in the paper, making them clearly visible. A sticky transparent plastic film is then placed over the indentation patterns on the paper to preserve them for examination and possible presentation as evidence.

Detection of Alterations

Document examiners sometimes are called upon to detect whether documents have been modified through erasure, addition, or the blotting out of information. One of the most common ways in which documents are altered is through erasure of parts of the writing or type. Whenever a part of a document is erased (whether through use of a rubber eraser, a piece of sandpaper, or a razor blade, for instance), the surface fibers of the paper are disturbed. Microscopic examination of a document can thus reveal whether areas of it have been erased.

Some alterations to documents involve the overwriting or blotting out of segments of text. To uncover text that has been overwritten, a document examiner may employ the Video Spectral Comparator (VSC), an instrument that uses infrared illumination. Different kinds of inks have distinct chemical compositions that reflect light differently, and the VSC highlights such variations in light reflectivity. Differences in the inks that appear on a document are a strong indication that the document has been altered. The VSC is also sometimes able to uncover text that has been overwritten or blotted out because the light reflection of the ink of the text that has been covered up may be discernible under that of the ink that was used to cover it up. If precisely the same ink used in the original document was used to overwrite or blot out text, however, recovery of the original text may not be possible.

Identification of Typewriters

Typewriters have been used in the production of many kinds of questioned documents, from travel papers to wills to terrorist manifestos. In the forensic examination of typed documents, analysts are often concerned

Certification of Forensic Document Examiners

Forensic document examiners receive their specialized training on the job from experienced examiners; no colleges or universities in the United States offer degree programs or majors in forensic document examination. The American Board of Forensic Document Examiners (ABFDE), founded in 1977, is the only certifying board for the profession that is sponsored by the American Society of Questioned Document Examiners, the Canadian Society of Forensic Sciences, the Southeastern Association of Forensic Document Examiners, and the Southwestern Association of Forensic Document Examiners and is recognized by the American Academy of Forensic Sciences. The ABFDE's minimum requirements for certification as a forensic document examiner are a bachelor's degree, completion of a full-time training program (a two-year apprenticeship) in a recognized document laboratory, and full-time practice of forensic document examination.

with identifying the documents' sources by determining the makes and models of the typewriters used and when the typed documents were produced. They might also need to determine whether particular series of documents (such as several bomb threats) were prepared on the same typewriter.

Knowledge of distinguishing features among typewriters allows investigators to identify the kind of typewriter used to produce a given document. In many cases, analysts can match a document up with an individual typewriter. Some of the distinguishing characteristics among typewriters that make such identification possible include the typeface that was produced, whether the type was produced by a manual or electric typewriter, whether the typewriter used fabric or carbon ribbon, and whether the type was imprinted with a type bar or with daisy wheel or ball printing elements.

The style of typeface that appears in a typed questioned document is useful for tracking down the make and model of the typewriter, as the typeface styles produced by different makes and models of typewriters are limited. Document examiners can compare the typefaces in questioned documents with typefaces in available databases to identify the makes and models of the typewriters that produce them.

A document analyst may connect an individual typewriter to a document by examining the impressions left on the typewriter ribbon to find the portion of the ribbon on which particular text was typed. In addition, unique features (that is, tool marks) are imparted on documents by the typewriters that produce them, because every typewriter has moving parts that experience random damage and general wear. Such unique features can be used to connect documents to particular typewriters.

Identification of Computer Printers, Photocopiers, and Fax Machines

In cases that involve documents produced by computer printers, photocopiers, or fax machines, analysts may be asked to identify the makes and models of the machines used or to compare questioned documents with samples printed from suspected machines. In conducting such an analysis, an examiner usually produces ten samples from each suspect machine to obtain a sufficient representation of the machine's characteristics. The examiner then undertakes a side-by-side microscopic comparison of the questioned document and the printed exemplars, focusing on such details as character shapes, the type of toner used, and the method by which the toner was applied to each document.

Different computer printers (including ink-jet, laser, thermal, and dot-matrix printers) have characteristic ways of printing documents. Investigators also look for any tool marks on documents that have been made by the belts, pinchers, rollers, and gears that move the paper through a machine. Many laser printers are designed to mark documents so that documents may be traced back to them. A document analyst may identify the source of a photocopied document by noting defects that are reproduced on copies from the glass platen, lens, or drum of a particular machine. The source of a document produced by a fax machine may be identified by the document's header, known as the transmitting terminal identifier (TTI). The TTI, which appears at the top of each fax page, identifies the machine that sent the document. Law-enforcement investigators have access to a database of TTI fonts and the corresponding fax machines that use them.

Daniel Pontzer

The FBI's Questioned Document Databases

The Federal Bureau of Investigation's Questioned Documents Unit maintains several electronic databases that can be extremely helpful to document examiners: the Anonymous Letter File, the Bank Robbery Note File, the National Fraudulent Check File, and the Watermark File. By comparing questioned documents with the images of ransom notes, extortion letters, and other anonymous communications stored in these files, examiners can establish associations between different cases. The FBI reports that these databases have been particularly effective in helping law-enforcement authorities to solve crimes committed across state lines.

Further Reading

Bennett, Wayne W., and Kären M. Hess. *Criminal Investigation*. 8th ed. Belmont, Calif.: Wadsworth/Thomson Learning, 2007. Introductory text discusses the elements of effective criminal investigations and the equipment, technology, and procedures used by forensic scientists.

Gaensslen, R. E., Howard A. Harris, and Henry C. Lee. *Introduction to Forensic Science and Criminalistics*. New York: McGraw-Hill, 2008. General introduction to forensic science includes discussion of the types of document examination work done in crime labs for criminal cases and by private examiners for civil cases.

Kelly, Jan Seaman, and Brian S. Lindblom, eds. *Scientific Examination of Questioned Documents*. 2d ed. Boca Raton, Fla.: CRC Press, 2006. Collection of essays by experts in the field provides comprehensive coverage of the history and techniques of document examination.

Morris, Ron N. *Forensic Handwriting Identification: Fundamental Concepts and Principles*. New York: Academic Press, 2000. Illustrated text addresses the major principles of handwriting analysis, including information on how various physiological conditions can affect writing. Useful for both students and practitioners.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007. Comprehensive introductory textbook covers all aspects of forensic science, including the methods and technologies used in document examination.

See also: Check alteration and washing; Fax machine, copier, and printer analysis; Forensic accounting; Forensic linguistics and stylistics; Forgery; Handwriting analysis; Hitler diaries hoax; Hughes will hoax; Oblique lighting analysis; Paper; Questioned document analysis; Secret Service, U.S.; Steganography; Typewriter analysis; Writing instrument analysis.

Dosimetry

Definition: Calculation of radiation exposure (quantity or dose of ionizing radiation—such as X rays or gamma rays—absorbed by matter in tissue) over a given period of time.

Significance: A high degree of concern surrounds the illicit acquisition and dissemination of radioactive materials by criminals and terrorist organizations. Forensic scientists apply dosimetry in investigating such crimes through geological and archeological dating, retrospective dosimetry, and personnel dosimetry.

Using dosimetry, investigators can determine how much radiation exposure a given sample has received, the sample's origination point, who has come in contact with the material, and whether or not the sample poses a potential hazard.

A radiation dosimeter is a device that measures cumulative (total) radiation exposure. Dosimeters differ from Geiger counters, which are also radiation detectors but give only moment-to-moment readings of radiation levels. Radiation doses are reported in grays (Gy) for matter and sieverts (Sv) for biological tissue. The non-SI (International System of Units) unit for radiation is rads, and that for dose equivalent is rems (1 Gy = 100 rads and 1 Sv = 100 rems). Mineral specimens produce radioactivity ranging from 0.5 to 200 millirems per hour measured at approximately one-half inch from the specimen.

The governments of most nations have established guidelines for permissible occupational radiation dose levels. Typically, the whole-body dose limit for routine exposures is 5 rems per year. This limit is based on the total amount of internal and external exposure. Specific limits have also been set for individual organs that must be met in addition to the whole-body dose limit: For the extremities the limit is typically 50 rems per year; for skin and other organs, 50 rems per year; and for the lens of the eye, 15 rems per year.

A personal radiation dosimeter is a small electronic device that resembles a pen; it is often worn clipped to clothing to measure an individual's radiation exposure. By using a magnifying and illumination lens, the wearer can read the exposure level directly by looking into the dosimeter. This is considered to be the most effective method of determining personal radiation exposure, as the biological damage caused by radiation is cumulative. The film badge dosimeter is an inexpensive alternative to the electronic dosimeter. It is a plastic badge containing a piece of photographic film. The badge is worn on the individual's clothing, and the film is gradually exposed with the wearer's radiation exposure. The film is periodically removed from the badge and developed, and through analysis of the developed film's optical density, the cumulative dosage measurement can be determined.

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Further Reading

Ehmann, William D., and Diane E. Vance. *Radiochemistry and Nuclear Methods of Analysis*. New York: John Wiley & Sons, 1991.

Moody, Kenton James, Ian D. Hutcheon, and Patrick M. Grant. *Nuclear Forensic Analysis*. Boca Raton, Fla.: CRC Press, 2005.

Stabin, Michael G. *Radiation Protection and Dosimetry: An Introduction to Health Physics*. New York: Springer, 2007.

See also: Chemical terrorism; Crime scene investigation; Crime scene protective gear; Decontamination methods; Environmental Measurements Laboratory; Isotopic analysis; Radiation damage to tissues.

Driving injuries

Definition: Injuries caused by air pressure or projectiles driven from an explosion.

Significance: By examining the driving injuries caused by an explosion, forensic scientists can help determine where and how the explosion occurred and whether the explosion was caused by low-order or high-order explosives.

The most common injuries that result from an explosion are injuries caused when the force of the blast drives air pressure or objects, such as pieces of glass, into the body. By determining the type of object that caused such an injury, the material making up the object, the angle at which the object hit the body, and the force with which it entered or hit the body, investigators can help determine where the bomb or other explosive device was placed when it detonated and where and how it was manufactured.

Types of Explosions

Driving injuries can occur with any type of blast or explosion, either natural or human-made. Such injuries are often seen following industrial explosions, such as mining accidents or chemical explosions, and as the result of motor vehicle accidents. Terrorist attacks involving explosions, such as car or suicide bombings, can also result in driving injuries, as can the explosions associated with warfare. Driving injuries may also occur as the result of hurricanes, tornadoes, or fireworks explosions.

Human-made explosions are particularly damaging to the body because most are specifically designed to project objects into the surrounding area, with the goal of causing bodily harm. For example, military ordnance is designed to shatter into shrapnel to cause body damage, and bombs are often filled with metal objects such as nails or glass that are flung out into the surrounding area. Explosions that occur in enclosed places—such as a mine shaft, a building, or a bus—cause higher rates of driving injuries, and more serious injuries and deaths, than do explosions that occur in open areas.

Types of Driving Injuries

The types of driving injuries are generally classified as primary, secondary, tertiary, and miscellaneous, or quaternary. Primary driving injuries are caused by air pressure emitted, or driven, from the explosion. Because they involve air pressure, they are usually limited to those areas of the body containing air or fluid, such as the lungs, eardrums, eyes, and stomach or intestinal tract, which can rupture from the force. These injuries occur with high-order explosives and may include abdominal hemorrhage or perforation, concussion, eye rupture, pulmonary rupture ("blast lung"), and tympanic (eardrum) rupture.

Secondary driving injuries are caused by projectiles or other objects, such as glass or shrapnel, being driven into the body by the force of the explosion. These injuries occur with either high- or low-order explosives and may include blunt trauma injuries (skin is not broken but significant surface and underlying damage is present) and penetrating injuries (an object actually penetrates the skin and enters the body, often in the eye).

Tertiary driving injuries occur when the force of the blast is so strong that the body actually becomes a projectile. The body may be slammed into a standing object or even into other bodies. These injuries occur with high-order explosives and may include amputation, brain injuries (closed or open), and fractures.

The category of injuries termed miscellaneous or quaternary driving injuries encompasses all types of injuries not contained in the first three categories. These may include brain injuries (closed or open), breathing injuries (such as asthma from dust or smoke or lung damage from toxic fumes), burns (from fires caused by the explosion), complications from preexisting conditions (such as heart problems), and crushing injuries (caused by the collapse of buildings or other structures).

Specific Driving Injuries

Certain abdominal, brain, ear, eye, and lung injuries form a pattern specific to driving injuries from a high-order explosion. Abdominal injuries from such an explosion may not be noticeable at first because they occur with no open wounds, but abdominal organs may suffer injuries such as bowel perforation, testicular rupture, abdominal hemorrhage, and organ lacerations. A high-order explosion can also cause concussion even without a direct blow to the head, and rupture of the eardrum may occur with no blow to the ear or head itself.

About 10 percent of survivors of high-order explosions have eye injuries, some of which are significant. These injuries are usually perforations from objects driven into the eye from the force of the blast and are noticeable at the time, but some may not appear or be noticed until days or weeks after the explosion.

"Blast lung" is the most common injury that causes death if an injured person survives the initial explosion. It occurs when air is forced into the lungs, exploding lung tissues and causing bleeding. It produces a very distinctive "butterfly" pattern on a chest X-ray. Symptoms of blast lung are usually obvious immediately after the explosion, but occasionally they do not show up for a few days after the injury.

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Further Reading

Bolz, Frank, Jr., Kenneth J. Dudonis, and David P. Schulz. *The Counterterrorism Handbook: Tactics, Procedures, and Techniques*. 3d ed. Boca Raton, Fla.: CRC Press, 2005. Explains procedures to be followed in the event of a terrorist bombing attack, including procedures for handling victims of driving injuries.

Crippen, James B. *Improvised Explosive Devices (IED): A Comprehensive Guide*. Boca Raton, Fla.: CRC Press, 2008. Examines the mechanics of IEDs and how they cause driving injuries.

Ellis, John W. *Police Analysis and Planning for Homicide Bombings: Prevention, Defense, and Response*. Springfield, Ill.: Charles C Thomas, 2007. Discusses how law-enforcement agencies respond to homicide bombings, including the handling of driving injuries.

Hattwig, Martin, and Henrikus Steen, eds. *Handbook of Explosion Prevention and Protection*. Weinheim, Germany: Wiley-VCH, 2004. Discusses how people can protect themselves and others from driving injuries caused by explosions.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005. Comprehensive introductory textbook includes a chapter on the investigation of explosions.

See also: Antemortem injuries; Blast seat; Blunt force trauma; Bomb damage assessment; Bombings; Bureau of Alcohol, Tobacco, Fire-

arms and Explosives; Improvised explosive devices; Oklahoma City bombing; World Trade Center bombing.

Drowning

Definition: Death caused by a lack of oxygen that may have resulted from the presence of water in the lungs or from the closure of the upper airway, leading to cardiopulmonary arrest.

Significance: Unexpected deaths require forensic investigation to determine cause and manner of death. In drowning cases, cause of death is not always obvious, so it is important that forensic examiners be familiar with the types of evidence that may point to drowning.

The majority of drowning deaths are accidental. Nearly half of drowning victims are small children who were unsupervised and unable to swim. Among adults, accidental drowning is often associated with the consumption of large amounts of alcohol. With intoxication, judgment becomes impaired and risky behavior becomes more likely. Many of these drowning deaths are preventable. Close supervision of children around water and swimming lessons early in childhood can decrease the likelihood of accidental drownings. Adult deaths from drowning can be reduced through the limitation of alcohol use during water activities and requirement of appropriate use of life-preservation devices.

Suicide is the second-most-common cause of death by drowning. Such suicides may be mistaken for accidental deaths. Murder of adults by drowning is rare; murder of children by this method is also rare, but may be less rare than murder of adults.

In drowning cases the cause of death is not always obvious. This is particularly true when the deceased person has been found submerged in water, whether in a bathtub or in an ocean. In such circumstances, it may be assumed that the cause of death is drowning, but this may or may not be correct. Initially, the only known information is that the person was found in water; it is not known whether the person may have been dead prior to entering the water.

No tests are available that can prove or disprove drowning as the cause of death. Most drowning victims have water in their lungs, but a small percentage experience “dry” drowning, which occurs when the airway closes before water can enter the lungs. Water found in the lungs on autopsy, moreover, proves only that the person was in water at some point. Foamy fluids, vomit, mud, or plant material may be found in the mouth of a body pulled from water, but such evidence does not prove cause or manner of death.

When a body found in water is removed from the water, it may or may not exhibit signs of trauma initially. Neck or head injuries may have occurred if diving was involved, but these may not be apparent until an autopsy is performed. The body may have small injuries as a result of coming into contact with objects in the water. Animals may have fed on the body if it remained submerged in water for a prolonged time. The eyes may appear bloodshot from asphyxiation, which may indicate death by drowning. The presence of injuries or bloodshot eyes, however, does not prove death by drowning.

Amy Webb Bull

Further Reading

Brenner, John. *Forensic Science: An Illustrated Dictionary*. Boca Raton, Fla.: CRC Press, 2003.

Dix, Jay, Michael Graham, and Randy Hanzlick. *Asphyxia and Drowning: An Atlas*. Boca Raton, Fla.: CRC Press, 2000.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005.

Shkrum, Michael J., and David A. Ramsay. *Forensic Pathology of Trauma: Common Problems for the Pathologist*. Totowa, N.J.: Humana Press, 2007.

See also: Asphyxiation; Buried body locating; First responders; Hypothermia; Petechial hemorrhage; Suffocation; Toxicological analysis.

Drug abuse and dependence

Definition: Chronic but treatable brain diseases involving compulsive drug-seeking and drug-using behaviors that persist despite immediate or potentially harmful consequences for the drug-abusing individuals, their families, and their communities.

Significance: Drug abuse and drug dependence are major threats to public health and safety, costing billions of dollars annually in health care and criminal justice system expenditures in addition to losses related to work productivity and unemployment. Addictive behavior is one of the most pervasive and intransigent mental health problems in the world, affecting millions of people annually.

Drugs are psychoactive substances that affect moods and behaviors by altering brain chemistry and function. Drugs of abuse include medically prescribed (barbiturates and pain relievers), legal (cigarettes and nicotine), and illegal (marijuana and heroin) substances. Some drugs, such as alcohol, have been used since ancient times, whereas others, such as methamphetamine and so-called designer drugs, are relatively new. People consume drugs to feel good (some drugs result in feelings of euphoria, confidence, and relaxation), to keep from feeling bad (some drugs combat feelings of anxiety, depression, and hopelessness), to accelerate performance (some drugs heighten alertness and enhance physical strength and prowess in athletic competition), and to experience altered sensory perceptions (some drugs cause users to see or hear unusual or unreal phenomena).

Drugs of abuse can be placed into five major classes according to their effects. The first class consists of stimulants, which increase alertness and decrease fatigue. Examples of stimulant drugs are amphetamines, Benzedrine, caffeine, Dexedrine, ephedrine, and nicotine. The second class consists of depressants, which reduce tension, alleviate nervousness, and induce sedation. Examples of sedative drugs are barbiturates (such as Nembutal, Seconal, Tunial, and Veronal), Valium, and Xanax. The third class consists of hallucinogens, which change sensory perceptions. Examples of hallucinogens are cannabis (marijuana), lysergic acid diethylamide (LSD), mescaline, phencyclidine (PCP), and psilocybin. The fourth class consists of opiates, which induce sleep, euphoria, and relaxation and also relieve pain and anxiety. Examples of opiates are codeine, heroin, opium, OxyContin, Percodan, and morphine. The fifth class consists of performance enhancers, which increase athletic strength and speed and stimulate skeletal muscle growth and recovery. Examples of performance enhancers are anabolic steroids such as Anadrol, Depo-Testosterone, Dianabol, and Winstrol.

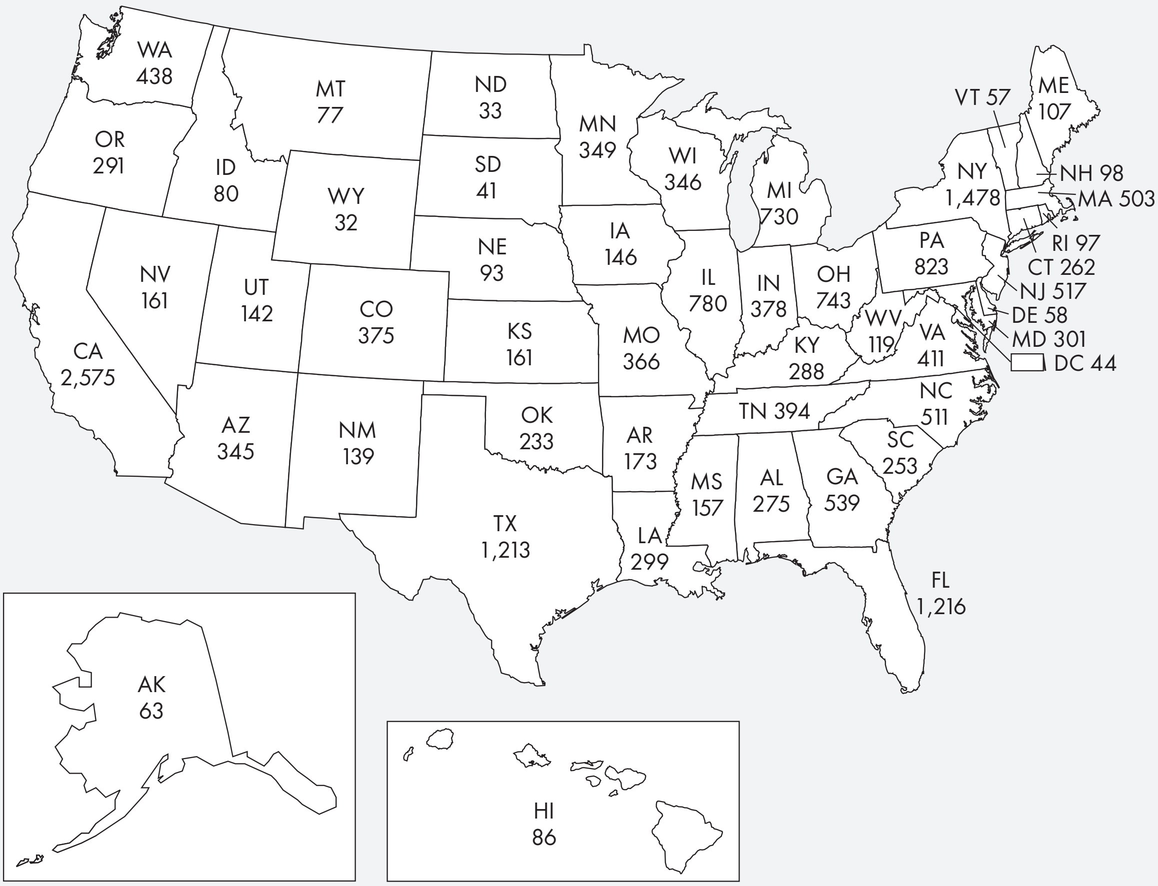
Individual drug abusers typically prefer some classes of drugs over others and prefer some particular drugs within given classes. When they have difficulty obtaining their preferred drugs, they often substitute others in the same classes that produce similar effects. Psychoactive drugs in the same class can be compared based on their potency and efficacy. "Potency" refers to the amount a user must ingest to experience a certain effect, whereas "efficacy" refers to whether a drug can produce an effect regardless of dosage. Both the strength and the potency of substances can determine abusers' drugs of choice as well as the drugs' potential for abuse and dependence.

The Addictive Process

Drug use can escalate to abuse or dependence problems, which are also called substance-use disorders. The progression to uncontrolled use depends on several risk factors. For example, biological factors play a role in addiction—that is, genetics can predispose an individual to addictive behavior. Such a predisposition is shared among close biological relatives. Scientists estimate that genes account for nearly half of a person's vulnerability to a substance-use disorder.

Age of first use and psychiatric history are also important elements in risk for problems with drug use. Younger users are more likely to become addicted because developing adolescent brains are more susceptible to drugs' ability to

Drug Users in the United States, 2004-2005



Source: U.S. Substance Abuse and Mental Health Services Administration, *National Survey on Drug Use and Health, 2004 and 2005*. Figures represent the estimated numbers (in thousands) of persons over the age of twelve who used any illicit drug at least once within the month preceding the moment of the study. "Illicit drugs" included marijuana, cocaine, heroin, hallucinogens, inhalants, and psychotherapeutics used for nonmedical reasons.

change brain chemistry and function. Persons with mental illness are also more likely to abuse or become dependent on drugs. In addition, exposure to parents' or peers' use of drugs can increase the risk of addiction. The mode of drug ingestion can also increase the potential for drug abuse and dependence. A drug that is inhaled or injected intravenously is more addictive than a drug that is ingested orally. The former reaches the brain faster and produces more intense highs and lows. Drug-seeking behavior intensifies in response to the cycle of peaks and valleys that the user experiences.

Psychoactive drugs are thought to become addictive through their activation of the brain's mesocorticolimbic dopamine pathway, which extends from the brain's ventral tegmental area to the nucleus accumbens to the frontal cortex. Drugs of abuse stimulate this pleasure circuit by increasing the amount of dopamine in the brain two- to tenfold; this is extremely rewarding to users and compels them to repeat the experience. Drugs of abuse either mimic the effects of dopamine on neurotransmitters or block the reabsorption of dopamine to activate neurons. Eventually, the brain shuts down its own capacity to produce dopamine, causing the user to ingest the drug merely to stave off feelings of listlessness, depression, and other withdrawal symptoms. Drugs of abuse also affect the brain's frontal regions, impairing judgment and leading addicts to pursue drugs compulsively, even as the rewards of use steadily diminish. Relapse (return to drug use following a period of abstinence) is thus common among persons with substance-use disorders; it can be triggered by stress, mood changes, and drug-related cues that remind the abuser of the substance.

Substance-Use Disorders

Substance-abuse and -dependence disorders are diagnosed according to the criteria specified in the American Psychiatric Association's *Diagnostic and Statistical Manual of Mental Disorders*. A substance-abuse disorder is diagnosed when drug use in the past twelve months leads to significant distress and impairment in functioning and meets at least one of the following diagnostic criteria: failure to fulfill obligations at work, school, or home; recurring use of substances in dangerous situations (such as driving while intoxicated); recurring substance-use-related criminal justice involvement; and continued substance use that leads to interpersonal conflicts.

A drug-dependence disorder, which is more serious than a drug-abuse disorder, is diagnosed when drug use in the past twelve months has reached the level of abuse and meets at least three of seven criteria that include tolerance (increasing amounts of the drug must be taken to achieve desired effects), physical withdrawal (symptoms that accompany the cessation of drug use, such as tremors, chills, drug craving, restlessness, bone and muscle pain, sweating, and vomiting), and persistent failure to reduce drug consumption.

Prevalence of Substance-Use Disorders

The annual National Survey on Drug Use and Health assesses the prevalence of substance-use disorders in the United States in the preceding twelve months. In 2005, the findings of this survey indicated that an estimated 22 million persons aged twelve and older were classified with a substance-abuse or -dependence problem (9 percent of the U.S. population). Among these individuals, more than 3 million were classified with abuse of or dependence on both alcohol and illicit drugs, more than 3.5 million abused or were dependent on illicit drugs but not alcohol, and more than 15 million abused or were dependent on alcohol but not illicit drugs.

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Further Reading

Abadinsky, Howard. *Drug Use and Abuse: A Comprehensive Introduction*. 6th ed. Belmont, Calif.: Thomson/Wadsworth, 2008. Covers all aspects of drug and alcohol abuse, including the history of drugs and their pharmacological effects. Also discusses the impacts of drug abuse on society.

Hoffman, John, and Susan Froemke, eds. *Addiction: Why Can't They Just Stop?* New York: Rodale, 2007. Companion volume to a television series of the same name presents detailed descriptions of the effects of drugs on the brain, drug treatment methods, and recovery. Features many engaging case studies and sidebars.

Karch, Steven B., ed. *Drug Abuse Handbook*. 2d ed. Boca Raton, Fla.: CRC Press, 2007. Provides a compendium of authoritative information on various aspects of drug abuse. Contributing authors include medical, legal, and treatment professionals.

National Institute on Drug Abuse. *Drugs, Brains, and Behavior*. Washington, D.C.: National Institutes of Health, 2007. Brief, highly readable document explains the science of addiction in nontechnical terms.

Substance Abuse and Mental Health Services Administration. *Results of the 2005 National Survey on Drug Use and Health: National Findings*. Washington, D.C.: Author, 2006. Presents the findings of an annual survey on drug use conducted by the U.S. Department of Health and Human Services with a sample of the general population of the United States aged twelve years old and older. Includes information on national estimates of rates of use, numbers of users, and other measures

related to illicit drugs, alcohol, and tobacco products.

See also: Amphetamines; Antianxiety agents; Barbiturates; Club drugs; Crack cocaine; Drug classification; Drug paraphernalia; Forensic odontology; Hallucinogens; Harrison Narcotic Drug Act of 1914; Illicit substances; Inhalant abuse; Narcotics; Opioids; Psychotropic drugs.

Drug and alcohol evidence rules

Definition: Proper procedures for collecting and handling evidence to ensure its acceptance by a court in criminal proceedings related to the use or possession of drugs or alcohol.

Significance: To be sure that the drug and alcohol evidence collected and analyzed during an investigation is accepted in court, first responders, investigators, and laboratory technicians must handle and document the evidence in ways that meet the requirements for admissible evidence.

Statutory rules of evidence are laws that help determine what evidence will be accepted by the court. They are designed to produce a fair, orderly, and efficient legal process that results in the determination of the truth. For example, statutory laws prevent the court from accepting hearsay evidence or evidence that may have been tampered with or altered. In 1975, the U.S. Congress established the Federal Rules of Evidence. In addition to federal evidence laws, each U.S. state has its own set of statutes concerning the admissibility of evidence.

Alcohol Evidence

Alcohol is relevant evidence primarily in cases of underage consumption of alcohol and driving under the influence (DUI) of alcohol. The amount of alcohol a person has consumed can be determined through the use of machines that measure breath alcohol (such as the Breathalyzer), urine testing, or blood testing. In cases of alcohol consumption by underage persons, testing must prove only the presence of alcohol in the body, because any amount of alcohol consumption by an underage individual is a violation of the law. In those of legal drinking age, the evidence must show that the amount of alcohol in the bloodstream is above the legal limit.

The most common reason for a police officer to make a suspected DUI stop is observation of a pattern of driving consistent with the driver's being under the influence of alcohol. If the officer then observes behavior consistent with DUI or smells alcohol, the driver may be asked to perform a field sobriety test. This involves actions such as touching the nose, walking on a road line, or reciting the alphabet. Based on the results of the field sobriety test, the individual may be asked to take a preliminary alcohol screening (PAS) test, commonly called a Breathalyzer test. The PAS gives a rough estimate of the amount of alcohol in the bloodstream. If the individual is arrested for DUI, he or she must provide a blood or urine sample. Each jurisdiction establishes a standard procedure for the collection of these samples.

Urine and blood samples are analyzed by the toxicology section of the crime laboratory. Although procedures vary from state to state, the statutory laws of evidence require that each sample be labeled with the time, place, and person from which it came; that it be handled in a way that will not allow it to be tampered with or altered; and that a chain of custody (a written record of who had possession of the sample at all times, how it was stored, and what tests were done on it) is established and maintained.

Drug Evidence

Controlled substances can take the form of liquids, capsules, tablets, powders, plant material, or irregular masses. Unlike alcohol evidence, where testing is done to measure the quantity of alcohol in the blood, drug testing usually requires only identification of the type of drug in the evidence sample. The job of the toxicology laboratory is to use an array of standard chemical tests to identify the drug. Just as with other physical evidence, a chain of custody must be established for the evidence to be accepted in court.

Each jurisdiction establishes its own procedure for handling different types of drugs. If a large quantity of a drug is seized, only a small sample is taken, following an established sampling protocol, and sent for analysis. When a person is suspected of being under the influence of drugs, the laboratory determines what drug or its metabolites (breakdown products) are present in the individual's blood or urine. The quantity of illicit drug consumed is usually irrelevant. A standard six-drug panel screens for benzodiazepines, cocaine, marijuana, methamphetamine, opiates, and phencyclidine (PCP). The laboratory techniques used in drug analysis include gas chromatography, mass spectrometry, and immunoassay.

Investigators can request screening for drugs outside those detected by the six-drug panel. Prescription and so-called designer drugs may be difficult to identify, and extensive testing may be required to establish their presence. When a prescription drug is found in the blood, the quantity of drug is also measured and compared with the therapeutic medicinal dose. So long as the chain of custody is maintained, cross-contamination and tampering are prevented, and good records are kept of the tests performed, blood and urine samples generally meet the requirements for statutory submission of physical evidence.

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Further Reading

Best, Arthur. *Evidence: Examples and Explanations*. 6th ed. New York: Aspen, 2007. Provides useful examples that illustrate the rules of evidence. Intended primarily for law students.

Graham, Michael H. *Federal Rules of Evidence in a Nutshell*. 7th ed. St. Paul, Minn.: West, 2007. Presents concise explanations of the Federal Rules of Evidence along with commentary on the principles behind them.

Hawthorne, Mark R. *First Unit Responder: A Guide to Physical Evidence Collection for Patrol Officers*. Boca Raton, Fla.: CRC Press, 1999. Provides basic information on how first responders can maintain the integrity of crime scene evidence.

Mieczkowski, Tom, and Kim Lersch. "Drug Testing in Criminal Justice: An Historic Overview." *NIJ Journal* 243 (1998): 9-15. Reviews the basic uses and technology of drug testing in law-enforcement contexts.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007. General introductory text includes discussion of requirements for evidence submission.

See also: Alcohol-related offenses; Breathalyzer; Chain of custody; Courts and forensic evidence; Crime laboratories; *Daubert v. Merrell Dow Pharmaceuticals*; Drug confirmation tests; Drug paraphernalia; Forensic toxicology; Illicit substances; Sobriety testing.

Drug classification

Definition: System of categorizing types of drugs according to their properties, therapeutic effects, or other features.

Significance: Drugs can be classified in many different ways, but the system of drug classification to which forensic scientists refer most often is that created by the Controlled Substances Act of 1970. Law-enforcement agencies are often concerned with criminal activities related to drugs classified as controlled substances under this act.

Drugs may be divided into categories based on a number of different factors. Medical practitioners, for instance, most commonly use a system of drug classification based on therapeutic effects; for example, drugs that alleviate headaches are classified with other substances that have the same effect. Alternatively, drugs can be classified based on their pharmacodynamic effects—that is, the ways in which they interact with the human biological system. This way of classifying drugs is most commonly used by researchers who study drugs and their effects. Drugs can also be classified based on the risks they pose for abuse and dependence. Using such a system, many researchers who study addiction place alcohol and nicotine in the same category as other commonly abused substances, such as heroin and cocaine. The system of drug classification used most often in the forensic sciences is the system created by the Controlled Substances Act of 1970, which attempts to weigh the potential medical benefits of drugs against the risks the drugs pose for abuse, physical dependence, and psychological dependence.

Five Drug Schedules

The Controlled Substances Act created five schedules, or classifications, of drugs. The U.S. Department of Justice and the U.S. Department of Health and Human Services, which includes the Food and Drug Administration, are responsible for deciding which drugs should be included on the rather exhaustive list of substances that are regulated by the federal government. The list of substances includes drugs, minerals, organic materials, and the precursors to pharmacodynamic substances.

Schedule I drugs are those deemed to have a high potential for abuse and dependence while at the same time having no currently accepted medical uses in the United States. Drugs in this schedule are not available to the general population, no prescriptions can be written for these drugs, and only limited research has been conducted to examine their effects. Examples of Schedule I drugs are cannabis, heroin, ecstasy, and peyote.

Schedule II drugs are also considered to have high potential for abuse and dependence, but these drugs are considered to have some legitimate medical use. These drugs are legally available to the general population by prescription only, and the distribution of these drugs is subject to considerable regulation. Among the drugs included in Schedule II are morphine, oxycodone, methadone, opium, and phencyclidine (PCP).

Drugs that meet the criteria to be classified under Schedule III are thought to have lower risk for abuse than those regulated under Schedules I and II, have acceptable medical uses, and are considered to pose only moderate risk of dependence. These drugs are also available legally only by prescription, but the regulation of their distribution is less strenuous than that for Schedule II drugs. Drugs in Schedule III include anabolic steroids, hydrocodone, ketamine, and LSA (also known as d-lysergic acid amide or d-lysergamide), a precursor to and chemical relative of LSD (lysergic acid diethylamide).

The drugs included in Schedule IV are thought to have low risk for abuse, have medically acceptable uses in the United States, and have relatively low potential to create physical or psychological dependence. These drugs are available legally only by prescription and are regulated similarly to those in Schedule III. Schedule IV drugs include alprazolam (brand name Xanax), diazepam (Valium), dextropropoxyphene (Darvocet), and phenobarbital.

Drugs that are classified in Schedule V are thought to have a low risk for abuse, have medically accepted uses, and are considered to have limited risk for dependence. These drugs are legally distributed for medical purposes only by prescription. Some commonly used medications that are included in Schedule V are cough suppressants that have small amounts of codeine, antidiarrheal medications with small amounts of opium, and pregabalin (brand name Lyrica), a medication used to treat seizures and pain.

Criticisms of the U.S. Drug Classification System

The drug classification system created by the Controlled Substances Act has been the source of ongoing controversy, in large part because of the process by which drugs are assigned to each of the different schedules. Many observers have asserted that the process is political rather than based in science. Medical practitioners and researchers have argued, for example, that some of the drugs listed in Schedule I have legitimate medical uses, such as cannabis for cancer patients, and that these drugs are included in Schedule I only because changing their classification would be politically unpopular. Many have advocated for the reclassification of some substances so that additional research can be done to assess the drugs' medical value empirically.

Critics of the five-schedule classification system have also suggested that substances such as alcohol and nicotine, which are addictive and have no medical use, should be included in the list of controlled substances. In addition, some have noted inconsistency in the classification of drugs, pointing out that many drugs with similar pharmacological properties are classified into different drug schedules. For example, heroin, morphine, opium, and methadone all have similar chemical properties but they are listed in different schedules.

Some scholars have argued that the classification of drugs within the five-schedule system has been motivated by fear and xenophobic beliefs rather than science. Researchers have drawn connections between the passage of legislation banning the availability of certain drugs and the migration patterns of historically disenfranchised groups in the United States as well as stereotypes regarding their drug use. One specific example is the banning of peyote, which has long been a part of some Native American religious ceremonies.

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Further Reading

Earleywine, Mitch, ed. *Mind-Altering Drugs: The Science of Subjective Experience*. New York: Oxford University Press, 2005. Collection of essays by leading researchers focuses on the subjective experiences of drug users and how these are related to drug abuse.

Gahlinger, Paul M. *Illegal Drugs: A Complete Guide to Their History, Chemistry, Use, and Abuse*. New York: Plume, 2004. Wide-ranging work includes discussion of drug classifications.

Perrine, Daniel M. *The Chemistry of Mind-Altering Drugs: History, Pharmacology, and Cultural Context*. Washington, D.C.: American Chemical Society, 1996. Provides information on the pharmacological effects of psychoactive substances and highlights the cultural contexts in which illicit drugs are used.

Smith, Frederick P., ed. *Handbook of Forensic Drug Analysis*. Burlington, Mass.: Elsevier Academic Press, 2005. Comprehensive text covers all aspects of forensic drug analysis.

See also: Amphetamines; Antipsychotics; Club drugs; Controlled Substances Act of 1970; Crack cocaine; Drug abuse and dependence; Drug Enforcement Administration, U.S.; Hallucinogens; Illicit substances; Narcotics; Opioids; Psychotropic drugs; Stimulants.

Drug confirmation tests

Definition: Application of a second analytical procedure to verify the presence of a specific drug or drug metabolite identified in an initial drug test.

Significance: As corporations and sports organizations increasingly instituted mandatory drug testing of employees and athletes, it became apparent that the tests available produced many false positives—that is, they indicated that drugs were found in the bodily substances of individuals who were actually drug-free. Drug confirmation tests are conducted to ensure that individuals are not wrongfully dismissed from their jobs or denied participation in sporting events because of inaccurate test results.

Drug testing can be conducted on a variety of bodily substances (blood, urine, sweat, saliva, or hair) using a variety of tests. After an initial screening test indicates the presence of a banned substance in a person's body, a follow-up test may be done to verify or disprove the original finding; this second test is known as a drug confirmation test.

Federal Guidelines

In the United States, guidelines for drug testing were established by the Substance Abuse and Mental Health Services Administration (SAMHSA) in September, 1994. According to these guidelines, for every initial screening and confirmation test, a chain of custody must be established and followed in obtaining the specimen. Only authorized persons should handle and transport all specimens, in accord with the chain of custody, and care must be taken to ensure that samples are not diluted (by the addition of water or any other substance). If the result of an initial screening test is negative, no further testing needs to be done. If any specimen yields positive results on an initial screen, however, a confirmatory retest of that specimen must be done.

According to the SAMHSA guidelines, the new test conducted on the initial sample must be completely independent of the initial test and must use a technique that is completely different from that used in the original test. All confirmation tests must be of equal or greater sensitivity than the original test; they should be conducted using gas chromatography or mass spectrometry. Standard cutoff values (confirmatory test levels) have been established on these tests for marijuana, opiates, cocaine, morphine, codeine, phencyclidine (PCP), amphetamines, and methamphetamine. Any sample that has a test level above the standard cutoff is reported as positive. If a drug confirmation test result is negative, in spite of a positive initial screening, no further testing is done, and the test is reported as negative. If the drug confirmation test is positive for a specific substance, then that is considered a confirmed positive result for that specific drug, and again no further testing is done.

Substances Commonly Used in Drug Testing

Various bodily substances can be analyzed for the presence of drugs or their breakdown products (metabolites). Although blood analysis yields valid and reliable results, it is rarely done because of the invasive nature of blood testing. Urine drug testing (urine toxicology screening) is probably the most commonly used technique, whether for initial screening or confirmation screening. When a urine sample is used in testing for drugs or metabolites, the tester must be sure of the source of the urine (that is, that the person being tested has not substituted someone else's urine) and must be certain that the sample is pure and undiluted.

Saliva-based drug screens are becoming more widely used, as they are easily done, can be done in the presence of witnesses (thus confirming no substitutions), cannot be altered, and yield valid and reliable results similar to those obtained by urine testing. Drugs and their metabolites can be detected in saliva immediately after drug use and for up to three days following use.

Hair testing has often been used to detect drug use, as it is reasonably accurate and reflects drug use for a period of at least three months prior to testing. Some questions have been raised about false positives on hair tests, however; the different structures of hair among persons of different ethnic groups may increase the likelihood of false positives. Sweat drug screens involve the use of patches that are applied to the skin (usually on the chest) for ten to fourteen days. Sweat tests are rarely done because of issues with security and problems in detecting certain drugs.

Effectiveness of Testing Methods

Following the collection of samples, all drug testing is done in a laboratory setting. All samples brought into the laboratory are subjected to initial testing, known as the screening test. This testing is normally done by immunoassay, a method that is less sensitive and less expensive than the methods used in confirmation tests. Because the method used in screening tests is not highly sensitive, it is not unusual for these tests to produce false positive results. Any sample that tests positive initially is then subjected to confirmation testing. The methods used in confirmation tests, mass spectrometry and gas chromatography, produce results that are much more accurate than immunoassay, so samples that produced false positives in screening typically have negative results on these confirmation tests.

Reasons for false positives on drug screenings may include laboratory errors, antibiotic use, the use of nonprescription drugs such as ibuprofen or nasal decongestants, and the ingestion of poppy seeds. Even when false positive initial results are shown to be incorrect by the results of more precise confirmation tests, the record of the person tested may remain unfairly tarnished by the initial findings. For this reason, a number of observers have noted the need for increased public understanding of the reliability of the results of drug confirmation tests.

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Further Reading

Bahrke, Michael S., and Charles E. Yesalis, eds. *Performance-Enhancing Substances in Sport and Exercise*. Champaign, Ill.: Human Kinetics, 2002. Discusses the history of athletes' use and abuse of performance-enhancing drugs. Chapters 27 and 28 address the topic of drug testing in sports.

Jenkins, Amanda J., and Bruce A. Goldberger, eds. *On-Site Drug Testing*. Totowa, N.J.: Humana Press, 2002. Collection of essays by scientific experts discusses the various devices available for on-site drug testing. Explains each test's principles and assesses its advantages and disadvantages.

Mieczkowski, Tom, ed. *Drug Testing Technology: Assessment of Field Applications*. Boca Raton, Fla.: CRC Press, 1999. Collection of essays by contributors from many disciplines compares the various methods used in drug testing.

Mrozek, John. *Drug Screen Manual: The Tests, the Technology, the Risks, the Reality*. Boulder, Colo.: Paladin Press, 1998. Brief volume focuses on providing information for persons who may be subject to drug testing. Discusses possible inaccuracies in testing, particularly those that result from poor training of those who administer the tests.

Smith, Frederick P., ed. *Handbook of Forensic Drug Analysis*. Burlington, Mass.: Elsevier Academic Press, 2005. Focuses on methods used to detect drugs in the human body. Presents analyses of a number of drugs and discusses their chemical properties and the ways they are identified in tests.

See also: Amphetamines; Anabolic Steroid Control Act of 2004; Athlete drug testing; Barbiturates; Club drugs; Control samples; Crack cocaine; Illicit substances; Mandatory drug testing; Narcotics; Opioids; Performance-enhancing drugs; Sobriety testing; Stimulants.

Drug Enforcement Administration, U.S.

Date: Established on July 1, 1973

Identification: Federal agency responsible for coordinating enforcement of all U.S. laws and regulations regarding illicit drug use and trafficking.

Significance: In response to increasing use of illegal drugs in the United States, Richard M. Nixon's presidential administration established the Drug Enforcement Administration to provide a unified center for federal control of drugs. The agency is charged with preventing, deterring, and investigating the illegal growing, manufacture, and distribution of controlled substances in, or destined for, the United States.

The U.S. government recognized the problem of drug abuse in the nation at least as early as 1915, when the Internal Revenue Service was charged with drug control. In the fifty-eight years that followed, various federal agencies were involved in enforcing laws dealing with drug possession and use. The Drug Enforcement Administration (DEA) was established when the Nixon administration decided that increased drug trafficking and drug abuse had made it essential for all aspects of federal drug control to be housed in one agency.

Mission and Organization

The DEA was formed from the merging of two federal organizations that were already involved in drug control: the Office of Drug Abuse Law Enforcement and the Bureau of Narcotics and Dangerous Drugs. The new agency provided a centralized means of responding to increased concerns regarding drug trafficking in the United States. As a subsidiary of the U.S. Department of Justice, the DEA was charged with ensuring that the provisions of the Controlled Substances Act of 1970 were enforced. This act was designed to limit access to certain kinds of drugs and to control drugs of abuse within the United States and internationally.

The DEA is charged with enforcing the laws of the United States that deal with the regulation of controlled substances. The agency is responsible for prosecuting any organizations or individuals suspected of growing, manufacturing, or distributing any controlled substances intended for illegal use within the United States. The DEA is also involved in organizing and supporting programs designed to lessen the availability and illegal use of controlled substances within the United States.

The DEA works in conjunction with the governments of other nations to reduce the importation and availability of drugs of abuse by developing and supporting programs of crop eradication and substitution. The agency also cooperates in efforts with the United Nations, Interpol, and other international organizations that manage drug-control programs to reduce illicit drug use throughout the world. The DEA seizes assets resulting from illegal drug use and puts them to appropriate use in furthering its mission of drug control.

The head of the DEA is known as the administrator of drug enforcement. This individual is appointed to the post by the president of the United States and confirmed by the U.S. Senate; he or she reports directly to the Office of the Attorney General of the United States. The administrator oversees a large number of executives and other employees, but only the administrator and the deputy administrator of the DEA are directly appointed by the president. More than thirty major offices operate under the auspices of the DEA, and all individuals employed by the DEA are considered to be career employees of the U.S. government.

Regulation of Controlled Substances

The DEA has established a system of registration for medical professionals, researchers, and manufacturers that allows them access to substances that are classified as Schedule I drugs under the Controlled Substances Act. The drugs included in Schedule I are those that are not approved for medical use and have a large

DEA's Forensic Laboratories

The U.S. Drug Enforcement Administration provides this description of the work of the DEA's laboratories:

Scientific support to DEA Special Agents and other law enforcement personnel is one of the critical functions provided by DEA forensic chemists. This encompasses a wide variety of duties and forensic disciplines, including: Analyses of controlled substances and related substances and processing chemicals; crime scene investigation; latent fingerprint identification and photographic development; analysis and evaluation of digital (computer) evidence; development, monitoring, and processing of hazardous waste cleanups and disposals; and expert witness testimony.

In addition, DEA laboratories derive strategic intelligence through in-depth analysis of seized drugs. This includes: The identification of occluded (trapped) solvents in cocaine, heroin, methamphetamine, and methylenedioxymethamphetamine (Ecstasy); the examination of logos and tablet characteristics of Ecstasy and related "Club Drug" tablets; and the determination of the geographical and/or synthetic origins of cocaine, heroin, and methamphetamine. These "Signature Programs" help DEA monitor the trafficking patterns of drugs entering the United States. The analysis of Domestic Monitor Program samples provides price/purity information for heroin sold at the retail level.

Since their inception, DEA laboratories have applied the latest technologies to support criminal investigations. Beginning in the 1970's, DEA laboratories were at the forefront of forensic science by applying gas chromatography/mass spectroscopy (GC/MS), nuclear magnetic resonance (NMR) spectroscopy, and high performance liquid chromatography (HPLC) to forensic drug analysis. The novel use of state-of-the-art instruments continued into the 1990's as DEA's laboratories kept pace with developments in scientific instrumentation and computer technologies. Today, DEA laboratories are working with innovative technologies that will enable the laboratory system to remain at the forefront of forensic drug science.

potential for abuse. The DEA also mandates the registration of medical professionals to allow them to prescribe Schedule II drugs, which are drugs that do have known medical uses but also have great potential for abuse and great potential to cause dependence. The DEA issues each registered medical professional a unique number that allows the agency to track the distribution of controlled substances.

Many legally prescribed drugs are used for purposes other than those for which they were prescribed, and this diversion of legitimate drugs for illegal purposes is a concern of the DEA. By requiring all medical professionals who prescribe, dispense, or administer prescription drugs to register with the DEA and comply with the agency's regulatory requirements, the DEA seeks to reduce the diversion of drugs for illegal purposes.

Agency Effectiveness

Some observers have questioned the effectiveness of DEA programs in reducing the availability of illicit drugs, and few high-quality independent evaluations of the programs' impacts have been conducted. Although the DEA seized more than $1.4 billion in drug-related assets and more than $420 million in drugs in 2005, these figures are negligible compared with the estimated $64 billion in illegal drugs sold in the United States in a given year. Based on this figure, from the White House Office of Drug Control Policy, it would appear that the DEA has been relatively ineffective in controlling drug trafficking.

In general, the DEA has focused on programs that enable the interception of heroin and cocaine across federal borders. Although this has proved to be an important function of the agency, and one that is cost-effective, it does not touch on the drugs that are most widespread in terms of use. Many professionals in the field of drug control have argued that the DEA should focus more attention on the use and sale of marijuana and on traffic in prescription drugs that are used recreationally.

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Further Reading

Gray, Mike. *Drug Crazy: How We Got into This Mess and How We Can Get Out*. New York: Random House, 1998. Presents a full description of the abuse of drugs in the United States and suggests various ways in which the problem should be addressed.

Lyman, Michael D. *Practical Drug Enforcement*. 3d ed. Boca Raton, Fla.: CRC Press, 2007. Describes the methods used by the DEA and other law-enforcement agencies to control drug trafficking and drug use in the United States. Includes comparisons of the variety of enforcement techniques used in different jurisdictions.

Neubauer, David W. *America's Courts and the Criminal Justice System*. 9th ed. Belmont, Calif.: Wadsworth, 2007. Comprehensive volume on the American system of criminal justice includes an overview of the laws and punishments associated with drug trafficking.

Robbins, David. *Heavy Traffic: Thirty Years of Headlines and Major Ops from the Case Files of the DEA*. New York: Chamberlain Bros., 2005. Uses news stories and DEA case files to describe the agency's work on some particularly important cases.

Sells, David H., Jr. *Security in the Health Care Environment*. New York: Aspen, 2000. Describes the practices that health care facilities should use to provide safe and effective care for clients while adhering to the laws regarding the dispensing of drugs that are set forth by and enforced by the federal government.

U.S. Drug Enforcement Administration. *A History of the Drug Enforcement Administration from 1978 to 2003*. Washington, D.C.: Government Printing Office, 2003. Brief work reviews the role of the agency in drug control in the United States.

See also: Anabolic Steroid Control Act of 2004; Bureau of Alcohol, Tobacco, Firearms and Explosives; Canine substance detection; Chain of custody; Drug classification; Drug paraphernalia; Federal Bureau of Investigation; Federal Rules of Evidence; Harrison Narcotic Drug Act of 1914; Mandatory drug testing; Narcotics.

Drug paraphernalia

Definition: Products that have been created, modified, or adapted from their intended uses for the purposes of making, using, or concealing illegal drugs.

Significance: Law-enforcement agencies devote significant resources to the investigation of crimes related to drug abuse and drug trafficking. Forensic scientists are often involved in examining items collected from crime scenes to determine whether they have come into contact with illicit drugs and, if so, the exact nature of those drugs.

In the United States, the classification of particular items as drug paraphernalia may depend on the answers to three questions: Does national or local advertising address how the items are employed in the production, concealment, transportation, or use of illegal drugs? Are the items sold in a manner that implies that they are to be used in relation to illegal drugs? Can expert testimony establish that the items are employed in the production, concealment, transportation, or use of illegal drugs?

Whereas some items are specifically designed for the production, concealment, transportation, or use of illegal drugs, many items that can be classified as drug paraphernalia have other legitimate uses as well. For instance, aluminum foil is used to package drugs and to fashion temporary pipes for smoking marijuana or crack cocaine. Eyedrops are used to clear the redness from bloodshot eyes (a common side effect of drug use). Eyedroppers may be used to deliver LSD or to insert injection drugs into syringes. Small mirrors, razor blades, and credit cards are often used to cut up powder cocaine, and rolled-up dollar bills may be used to snort the drug. Sensitive electronic and mail scales are used to weigh drugs for sale. Ropes, belts, and pieces of rubber tubing are used as tourniquets to help veins pop so that drugs may be administered intravenously.

Some items of drug paraphernalia are sold under disclaimers that purport that they are to be used for smoking tobacco. Pipes, water or ice bongs, hookahs, and rolling papers are sold in various tobacco product shops (so-called head shops) with the unwritten implication that they are to be used to smoke marijuana.

Marijuana Paraphernalia

The most widely produced and used illegal drug in the United States is cannabis, more commonly known as marijuana. Marijuana typically consists of green or brown dried flowers and leaves, but the color and texture may vary greatly depending on the strain, batch, and freshness of the product. Marijuana produces psychoactive and disorienting physiological effects such as decreased motor coordination, dizziness, sleepiness, and increased appetite.

Marijuana is usually smoked, whether in the form of a cigarette (known as a joint) or a hollowed-out cigar (blunt) or in some kind of pipe, such as a water or ice bong. It is also sometimes ingested in foods, such as brownies. Cannabis resin is also collected, dried, and compressed into black balls or sheets to produce hashish. Users of hashish break off pieces of these balls and place them in pipes or bongs to smoke the drug.

The following are examples of items of paraphernalia associated with cannabis:

- Plastic sandwich bags and similar small containers (used to store and transport the drug)
- Sensitive electronic and mail scales (used to weigh the drug to set prices for sale)
- Tobacco rolling papers (used to roll marijuana cigarettes)
- Razor blades (used to slit cigars and remove the tobacco so that it may be replaced with marijuana)
- Incense and air deodorizers (used to disguise the odor of marijuana smoke)
- Fabric softener sheets (used in making "blow tubes" from empty toilet paper rolls to absorb the odor of exhaled marijuana smoke)
- Pipes and bongs (used for smoking the drug)
- Roach clips (items used to hold the ends of marijuana cigarettes so that they may be smoked in their entirety, such as alligator clips, tweezers, and medical hemostats)

The commissioner of the U.S. Department of Customs (left) and the director of the Office of Commercial Fraud examine samples of more than 300,000 seized items of suspected drug paraphernalia in Washington, D.C. The 1989 haul was one of the largest such seizures in U.S. history. *(AP/Wide World Photos)*

Cocaine and Crack Cocaine Paraphernalia

Cocaine is a highly addictive white powder processed from the coca plant. It stimulates the central nervous system and acts as an appetite suppressant. When taken in small amounts, cocaine typically makes the user feel euphoric, energetic, talkative, and mentally alert. Powder cocaine is usually consumed through inhalation through the nose, or snorting.

Crack cocaine is made from processing cocaine with baking soda and water. The addition of baking soda forms the drug into a solid that may be vaporized and inhaled. (The name "crack" is derived from the crackling sound made when the drug is vaporized.) Inhalation of crack cocaine vapors provides users with a more intense, but short-lived, high than would be achieved from snorting it. On average, crack is made up of about 40 percent cocaine. The amount of cocaine in a batch of crack, as well as the other substances present, depends on the manufacturer. On the street, crack is sold as little white to tan pellets or "rocks." A user places a rock in a pipe fitted with a fine mesh screen, heats the rock with a flame, which causes it to vaporize, and then inhales the fumes.

The following are examples of items of paraphernalia associated with cocaine and crack:

- Small mirrors or glassy surfaces, razor blades or credit cards, and rolled-up dollar bills or short plastic straws (used to cut up and snort cocaine)
- Glossy, nonporous magazine paper folds or aluminum foil that will not absorb powder (used to conceal the drug)
- Strainers (used to break up cocaine and to mix up crack)
- Small spoons (used to snort cocaine)
- Pipes with fine mesh screens (used to smoke crack)
- Cigarette lighters (used to vaporize crack so that it may be inhaled)

Inhalant Paraphernalia

Most inhalant abuse involves everyday household products. Among the products commonly used by inhalant abusers are ink correction fluids, marking pens, nail polish removers, butane, gasoline, glues and adhesives, paint and paint thinners, and aerosol sprays of many kinds, including cooking sprays, hair sprays, disinfectants, furniture polishes, oven cleaners, and deodorants. Some users spray the contents of aerosol sprays into plastic bags and then inhale the vapors produced. With substances such as propane and butane, users generally inhale the gases directly or from saturated rags. The effects of solvent intoxication vary widely, depending on the amounts and types of solvents or gases inhaled.

Paraphernalia Intended to Fool Drug Tests

A variety of products are marketed in head shops and on the Internet that claim to help drug users pass drug tests. Various drinks, pills, powders, and teas are advertised as being able to speed up the body's ability to metabolize and thus wash out or disguise the presence of drugs. Some Web sites sell "clean" urine and urine powder or agents that a person can supposedly add to his or her own urine to produce a clean sample. Certain shampoos are advertised as being able to negate evidence of drug use in hair follicle testing. Whether any of these products works or not depends on the type of drug tested for, the level of drugs in the body, the amount of time since last use, the type of test being performed, and the method used to fool the test.

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Further Reading

Abadinsky, Howard. *Drug Use and Abuse: A Comprehensive Introduction*. 6th ed. Belmont, Calif.: Thomson/Wadsworth, 2008. Provides an interdisciplinary survey of the impacts of drugs on American society, including the pharmacological effects of drugs on the body, implications of U.S. drug policy, and the criminal justice system's response to the drug problem.

Hicks, John. *Drug Addiction: "No Way I'm an Addict."* Brookfield, Conn.: Millbrook Press, 1997. Discusses drug-abuse treatment strategies, with particular focus on amphetamine addiction.

Karch, Steven B., ed. *Drug Abuse Handbook*. 2d ed. Boca Raton, Fla.: CRC Press, 2007. Compendium of authoritative information on various aspects of drug abuse includes contributions by medical, legal, and treatment professionals.

LeVert, Suzanne. *Drugs: Facts About Cocaine*. Tarrytown, N.J.: Marshall Cavendish, 2006. Discusses cocaine use and abuse in detail. Features personal stories of addiction and treatment.

Menhard, Francha Roffé. *Drugs: Facts About Amphetamines*. Tarrytown, N.J.: Marshall Cavendish, 2006. Provides information on the characteristics, legal status, history, abuse, and treatment of addiction to amphetamines and methamphetamine.

Walker, Samuel. *Sense and Nonsense About Crime and Drugs: A Policy Guide*. 6th ed. Belmont, Calif.: Thomson/Wadsworth, 2006. Challenges many common misconceptions and myths about crime control and drug policies in the United States, with the aim of stimulating critical thinking.

See also: Amphetamines; Barbiturates; Club drugs; Crack cocaine; Crime scene screening tests; Drug abuse and dependence; Drug and alcohol evidence rules; Drug classification; Drug Enforcement Administration, U.S.; Inhalant abuse; Mandatory drug testing; Narcotics; Opioids; Psychotropic drugs.

DSM-IV-TR. See *Diagnostic and Statistical Manual of Mental Disorders*

Duty to warn. See *Tarasoff rule*

E

E. coli. See *Escherichia coli*

Ear prints

Definition: Two-dimensional replicas of external ear parts made from impressions left on surfaces.

Significance: When human ears touch surfaces, they can leave impressions; if such impressions are found at crime scenes, investigators may be able to use them as evidence in identifying suspects.

The ears of human beings assume something close to their final shape a few months after birth. The ears continue to increase in size through the early teens, but afterward, ear form remains fairly stable unless altered by disease, surgery, accident, or piercing.

The human auricle, the visible part of the outer human ear, has a convoluted design. In most adults, the two auricles differ from each other as well as from the auricles of other adults. The apparent uniqueness of auricle shape is the basis for the forensic endeavor sometimes called earology.

The idea of an ear identification system found support in the studies of an early twentieth century doctor working in Prague, R. Imhofer, who examined photographs of five hundred ears. Imhofer discovered that he needed only four characteristics to distinguish one ear from the others. In 1964, American police official Alfred V. Iannarelli published a book on his research into ear shapes. Iannarelli claimed that external ears have unique shapes and that ear features can be classified with a system similar to that used to classify fingerprints.

Criminal investigators occasionally find ear impressions left at crime scenes. Burglars, for example, often listen at windows, with their ears pressed against the glass, before breaking into houses. Perspiration, oils, and wax on the burglars' outer ears may leave prints that crime scene specialists can reveal with standard fingerprint visualization techniques.

Investigators may use latent ear prints in several ways. If an ear print found at a crime scene does not match the ear prints of a potential suspect, the crime scene print may be used to exclude that person as a suspect. If the latent ear print appears similar to one or the other of a potential suspect's ear prints, the ear print may be used as evidence that the suspect could have visited the crime scene.

In the United States, judges typically have not allowed prosecutors to use ear prints for positive identification. An exception occurred in a Washington State murder trial when the judge allowed prosecution witnesses to testify that a defendant was the probable source of a latent ear print found at the murder scene. The defendant appealed, resulting in a leading 1999 case on ear-print evidence, *State of Washington v. Kunze*.

The *Kunze* appellate judges applied the *Frye* test (under which the scientific theory or method used to generate evidence must be determined to be generally accepted as reliable in the scientific community) to determine whether the novel scientific evidence of an ear print should be admitted into court. The judges concluded that latent ear prints offer class characteristics but not individual characteristics. That is, in the view of the Washington State court, ear impression evidence can support an opinion that a particular person cannot be excluded as the maker of a latent print, but it cannot support an opinion that a particular person probably made a latent print.

Phill Jones

Further Reading

Abbas, Ali, and Guy N. Rutty. "Forensic Web Watch." *Journal of Clinical Forensic Medicine* 10 (2003): 129-131.

Champod, Christophe, Ian W. Evett, and Benoit Kuchler. "Earmarks as Evidence: A Critical Review." *Journal of Forensic Sciences* 46, no. 6 (2001): 1275-1284.

See also: Biometric identification systems; Class versus individual evidence; Courts and forensic evidence; Fingerprints; Forensic sculpture; *Frye v. United States*; Integrated Automated Fingerprint Identification System; Sinus prints.

Ebola virus

Definition: Virus of the family Filoviridae that causes hemorrhagic fevers with a high mortality rate.

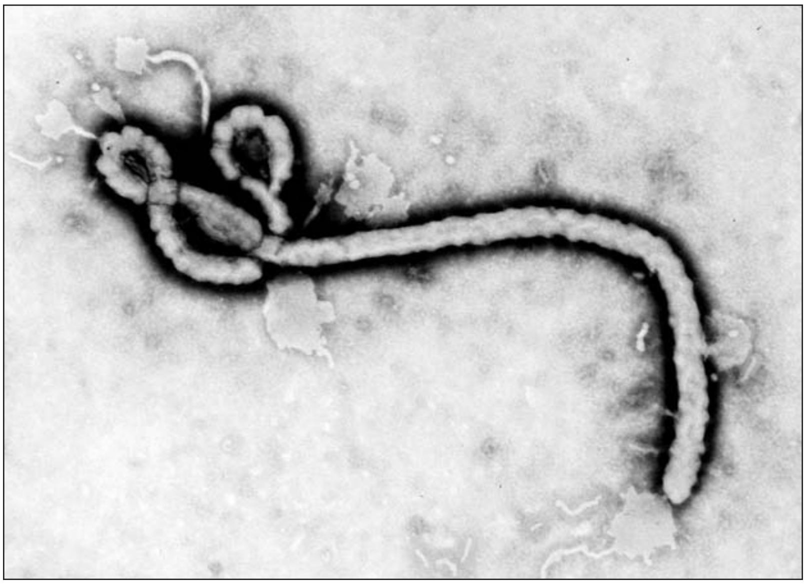
Significance: Given increasing attention to international terrorism and the potential use of biological weapons in terrorist attacks, forensic scientists have focused awareness on the pathology and symptoms of such potential threats as Ebola virus.

Ebola virus is considered an emerging virus; it was first recognized by the international medical community in 1976, following two outbreaks of hemorrhagic fever in African villages along the Ebola River. The distinctive shape of Ebola virus—a long filament that is frequently twisted into U, 6, or knot shapes—is a characteristic of the virus family to which Ebola virus belongs, the Filoviridae.

The four recognized strains of Ebola virus—Zaire, Sudan, Côte d'Ivoire (or Ivory Coast), and Reston—are named after the sites where the strains first broke out. The genome of the Ebola virus, a single strand of RNA (ribonucleic acid), has been completely sequenced. Researchers have been able to generate Ebola virus particles through a process called reverse genetics, in which the viral genome and genes for a few key viral proteins were added to cells that then synthesized new, infectious viruses. The Ebola virus genome is small and could theoretically be assembled in a laboratory, a fact that contributes to fears that the virus could someday be used as a biological weapon.

Ebola virus infects only primates, both humans and nonhuman primates such as chimpanzees and gorillas. Because the virus causes a highly lethal disease in primates, primates cannot be the environmental reservoir for the virus. Researchers trapped small animals near the site of an outbreak and discovered that three species of fruit bats had genetic material from the Ebola virus, although the bats were asymptomatic. Such bats were a food source for the local villagers, suggesting a possible route for transmission of the virus to humans.

The virus can be transmitted through fluids such as blood, saliva, and feces and preferentially infects liver tissue and cells of the immune system. Researchers have used an aerosolized preparation of the virus to infect rhesus mon-



A transmission electron micrograph of the Ebola virus. *(Centers for Disease Control and Prevention)* keys; this suggests that airborne transmission of the virus is possible. In individuals who develop hemorrhagic fever after contracting Ebola, the virus replicates rapidly in all tissues. Mortality rates are high, ranging from 50 to 90 percent, depending on the infecting virus strain. No treatments or vaccines have yet been developed for Ebola virus infection in humans, but a vaccine has been developed that appears to protect nonhuman primates against infection.

Diagnosis of Ebola virus hemorrhagic fever can be difficult because early symptoms (fever, severe headache, joint and muscle aches, chills, sore throat, and weakness) mimic those of other infectious diseases. Later symptoms that are more clearly characteristic of Ebola infection are nausea and vomiting, diarrhea (possibly bloody), red eyes, raised rash, hiccups, stomach pain, and bleeding from many sites, including nose, mouth, rectum, eyes, and ears. The blood of infected individuals usually contains high concentrations of the virus. Diagnostic laboratory tests for the virus include ELISA (enzyme-linked immunosorbent assay) to detect antibodies to the virus and reverse transcriptase-polymerase chain reaction (RT-PCR) to detect specific genes of the virus.

Lisa M. Sardinia

Further Reading

Close, William T. *Ebola: Through the Eyes of the People*. Marbleton, Wyo.: Meadowlark Springs, 2002.

Zubay, Geoffrey L. *Agents of Bioterrorism: Pathogens and Their Weaponization*. New York: Columbia University Press, 2005.

See also: Biodetectors; Biological terrorism; Biotoxins; Blood agents; Centers for Disease Control and Prevention; Hemorrhagic fevers; Pathogen transmission; U.S. Army Medical Research Institute of Infectious Diseases; Viral biology.

Electrical injuries and deaths

Definition: Injuries or death caused by electricity passing through the body.

Significance: Death from electrocution often leaves no external signs, and investigators must determine the cause of death from the circumstances. Sometimes, however, forensic pathologists are able to detect marks on the body of a person killed by electricity that show the entry or exit of the electrical current; in other cases, internal injuries may indicate electrocution.

Most injuries and deaths resulting from contact with electricity are accidental. The human body is very susceptible to injuries and death from electricity because the body is made up mostly of water and other types of fluids, and electricity passes through water with low resistance. When electricity passes through a body, it causes damage, sometimes massive damage, to tissues. If the body is wet it has even less resistance, causing higher currents to pass through and thus more tissue damage. Many electrocutions occur in bathrooms, where wet skin and electrical appliances make a deadly combination, or in bodies of water, such as lakes. Electrical injuries are more common in men than in women, but women do experience such injuries. In pregnant women, electric shock may cause miscarriage.

How Electricity Causes Death

The amount of tissue damage and whether death occurs from electric shock depends on how large the electrical current is and how long it continues to run through the body. Generally, when a person touches something emitting an electrical current, the resulting pain causes the person to release the object before any tissue damage occurs. If the electrical current is strong enough, however, it causes the muscles to contract in a spasm, and the person is unable to let go of the object emitting the current. The longer the body stays in contact with this object, the more electrical current flows through the body

Lightning Strikes

In a lightning strike on the human body, the body is exposed to high voltage as well as a compression wave that acts as an explosion. Those who survive this type of electrocution are very lucky.

The bodies of some persons who die in lightning strikes show no obvious marks of their electrocution, but they may be discovered in strange and unexplained circumstances. For example, occasionally the body of a person who has been struck by lightning may be found unclothed, which may lead investigators to consider homicide or sexual assault as the cause of death, particularly if no signs of electrocution are obvious. Metals—such as pieces of jewelry, buttons, or zippers—on a body that has been struck by lightning may be completely melted, causing strange burns and other wounds. The bodies of lightning victims may have other severe burns, lacerations, or even fractures due to the concussive wave of energy released by lightning strikes.

An unusual sign that occurs only on the bodies of some lightning victims is known as the Lichtenberg figure. This strange red pattern, which looks something like a fern, appears usually on the back, buttocks, shoulders, or legs. The appearance of a Lichtenberg figure on a body is a sure sign that the person was the victim of a lightning strike; however, this pattern does not appear in every case of death by lightning strike. When this figure does appear, it fades within about forty-eight hours after the strike, leaving no other marks. The reasons Lichtenberg figures sometimes appear are unknown, and no pattern has been discerned regarding when and where they occur.

and the more damage is done to tissues and internal organs. Long contact with a high current of electricity can cause the heart to begin to beat irregularly, leading to cardiac arrest.

Contact with high-voltage power cables generally does not cause cardiac arrest. This kind of electrical contact is more likely to cause serious internal burns and damage to organs and tissues, which can cause death. If the current passes through the brain stem, where breathing is controlled, the result can be respiratory failure.

The possibility of death from contact with electricity is increased when the electric current passes through the chest or head. Contact with electrical current of more than 250 volts generally causes death, but death may also result from current as low as 32 volts.

Signs of Electrocution

External signs of electrocution may be minimal and hardly noticeable, or they may be obvious, such as severe burns. If the circumstances surrounding a death point to electrocution and no obvious signs are visible, the forensic pathologist will often examine the victim's hands for small burn marks or marks that look like blisters with white rims and dark centers. Such marks, which are characteristic of the entry and exit points of electrical current, are also sometimes found on body parts other than the hands, such as the feet.

Marianne M. Madsen

Further Reading

Bazelyan, Eduard M., and Yuri P. Raizer. *Lightning Physics and Lightning Protection*. Philadelphia: Institute of Physics Publishing, 2000. Presents a comprehensive discussion of lightning, including the kinds of injuries caused by lightning and techniques for protecting against such injuries.

Fish, Raymond M., and Leslie A. Geddes. *Medical and Bioengineering Aspects of Electrical Injuries*. Tucson, Ariz.: Lawyers & Judges Publishing, 2003. Outlines different aspects of electrical injuries in humans and includes a section on injuries that occur to different parts of the body.

Geddes, Leslie A., and Rebecca A. Roeder. *Handbook of Electrical Hazards and Accidents*. Tucson, Ariz.: Lawyers & Judges Publishing, 2006. Provides useful background in the principles of electricity and includes discussion of the impacts of electricity flowing through the body.

Nabours, Robert E., Raymond M. Fish, and Paul F. Hill. *Electrical Injuries: Engineering, Medical, and Legal Aspects*. 2d ed. Tucson, Ariz.: Lawyers & Judges Publishing, 2004. Presents a complete summary of the various issues related to electrical injury. Includes chapters titled "The Forensic Electrical Engineer" and "The Effects of Electrical Energy on Humans."

Rakov, Vladimir A., and Martin A. Uman. *Lightning: Physics and Effects*. New York: Cambridge University Press, 2003. Covers all aspects of lightning, including the effects of lightning strikes on human bodies.

See also: Autopsies; Burn pattern analysis; Forensic pathology; Less-lethal weapons; Structural analysis.

Electromagnetic spectrum analysis

Definition: Technique for identifying substances based on how they absorb specific wavelengths of energy.

Significance: Forensic scientists are called upon to analyze and identify many unknown substances. Electromagnetic spectrum analysis is an important tool used in the identification of the component elements found in substances such as explosives residues, poisons, pharmaceuticals, and hazardous chemicals.

The electromagnetic spectrum is the entire range of electromagnetic radiation. Radiation is classified by wavelength, which determines the behavior of the radiation. Beginning with the longest waves, which have the lowest frequencies, the electromagnetic spectrum can be divided as follows:

- Radio waves, which are used for radio and telephone broadcasts and cellular phones
- Microwaves, which are easily absorbed by water and so are good for heating food
- Infrared radiation, which is invisible to the eye but can be detected with special infrared film
- Visible light, which is the small band of electromagnetic radiation detectable by the human eye
- Ultraviolet radiation, which causes sunburn and damage to the genetic material in cells (deoxyribonucleic acid, or DNA)
- X rays, which pass through soft tissue and so are used in medical and forensic procedures to enable visualization of harder material such as bones
- Gamma rays, which are high-energy penetrating waves produced by radioactive material

The mid-infrared region of the electromagnetic spectrum is of most use to forensic scientists. This is sometimes called the "fingerprint region" of the spectrum because it is most useful in identifying unknown compounds. In infrared spectroscopy, a beam of a specific wavelength of infrared radiation is split, with one part passing through a sample of an unknown compound and the other through a known reference sample. A detector measures the energy of each beam after it has passed through each sample. The energy absorbed by the unknown sample is calculated through comparison of the measurements of the two beams. The amount of energy absorbed depends on the shape of the molecules in the compound. A computer manipulates the information to produce a characteristic print or graph that the forensic scientist can compare with reference graphs of known substances to identify the unknown substance.

Among the many variations on spectroscopy is Fourier transform infrared (FTIR) spectroscopy, which is often used in forensic analysis. Ultraviolet spectroscopy, which uses shorter ultraviolet light, is sometimes used to identify organic compounds. Forensic laboratories need only tiny amounts of unknown substances to identify their components using spectroscopy.

Martiscia Davidson

Further Reading

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific* *and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005.

Richards, Austin. *Alien Vision: Exploring the Electromagnetic Spectrum with Imaging Technology*. Bellingham, Wash.: SPIE Press, 2001.

See also: Analytical instrumentation; Fourier transform infrared spectrophotometer; Imaging; Infrared detection devices; Nuclear spectroscopy; Spectroscopy; Ultraviolet spectrophotometry.

Electronic bugs

Definitions: Bugs are hidden microphones used to listen in on conversations surreptitiously; bug detectors are devices designed to find any bugs in a given area.

Significance: The invention and subsequent deployment of bugs in covert surveillance was quickly followed by the invention of bug detectors. Over time, the makers of bugs have created increasingly sophisticated devices in their attempts to evade the ever-widening scope of detection achieved by competing detectors.

The designs of the listening devices known as bugs are limited only by the imaginations of the designers. Bugs can be broadly divided into four types: radio-transmitting, nonradio, telephone-based, and reflection-based.

Radio-Transmitting Bugs and Their Detection

The simplest type of bug to place, and the simplest to detect, is the type that functions by transmitting a radio signal to the listener or, more often, to a remotely located tape recorder. Such a bug can be placed quickly because it requires no installation of wires; in addition, the user can change recording tapes without having to gain access to the bug itself. Bugs of this type can be extremely small. They can operate off battery power or, if located in an electrical or telephone outlet, can draw power from the outlet and operate indefinitely.

The simplest detectors for radio-transmitting bugs are broad-spectrum radio receivers. These report, by indicator lights or audio hum, whether radio signals, at any frequency, are being emitted near them. In practice, the sensitivity of a radio receiver being used for bug detection must be lowered so that it does not report ordinary radio and television signals. Once the sensitivity is lowered, the broad-spectrum receiver has a very short detection range for bugs, so the user must conduct a careful sweep with the detector to ensure that no bugs are missed.

Better than the broad-spectrum receiver is the frequency counter, which displays the frequency of a radio signal upon detecting it. A great (and quite costly) improvement over both the broad-spectrum receiver and the frequency counter is the spectrum analyzer, which not only detects all radio signals but also displays their frequencies and strengths on a bar graph. The user can thus ignore powerful but innocent transmissions—radio and television stations—and focus on others.

A more sophisticated search for radio bugs requires two tools. The first, an audio emitter, is placed in the room being swept and emits a loud audio signal on a single frequency. The other tool is a radio scanner that automatically sweeps all frequencies within its range, briefly listening to each frequency. It stops and sounds an alert if it hears a radio transmission containing the audio signal given off by the emitter.

Bug manufacturers attempt to evade these detectors with technology such as burst transmission, in which the bug itself records signals, compresses them, and then sends them in brief bursts, five or ten minutes apart. Another device that can evade such detectors is the remotely controlled bug, which is turned on only when a conversation is to be overheard and thus is likely to be missed in general sweeps.

Nonradio Bugs and Their Detection

Detecting bugs that do not transmit radio signals is much more difficult, but makers of bug detectors have evolved tools aimed at these as well. The simplest is an ultrasound generator, which, under the right conditions, can cause a microphone's diaphragm to vibrate and give off an audible sound. This kind of detector can find hidden tape recorders because most of them, when running, give off faint ultrasonic signals that can be picked up by specialized listening devices.

The most sophisticated tool for seeking nonradio bugs is the nonlinear junction detector. This device transmits a microwave signal that is reflected back (at a slightly different frequency, known as a harmonic) by transistors and similar electronic components used in bugs. This type of detector will spot even bugs that are not transmitting. Bug makers seek to evade these detectors by encasing their bugs in metal shielding that blocks the microwaves.

U.S. ambassador to the United Nations Henry Cabot Lodge (left) addresses the U.N. Security Council in May, 1960, about an electronic bug he accused Soviet authorities of planting in the U.S. embassy in Moscow. The reflection-based system was hidden in the wooden carving of the Great Seal of the United States shown here; the seal had been presented to the embassy as a gift by Soviet schoolchildren. *(AP/Wide World Photos)*

Telephone- and Reflection-Based Bugs and Their Detection

Telephone-based bugs, also known as infinity transmitters, rely on devices, usually installed in telephones, that allow them to transmit over telephone lines and allow the listeners to call in without the telephones ringing. Such devices can be detected by electronic tests of the telephone lines.

A reflection-based bug functions by reflecting radiation off an object that serves as a diaphragm. Sound causes the object to move, and the movement is shown in the reflected radiation. At a simple level, an infrared laser can be reflected off a windowpane to reveal conversations inside the room where the window is located. During the Cold War, the Soviets used a more complex reflectio -based system to bug the U.S. embassy in Moscow. Soviet schoolchildren presented the embassy with a gift: a wooden carving of the Seal of the United States in which was hidden a metal diaphragm with a tiny antenna. When a microwave beam was directed at the seal, the antenna absorbed the energy and radiated it back, varying with the audio in the room. The bug was operational for seven years before it was accidentally detected.

Searches for reflection-based bugs center on searches for the beams used to radiate them, which are usually infrared or microwave beams. Such searches are complicated by the fact that the beams are radiated only when the bugs' users are attempting to listen in on conversations.

David T. Hardy

Further Reading

Clark, Laura, and William E. Algaier. *Surveillance Detection: The Art of Prevention*. St. Louis: Cradle Press, 2007. Brief volume focuses on ways that individuals can protect themselves from observation by others using covert surveillance devices.

Hauser, Greg. *Techniques in Countersurveillance : The Fine Art of Bug Extermination in the Real World of Intelligence Gathering*. Boulder, Colo.: Paladin Press, 1999. Provides detailed coverage of the topic.

Shannon, M. L. *Don't Bug Me: The Latest High-*

Tech Spy Methods. Boulder, Colo.: Paladin Press, 1992. Excellent introductory manual provides a broad overview of the subject.

See also: Closed-circuit television surveillance; Electronic voice alteration; Facial recognition technology; Night vision devices; Satellite surveillance technology; Telephone tap detector; Voiceprints.

Electronic voice alteration

Definition: Changing of the pitches of voices artificially through computer or other electronic manipulation or the electronic scrambling of voice communications so that they are unintelligible to eavesdroppers.

Significance: Most common uses of voice alteration represent attempts to hide the identities of the speakers. Voice-altering technology comes to the attention of forensic scientists in situations such as criminal wiretap, kidnap, and terrorist cases in which altered voices are recorded and the persons speaking must be positively identified. The scrambling of voice communications, another kind of electronic voice alteration, is used by military and security services to prevent outsiders from accessing the contents of messages.

Electronic voice alteration is most often done to disguise the identities of speakers involved in criminal activities such as stalking or threatening, when the speakers anticipate that recordings might be made of their voices or their communications might be intercepted by wiretaps. Voice alteration is also sometimes used by persons who imitate the voices of others to gain access to protected information or places. For example, some computer files and physical locations are protected by voice recognition systems that may be fooled by electronically altered voices. Voice alteration may be used in the impersonation of persons over the telephone to acquire information to which those persons have restricted access. Electronic voice manipulation is also sometimes used to protect the identities of witnesses or victims of crimes who agree to speak about their experiences publicly, such as on radio or television programs.

Several types of voice-changing devices are widely available commercially. One is a portable device that can be held over the mouthpiece of a telephone. More sophisticated devices can be connected to landline telephones. These voice-changing devices alter the pitch of the speaker's voice, making it sound higher or lower. They produce the most natural and human-sounding voices when the pitch is adjusted by no more than two octaves. The greater the change, the more artificial, electronic, or cartoonish the voice sounds. Professional-quality equipment is required to convert the low-pitched bass voice of a man into a natural-sounding woman's speaking voice.

Forensic scientists who specialize in the detection and analysis of altered voices are called forensic linguists or forensic stylists. Voice-altering equipment cannot change speakers' accents or speech patterns, and forensic linguists are able to use these factors, along with word choice, grammar, and sentence complexity, to identify the persons behind electronically altered voices.

A different type of electronic voice alteration is used in speech encryption. Speech encryption—the scrambling or compressing of voices—is done for security purposes, to protect the contents of voice transmissions from eavesdroppers. An electronically compressed or digitally scrambled conversation sounds like nonsense to anyone listening. The intended recipient, however, has the hardware and software needed to decode the message, making it intelligible. This type of electronic voice alteration is used most extensively by the military and security services and is the basis for their secure telephone systems.

Martiscia Davidson

Further Reading

Diffie, Whitfield, and Susan Landau. *Privacy on the Line: The Politics of Wiretapping and Encryption*. Cambridge, Mass.: MIT Press, 2007.

Hollien, Harry. *Forensic Voice Identification*. San Diego, Calif.: Academic Press, 2002.
Tanner, Dennis C. *Medical-Legal and Forensic Aspects of Communication Disorders, Voice Prints, and Speaker Profiling*. Tucson, Ariz.: Lawyers & Judges Publishing, 2007.
Tanner, Dennis C., and Matthew E. Tanner. *Forensic Aspects of Speech Patterns: Voice Prints, Speaker Profiling, Lie and Intoxication Detection*. Tucson, Ariz.: Lawyers & Judges Publishing, 2004.

See also: Biometric identification systems; Electronic bugs; Forensic linguistics and stylistics; Telephone tap detector; Voiceprints.

Electrophoresis

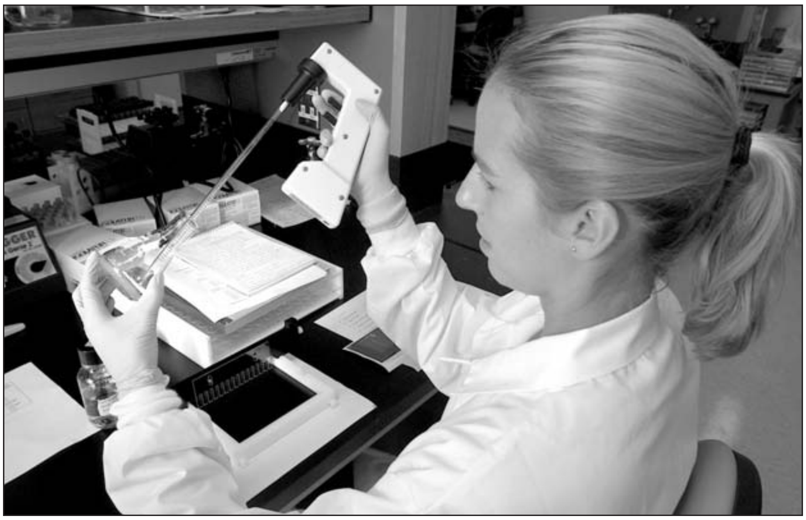
Definition: Analytical technique that uses electrical fields to separate and analyze charged molecules.

Significance: When analyzing biological and nonbiological samples, such as when conducting DNA fingerprinting or drug testing, forensic scientists frequently use electrophoresis separation methods.

Electrophoresis is the migration of molecules in response to electrical fields. Any molecule that possesses an electrical charge—including biological molecules such as nucleic acids (DNA and RNA), proteins, and carbohydrates, as well as the molecules that make up many drugs—can be electrophoretically separated on the basis of size, shape, and electrical charge. Electrophoresis generally involves placing a sample within a supporting medium, applying an electrical current across the medium for a period of time, then visualizing the locations of molecules within the medium.

Electrophoresis of biological molecules such as DNA (deoxyribonucleic acid) commonly employs gels composed of agarose or polyacrylamide. These gels are porous and act as molecular sieves that retard the movement of molecules primarily on the basis of size. Generally, such a gel is in the form of a slab with wells formed at one end of the slab. The gel is placed in an apparatus with a positive electrode at one end and a negative electrode at the other end. The gel is submerged in a buffer solution that contains ions that will conduct an electrical charge. DNA molecules are negatively charged and will migrate through the gel toward the positive electrode. Smaller molecules will migrate more rapidly than larger molecules. The separated molecules can be stained with a fluorescent dye (most commonly ethidium bromide), and their positions within the gel can be compared with the positions of DNA molecules of known size.

Agarose gels have a large range of separation but a relatively low resolving power. With the alteration of the concentration of agarose in the gel, DNA fragments of two hundred to fifty thousand base pairs can be separated, making this method useful for forensic techniques such as short tandem repeat (STR) and restriction



A microbiologist at the Centers for Disease Control and Prevention's Meningitis and Special Pathogens Branch runs a pulsed-field gel electrophoresis analytical test, a technique used in the typing of bacterial organisms. *(Centers for Disease Control and Prevention)* fragment length polymorphism (RFLP) analyses. Polyacrylamide gels have a very high resolving power; DNA molecules that differ in size by a single nucleotide can be differentiated using polyacrylamide gel electrophoresis (PAGE). PAGE is usually used to separate DNA molecules less than five hundred base pairs in length, making it the method of choice for DNA sequencing.

Capillary electrophoresis (CE) is an automated extension of gel electrophoresis in which molecules are separated on the basis of the charge-to-size ratio of the molecules. The molecules do not migrate through a slab gel matrix; rather, the samples are electrophoresed through a conductive liquid or gel medium within a small-diameter (25- to 100-millimeter) capillary tube. CE has been used for DNA sequencing, STR analysis, and analysis of polymerase chain reaction (PCR) products. Its use in forensic toxicology has received increasing attention, as it enables quick screening of biological fluids for a variety of illicit drugs as well as analysis of drug samples to detect impurities that may be unique to particular drug sources.

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Further Reading

Clark, David P. *Molecular Biology: Understanding the Genetic Revolution*. New York: Elsevier, 2005.

Hudson, John C., Murray J. Malcolm, and Mauro Golin. "Screening Biological Specimens for Drugs of Forensic Significance." In *Clinical and Forensic Applications of Capillary Electrophoresis*, edited by John R. Petersen and Amin A. Mohammad. Totowa, N.J.: Humana Press, 2001.

Martin, Robin. *Gel Electrophoresis: Nucleic Acids*. Oxford, England: BIOS Scientific Publishers, 1996.

See also: Analytical instrumentation; DNA analysis; DNA fingerprinting; DNA profiling; DNA sequencing; DNA typing; Mitochondrial DNA analysis and typing; Multisystem method; Paternity testing; Pathogen genomic sequencing; Restriction fragment length polymorphisms; Short tandem repeat analysis; Y chromosome analysis.

Energy-dispersive spectroscopy

Definition: Analytical technique used to construct an elemental profile of a sample of interest.

Significance: Forensic scientists are often asked to compare items such as pieces of paper, glass, or metal that frequently appear quite similar under visual examination. Energy-dispersive spectroscopy is an indispensable tool under these circumstances; using this technique, analysts can determine whether particular items contain the same trace elements and establish further evidence of common origin on an atomic level.

Energy-dispersive spectroscopy (EDS) allows forensic scientists to determine which elements are present near the surface of a sample of interest and also in what approximate ratio these elements occur. This method is extremely useful for the comparison of two pieces of evidence to see if they are consistent with each other. For example, two coins, one known to be ancient and one purported to be ancient, might be compared to determine whether the second coin is a fake. EDS reveals whether the metals present in the two coins are the same or different, as well as the proportions of the metals in each coin; if the metals or their proportions are significantly different between the two coins, it may be concluded that the second coin is a fake.

The EDS instrument detects and measures the energy of X rays that are emitted from an excited sample. When an atom is excited, it can relax in such a way that it emits X rays with a characteristic energy for that specific element. EDS software can determine which elements are present based on the energies of the X rays that are detected.

EDS is almost always coupled to a scanning electron microscope (SEM), which provides an electron beam to excite the sample of interest and allows an image of the surface being analyzed to be collected at the same time. If it is useful, a mapped image of the surface can be collected for various elements that shows the distribution of the elements in the area of the sample being examined.

Gunshot residue (GSR) analysis is often performed using SEM/EDS. It is known that GSR consists primarily of small, spherical particles made of lead, barium, and antimony. When a firearm is discharged, GSR plumes in all directions and deposits on the target, the surrounding area, and the hands of the shooter. In order to determine whether someone has recently fired a weapon, an analyst swabs that person's hands and inserts the swab into the SEM with EDS detector. The SEM can be used to locate tiny spherical particles, and EDS can be performed to see which elements are present. If lead, barium, and antimony are present with no significant amount of other metals, it can be concluded that the particles are GSR.

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Further Reading

Flegler, Stanley S., John S. Heckman, and Karen L. Klomparens. *Scanning and Transmission Microscopy: An Introduction*. New York: Oxford University Press, 1993.

Goldstein, Joseph, et al. *Scanning Electron Microscopy and X-Ray Microanalysis*. 3d ed. New York: Kluwer Academic/Plenum, 2003.

Schwoeble, A. J., and David L. Exline. *Current Methods in Gunshot Residue Analysis*. Boca Raton, Fla.: CRC Press, 2000.

See also: Analytical instrumentation; Atomic absorption spectrophotometry; Gunshot residue; Laser ablation-inductively coupled plasma-mass spectrometry; Nuclear spectroscopy; Scanning electron microscopy; Trace and transfer evidence; Ultraviolet spectrophotometry.

Environmental Measurements Laboratory

Date: Established in 1947 as the Health and Safety Division of the Atomic Energy Commission

Identification: U.S. government-owned and -operated scientific laboratory, part of the Science and Technology Directorate of the Department of Homeland Security, that monitors local and global radiation levels and operates as part of the emergency response group for investigation and remediation of radiological incidents and accidents.

Significance: The Environmental Measurements Laboratory is part of the American arsenal of defense aimed at countering nuclear and other radiation-based threats. The lab specializes in the study of ways to prevent and respond to radiological and nuclear events. Through its pilot deployment programs, the laboratory provides the Department of Homeland Security with information about and evaluation of radiation and radioactivity measurements in the laboratory and in the field.

The beginnings of the Environmental Measurements Laboratory (EML) go back to the famed Manhattan Project of World War II, which developed the first nuclear weapon. That project's Medical Division served the function of ensuring radiation safety among personnel and their habitat, and, in a sense, the EML has continued to maintain the same basic function in all the ensuing years. The Medical Division's main goal was to provide information about industrial hygiene and radiation protection for workers on the Manhattan Project.

In 1947, the Medical Division laboratory became part of the newly created U.S. Atomic Energy Commission (AEC) and was renamed the Health and Safety Division. In 1953, the laboratory was again renamed, becoming the Health and Safety Laboratory (HASL), and its focus shifted to the measurement and assessment of

EML Mission and Vision Statements

Our Mission

The Environmental Measurements Laboratory advances and applies the science and technology required for preventing, protecting against, and responding to radiological and nuclear events in the service of Homeland and National Security.

Our Vision

- We envision . . . an applied research laboratory built upon its core competency and rich history in radiation and radioactivity measurements to execute its DHS [Department of Homeland Security] mission.
- We envision . . . demonstration and deployment of advanced radiological measurements and survey methods to interdict and respond to radiological and nuclear threats.
- We envision . . . regional leadership and technical assistance to operational end-users.
- We envision . . . active participation in standards development organizations, interagency workgroups, and local responder consortia to support acceptance of technologies and standards and facilitate information transfer to responder communities.

the accumulation and impacts of radioactive fallout from tests of nuclear weapons. The HASL established a series of global monitoring stations to sample and measure wet and dry radioactive fallout in the atmosphere using gummed film methodology. During the 1960's, the lab expanded its survey coverage to include measurements of radioactive fallout accumulations and impacts in soil, water, and biological materials and also in food products. As part of this work, the HASL established a quality-assurance program for environmental dosimeters and developed a procedures manual that established methodologies, equipment, and procedures for measuring all environmental radiation.

When the AEC was shut down in 1975, the Health and Safety Laboratory was transferred to the Energy Research and Development Administration. When that administration was absorbed by the Department of Energy in 1977, the laboratory's name was changed to the Environmental Measurements Laboratory. In the late 1970's and the 1980's, the EML's work included testing of contaminant radiation levels following the accidents at the Chernobyl nuclear plant in the Soviet Union and at the Three Mile Island nuclear plant in Pennsylvania as well as testing for radon in industrial workplaces, commercial buildings, and residential homes.

In 1997, the EML became part of the Office of Environmental Management. In this context, its work continued to focus on environmental monitoring, but the lab was also charged with nuclear plant decommissioning, decontamination, and remediation efforts as needed to make local landscapes safe with respect to residual radiation levels. Final efforts at each of these sites were concerned with long-term stewardship of the immediate areas as well as continued monitoring of the regions to ensure that safe levels of radiation were maintained.

Ongoing Tasks

In 2002, the EML was again transferred, this time into the newly created Department of Homeland Security, which itself was formed in response to the terrorist attacks on the World Trade Center and the Pentagon on September 11 of the previous year. As part of the Department of Homeland Security, the EML continues to monitor international radiation levels but has also taken on additional responsibilities as part of a team of first responders to radiation threats at all levels.

The EML also works with a number of federal departments and agencies—including the Department of Defense, Department of Energy, Environmental Protection Agency, Nuclear Regulatory Commission, U.S. Coast Guard, National Institute of Standards and Technology, and American National Standards Institute—on homeland security-related issues. The scope and breadth of the tasks carried out by the EML are illustrated by certain key ongoing projects of the lab, such as the New York/New Jersey Science and Technology Countermeasures Test Bed (which is aimed at detecting radiation and explosives), the Maritime Interceptor for Nuclear Detection, the Radiological Emergency Management System, and the Neutron "Ship Effect" Studies for the Port Authority of New York.

The EML develops and evaluates technologies and surveillance/monitoring systems specifically aimed at the detection and measurement of all types of radiological materials for possible interdiction and management. In this capacity, the laboratory both trains and offers the services of technical specialists in the development, analysis, and validation of standards who can provide guidance in the use of radioactivity measurement instruments and systems. EML staff members participate in standards development, serve on adoption committees, and work with interstate technical groups to develop user guidelines.

Forensic Science and the EML

The EML maintains the International Environmental Sample Archive, a database of radiation samples collected in each of the previous decades of atomic weapons testing. This archive includes atmospheric samples as well as other samples that contain signature isotopes. In the event that law-enforcement authorities need to determine the origins of any radioactive materials that could be used in terrorist weapons or otherwise pose a threat, the EML can use the archive to track the materials to their sources. The archive also enables the EML to track other nations' compliance with the terms of nuclear nonproliferation treaties. Other areas of study conducted by the EML that have applications for forensic science include chemical profiling, stable isotope analysis, and research concerning the commercial availability, uses, and impacts of radioactive substances.

Dwight G. Smith

Further Reading

Ahmed, Syed Naeem. *Physics and Engineering of Radiation Detection*. San Diego, Calif.: Academic Press, 2007. Clearly written textbook on radiation detection is suitable for both lower-division college students and professionals in the field.

Beck, Harold L., and Burton G. Bennett. "Historical Overview of Atmospheric Nuclear Weapons Testing and Estimates of Fallout in the Continental United States." *Health Physics* 82 (May, 2002): 591-608. Presents a useful review of the history of atomic weapons testing and its legacy of radiation poisoning.

Knoll, Glenn F. *Radiation Detection and Measurement*. 3d ed. New York: John Wiley & Sons, 2000. Widely used and exceptionally comprehensive textbook offers clear explanations of the methods and instruments used to detect and measure ionizing radiation. Covers both basic principles and practical applications.

Saha, Gopal B. *Fundamentals of Nuclear Pharmacy*. 5th ed. New York: Springer, 2004. Thorough, clearly written, and now standard textbook addresses all aspects of radiopharmaceuticals. Includes a chapter titled "Instruments for Radiation Detection and Measurement." Well illustrated.

Stabin, Michael G. *Radiation Protection and Dosimetry: An Introduction to Health Physics*. New York: Springer, 2007. Offers comprehensive treatment of a wide variety of topics relating to protection against radiation, from the history of radiation poisoning to modern dosimetry. A practical handbook for health physics professionals.

See also: Air and water purity; Bomb damage assessment; Chemical Biological Incident Response Force, U.S.; Decontamination methods; DNA banks for endangered animals; Dosimetry; Geographic profiling; International Association of Forensic Toxicologists; Nuclear detection devices; Radiation damage to tissues; Silkwood/Kerr-McGee case; Toxic torts.

Epidemiology

Definition: Study of the distribution and determinants of health-related states in populations.

Significance: Epidemiologists help to identify the causation of specific diseases or groups of diseases and assist in the development and evaluation of disease prevention programs and public health interventions. Forensic epidemiologists are involved in the investigation of public health problems that may have resulted from intentional or criminal acts. Such epidemiologists function in important roles as investigative experts, consulting experts, and expert witnesses.

Epidemiology, a very old science, is concerned with the risks associated with disease exposure, the identification and control of epidemics, and the monitoring of population rates of disease and exposure. In ancient Greece, Hippocrates first suggested that human disease may be related to external as well as personal environment. During the seventeenth century, the English statesman and philosopher Francis Bacon developed a set of inductive laws that formed the foundation of modern epidemiology. In 1662, John Graunt, a London haberdasher, collected mortality statistics and was the first to quantify patterns of disease in a population. In 1747, Scottish physician James Lind applied epidemiological observations in identifying the causation of scurvy and suggesting treatment for the disease.

During the period 1848-1854, British anesthetist John Snow conducted a series of classic studies of cholera that led to an understanding of the causation of the disease. Joseph Goldberger of the U.S. Public Health Service worked to identify the causation of pellagra from 1916 to 1918. During the 1920's, Austin Bradford Hill, an English statistician, studied the difference in mortality between people living in urban settings and those living in rural areas. Later, with his student Richard Doll, he conducted the classic study that established the role of cigarette smoking in causation of lung cancer. In more recent years, widely publicized epidemiological studies have investigated the effects of fluoride use on dental caries, the relationship between tampon use and toxic shock syndrome, the relationship between human papillomavirus exposure and cervical cancer, the effects of exposure to Agent Orange, and the effects of hormone replacement therapy.

The term "forensic epidemiology" was first used in 1999 in the context of the presentation of an epidemiologist as an expert witness during legal proceedings. The field of forensic epidemiology gained national attention in the United States with the involvement of epidemiologists in the investigation of terrorist attacks in 2001 in which letters containing the bacterium that causes anthrax were mailed to various people in New York City, Florida, and Washington, D.C.

Descriptive Epidemiology

Epidemiology can be divided into two categories: descriptive and analytical. Descriptive epidemiology deals with time, place, and person distribution of the health-related state being discussed. One type of study conducted in descriptive epidemiology is the correlational study, in which researchers compare the frequencies of health-related states between different groups during the same time period or in the same population at different time periods. Another type of study in descriptive epidemiology involves case reports and case series, which are descriptive accounts of individual cases. Descriptive epidemiology also produces cross-sectional surveys, which are snapshot accounts that capture both disease exposure and outcome at the same point in time.

Analytical Epidemiology

Analytical epidemiology deals with determinants of health-related states and aims at testing the hypotheses developed from descriptive studies. Its purpose is to find statistical associations to establish cause-effect relationships. Among the types of studies conducted in analytical epidemiology are case-control studies, in which series of persons with a given disease are compared with those without the disease and the exposure of interest is examined. Another type is the cohort study, in which a group of people with the exposure and a group without the exposure are followed over time, and the disease manifestation in the two groups is examined. Intervention trials are also conducted in analytical epidemiology; in such a study, the exposure status of each participant is assigned by the investigator.

Manoj Sharma

Further Reading

Brownson, Ross C., Patrick L. Remington, and James R. Davis. *Chronic Disease Epidemiology and Control*. 2d ed. Washington, D.C.: American Public Health Association, 1998. Easy-to-read textbook discusses methods in chronic disease epidemiology and addresses the lifestyle risk factors of tobacco use, alcohol use, physical inactivity, diet and nutrition, high blood pressure, and cholesterol.

Goodman, Richard A., et al. "Forensic Epidemiology: Law at the Intersection of Public Health and Criminal Investigations." *Journal of Law, Medicine, and Ethics* 31 (2003): 684-700. Seminal article defines the field of forensic epidemiology, summarizes past and current applications of forensic epidemiology, and discusses the joint training for law enforcement and public health officials in forensic epidemiology.

Hennekens, Charles H., and Julie E. Buring. *Epidemiology in Medicine*. Boston: Little, Brown, 1987. Textbook in epidemiology from a clinical perspective. Basic concepts are presented along with types of epidemiological studies, description and analysis of epidemiological data and epidemiology in disease control.

Koehler, Steven A., Shaun Ladham, Abdulrezzak Shakir, and Cyril H. Wecht. "Simultaneous Sudden Infant Death Syndrome: A Proposed Definition and Worldwide Review of Cases." *American Journal of Forensic Medicine and Pathology* 22 (March, 2001): 23-32. Interesting example of the application of forensic epidemiology examines the case of sudden infant death syndrome in twins.

Lilienfeld, David E., and Paul D. Stolley. *Foundations of Epidemiology*. 3d ed. New York: Oxford University Press, 1994. Excellent introductory text presents the basics of demographic studies, epidemiological studies, and the uses of epidemiological data.

See also: Bacterial biology; *Escherichia coli*; Forensic pathology; Geographic profiling; Hantavirus; Mad cow disease investigation; Medicine; Pathogen transmission; U.S. Army Medical Research Institute of Infectious Diseases; Viral biology.

Epilepsy

Definition: Medical condition in which abnormal electrical impulses in the brain cause seizures.

Significance: The seizures associated with epilepsy may cause abnormal jerking of muscles, changes in consciousness, or changes in behaviors; they may also lead to accidents that can result in injury or death. Sudden unexplained deaths caused by epilepsy may appear suspicious and may lead to law-enforcement investigation.

Historically, many people believed that individuals with epilepsy commit violent crimes more often than do people who do not have the disorder. This belief is no longer generally accepted, despite the fact that some popular magazines in the 1990's featured articles that emphasized violent crimes committed by individuals with epilepsy. This kind of negative press coverage has contributed to perpetuating the stigma long associated with epilepsy. When violent crimes are committed by individuals with other chronic illnesses, the press coverage rarely mentions those illnesses.

Epilepsy most often causes loss of consciousness with abnormal muscle movement. Persons with epilepsy are at risk for injury due to their medical condition. Seizures may be brought on by lack of sleep, ingestion of alcohol, failure to take antiseizure medication, stress, pregnancy, or a variety of other factors. Persons with epilepsy must be careful when participating in activities that are potentially hazardous, such as driving, operating heavy equipment, swimming, or boating, as seizures during such activities can result in accidents that may cause injury or death to both the persons with epilepsy and others.

Individuals with certain types of epilepsy (such as temporal lobe epilepsy) may experience seizures during which they exhibit unusual behaviors that they are unable to remember afterward. These types of behavior may be somewhat bizarre, but they are not generally violent.

During a generalized epileptic seizure, the individual loses consciousness; if standing at the time, the person may be injured by the subsequent fall to the ground. The muscles begin contracting violently, causing the person to thrash about and possibly be injured. Choking on saliva may occur, and the person may vomit or secrete a foamy substance from the mouth. After the seizure, the individual will not remember the incident and may be tired, confused, or groggy for a period. During the investigation of accidental injuries related to epileptic seizures, persons with epilepsy may appear intoxicated or uncooperative. This period of confusion is temporary and resolves on its own within a few hours, but the fatigue or sleepiness may last an entire day.

Epileptic seizures may be associated with sudden, unexpected death in persons who are seemingly healthy, and law-enforcement investigators may mistakenly attribute such deaths to foul play. Investigators can clarify such situations by obtaining medical information from the death scenes or from the families of the deceased. Investigators should also be aware that research has found that suicide rates are higher among individuals with epilepsy than among the general population.

Amy Webb Bull

Further Reading

Byard, Roger. *Sudden Death in Infancy, Childhood, and Adolescence*. 2d ed. New York: Cambridge University Press, 2004.

Johannessen, Svein I., Torbjörn Tomson, Matti Sillanpää, and Birthe Pedersen, eds. *Medical Risks in Epilepsy*. Petersfield, Hampshire, England: Wrightson Biomedical Publishing, 2001.

See also: Carbon monoxide poisoning; Centers for Disease Control and Prevention; Forensic psychiatry; Psychotropic drugs; Toxicological analysis.

Erotic asphyxiation. *See* Autoerotic and erotic asphyxiation

Escherichia coli

Definition: Gram-negative, rod-shaped bacterium that inhabits the bowels of humans and many other organisms.

Significance: Because *Escherichia coli* is an important member of the bacterial flora found in the human colon, the presence of *E. coli* and related species (known as coliform bacteria) is used as an indication of fecal contamination of water and fresh foods. In addition, pathogenic strains of *E. coli*, especially O157:H7, are implicated in certain types of food poisoning. These strains carry toxin genes that cause diarrhea and sometimes the more serious disease hemolytic uremic syndrome, which can be fatal. *E. coli* O157:H7 has some potential to be used as a biological weapon.

Escherichia coli has been used as a model research organism for many years, and scientists know a great deal about the structure and physiology of this organism. *E. coli* was one of the first bacterial genomes to be sequenced completely and published in 1997. *E. coli* is normally not pathogenic. It is one of about two hundred different species of bacteria that inhabit the bowels of humans, where it serves a beneficial role by inhibiting growth of pathogenic species such as *Shigella* and *Salmonella*. Under normal conditions, it does no harm.

Public Health Investigations of *E. Coli* Cases

The Centers for Disease Control and Prevention describes what happens when cases of E. coli *infection arise:*

To find cases in an outbreak of *E. coli* O157 infections, public health laboratories perform a kind of "DNA fingerprinting" on *E. coli* O157 laboratory samples. Investigators determine whether the "DNA fingerprint" pattern of *E. coli* O157 bacteria from one patient is the same as that from other patients in the outbreak and from the contaminated food. Bacteria with the same "DNA fingerprint" are likely to come from the same source. Public health officials conduct intensive investigations, including interviews with ill people, to determine if people whose infecting bacteria match by "DNA fingerprinting" are part of a common source outbreak.

A series of events occurs between the time a patient is infected and the time public health officials can determine that the patient is part of an outbreak. This means that there will be a delay between the start of illness and confirmation that a patient is part of an outbreak. . . . The timeline is as follows:

1. **Incubation time:** The time from eating the contaminated food to the beginning of symptoms. For *E. coli* O157, this is typically 3-4 days.
2. **Time to treatment:** The time from the first symptom until the person seeks medical care, when a diarrhea sample is collected for laboratory testing. This time lag may be 1-5 days.
3. **Time to diagnosis:** The time from when a person gives a sample to when *E. coli* O157 is obtained from it in a laboratory. This may be 1-3 days from the time the sample is received in the laboratory.
4. **Sample shipping time:** The time required to ship the *E. coli* O157 bacteria from the laboratory to the state public health authorities that will perform "DNA fingerprinting." This may take 0-7 days depending on transportation arrangements within a state and the distance between the clinical laboratory and public health department.
5. **Time to "DNA fingerprinting":** The time required for the state public health authorities to perform "DNA fingerprinting" on the *E. coli* O157 and compare it with the outbreak pattern. Ideally this can be accomplished in 1 day. However, many public health laboratories have limited staff and space, and experience multiple emergencies at the same time. Thus, the process may take 1-4 days.

The time from the beginning of the patient's illness to the confirmation that he or she was part of an outbreak is typically about 2-3 weeks.

E. coli as an Indicator of Contamination

E. coli and many other bacteria make up some 70 percent by weight of fecal matter. Although *E. coli* itself (other than the O157:H7 strain) is not pathogenic, feces may contain other bacterial pathogens as well as many disease-causing viruses and protozoa. Water supplies my be contaminated by pathogens in several ways, including inadequate sewage treatment and runoff from irrigation of land where fertilizers containing animal excrement have been used. It is essential that any such contamination be identified quickly.

Although it is possible to test for specific disease-causing bacterial species and many viruses, such tests are relatively time-consuming and expensive, and many tests would have to be performed to identify possible pathogens. It is generally more useful to employ a faster, more generic test for the indicator organisms known as coliform bacteria. In the United States, the criteria for the presence of coliform bacteria are as follows: water-borne aerobic or facultative anaerobic, gram-negative, nonsporulating, rod-shaped bacteria that ferment lactose to form gas within forty-eight hours at 35 degrees Celsius. Because some soil and plant bacteria that are not constituents of fecal matter could be identified by this test, a more specific test for "fecal coliform" bacteria, primarily *E. coli*, requires growth in a special medium that turns yellow if *E. coli* is present and a separate culturing in another medium that produces a product that fluoresces blue under ultraviolet light. The U.S.

Environmental Protection Agency (EPA) is responsible for establishing criteria for the limits of acceptable levels of coliforms or fecal coliforms in water supplies, including the frequency of testing.

Pathogenic *E. coli*

The hundreds of strains of *E. coli* are distinguished by the presence of two surface antigens: O, an outer-membrane antigen, and H, an antigen on the flagellum. The strain of *E. coli* designated O157:H7 is pathogenic in humans. Another species of enteric bacteria is *Shigella dysenteriae*. *Shigella* causes dysentery in humans through the production of two Shiga toxins, Stx1 and Stx2, but cattle are relatively resistant to *Shigella*. At some point in the past, the genes for these two toxins were transferred laterally from *Shigella* bacteria to the *E. coli* O157:H7 strain, so that this strain acquired the ability to produce the Shiga toxins.

Cattle serve as a reservoir for both *Shigella* and *E. coli* O157:H7, and studies have shown that as many as 50 percent or more of dairy and beef cattle herds carry *E. coli* O157:H7, which may thus enter the food chain through water contaminated by cattle feces. O157:H7 contamination also sometimes comes from meat-processing facilities, where fecal material may contaminate processed beef. This is a particular concern in the case of ground beef destined for hamburgers at fast-food restaurants because in such processing the meat from hundreds of cattle is combined.

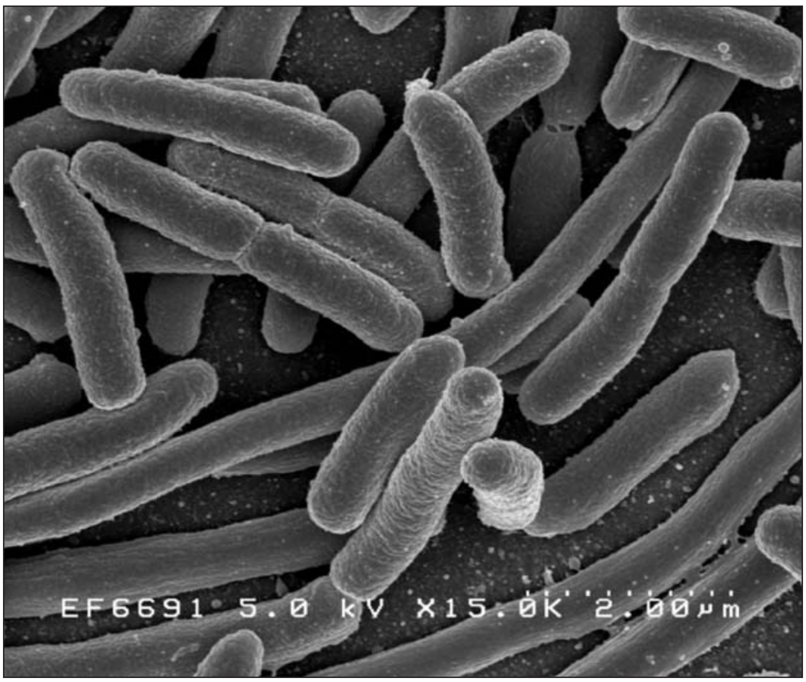
In addition to strain O157:H7, several other strains of *E. coli* can produce Shiga toxin. These are collectively called Shiga toxin-producing *Escherichia coli*, or STEC. Only about one-third of testing laboratories routinely test for STEC.

Disease Produced by *E. coli*

Pathogenic strains of *E. coli* produce diarrhea. In mild cases, the diarrhea is watery. This is common in newborn infants, and is not uncommon in pediatric wards of hospitals. Travelers who visit developing countries often experience a similar type of diarrhea, commonly referred to as traveler's diarrhea. Since 1993, a more serious form of diarrhea caused by O157:H7 has been recognized. This bloody diarrhea can lead to hemolytic uremic syndrome (HUS). The U.S. Centers for Disease Control and Prevention estimates that some seventy-three thousand cases of HUS occur each year, resulting in approximately sixty deaths. Antibiotics are not normally used to treat cases of *E. coli*, as they often make the situation worse by killing beneficial bacteria in the colon. Rather, the disease is allowed to run its course.

Although *E. coli* pathogenic strains have low lethality, concerns have been raised about the use of such strains as biological weapons. If introduced into local water supplies, *E. coli* O157:H7 or other STEC strains could cause widespread illness.

Ralph R. Meyer



Scanning electron micrograph of *Escherichia coli*, grown in culture and adhered to a cover slip. *(Rocky Mountain Laboratories, NIAID, NIH)*

Further Reading

Gyles, C. L. "Shiga Toxin-Producing *Escherichia coli*: An Overview." *Journal of Animal Science* 85, supp. 13 (March, 2007): E45-E62. Provides a technical review of pathogenic *E. coli*.

Kaper, James B., and Alison D. O'Brien, eds. *Escherichia coli O157:H7 and Other Shiga-Toxin-Producing E. coli Strains*. Washington, D.C.: ASM Press, 1998. One of the best resources available on the subject of pathogenic *E. coli*.

Madigan, Michael T., John M. Martinko, Paul V. Dunlap, and David P. Clark. *Brock Biology of Microorganisms*. 12th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2008. Excellent general textbook presents information on all aspects of bacteriology.

Neidhardt, Frederick C., ed. *Escherichia coli and Salmonella: Cellular and Molecular Biology*. 2d ed. Washington, D.C.: ASM Press, 1996. Definitive text on *E. coli*. Updated on a regular basis since 2002, but published only online.

Sussman, Max, ed. *Escherichia coli: Mechanisms of Virulence*. New York: Cambridge University Press, 1997. Collection of excellent discussions of *E. coli* pathogenesis.

See also: Bacteria; Bacterial biology; Bacterial resistance and response to antibacterial agents; Biological terrorism; Biotoxins; Centers for Disease Control and Prevention; Epidemiology; Food poisoning; Food supply protection; Pathogen genomic sequencing; Pathogen transmission.

Ethics

Definition: Principles of conduct, moral duty, and obligation that guide individuals in their decisions and actions.

Significance: As scientists, forensic scientists have a professional obligation to seek and to speak the truth about matters within their purview. As participants in a forensic process, they are subject to additional, sometimes conflicting, duties. This tension generates many ethical dilemmas.

Although witnesses in American courtrooms are called upon to tell the truth, the whole truth, and nothing but the truth, they may be enjoined from volunteering information. A witness's individual sense of relevance must often bow to a court's judgment. The legal system seeks truth, yet it sometimes defers to other values, such as fairness and confidentiality, and in general demands acceptance of formalized rules of procedure. In their capacity as experts, forensic scientists typically enjoy greater latitude than ordinary witnesses in expressing opinions and making judgments in the courtroom, but they too must operate within the often cumbersome and sometimes counterintuitive requirements of the "system" of "justice."

Forensic scientists are measured against a standard of professional integrity, although the professionalization of the scientific study of crime is far from complete. Professions are substantially self-regulating, usually through agreed-upon standards and codes of ethics, and this creates the need for them to articulate appropriate expectations and the responsibility of members of professions both to act correctly themselves and to provide appropriate correction for their errant colleagues. A case in point is William Tobin's campaign against the chemical analysis of bullet lead, also known as comparative bullet-lead analysis (CBLA).

Tobin's Exposure of CBLA

CBLA is a technique that the Federal Bureau of Investigation (FBI) used for four decades—the investigation of the assassination of President John F. Kennedy in 1963 was an early use—to make cases against defendants when traditional firearms analysis (that is, examination of barrel rifling on bullets) was not possible. By measuring the proportions of seven trace elements (antimony, arsenic, bismuth, cadmium, copper, silver, and tin) found in the lead of a bullet in evidence, forensic scientists sought to establish the probability that the bullet came from the same provenance as a bullet in the suspect's possession. The belief that the comparison of the chemical composition of bullets could connect two bullets rested on unexamined assumptions about the similarities and differences of the source lead from which the bullets were cast. FBI experts testified in thousands of cases that the facts ascertainable through CBLA established likely identity and therefore pointed toward the probable guilt of the accused. Sometimes, as in the case of Michael Behm, who was convicted of murder in 1997, CBLA provided essentially the only evidence of guilt.

In the 1990's, FBI metallurgist William Tobin began to question the validity of the technique. He felt strongly enough about the issue to research the matter, after his retirement in 1998, with Lawrence Livermore National Laboratory metallurgist Erik Randich. They analyzed data from two lead smelters in Alabama and Minnesota and discovered that the FBI techniques could not distinguish batches of lead produced months apart. They also discovered that differences existed within single batches. Their research was published in *Forensic Science International* in July, 2002.

Although he still defended the technique, the director of the FBI Laboratory requested that the National Research Council (NRC) of the National Academy of Sciences review CBLA. In February, 2004, the NRC report, titled *Forensic Analysis: Weighing Bullet Lead Evidence*, confirmed that only extremely limited claims could be made about the relationship between bullets based on CBLA. Given the NRC findings, a New Jersey appeals court overturned Behm's conviction in March, 2005. The results of the NRC study have obvious implications for many other cases as well.

In an article titled "Forensic Significance of Bullet Lead Compositions," which appeared in the *Journal of Forensic Sciences* in March, 2005, FBI research chemists Robert D. Koons and JoAnn Buscaglia argued that "compositional comparison of bullet lead provides a reliable, highly significant point of evidentiary comparison of potential sources of crime-related bullets." In September of that year, however, the FBI announced that it would no longer use CBLA. (In a curious subsequent development, Tobin and a member of the NRC committee, Clifford Spiegelman, suggested that a reanalysis of the bullet fragments from the Kennedy assassination might be in order.)

An article published in *New Scientist* in April, 2002, quoted Tobin as saying of the interpretation of bullet data based on CBLA, "It offended me as a scientist." In fact, Tobin has a long record as a critic of FBI procedures he regards as bad science and of testimonial practices he regards as unwarranted by the scientific data. To complain about testimony that unreasonably goes beyond what the data can support is to respond equally to the demands of science and the demands of ethics. It is a feature of commonsense justice that the punishment should fit the crime, and a basic requirement of that, in turn, is that the people who are punished should be guilty. Violating that requirement is both bad science and bad ethics.

Joyce Gilchrist's Tainted Evidence

Is it enough that the accused be guilty of some crime, or does it have to be the one in question? If the accused is guilty of the crime in question, does it matter whether the evidence actually shows that? The belief that one can convict the guilty by tweaking the evidence a little, or shading one's testimony a bit, is among the most common sources of unethical (and, often enough, criminal) behavior on the part of forensic scientists. The cautionary tale of former Oklahoma City Police Department forensic scientist Joyce Gilchrist probably falls into this category.

In May, 2007, Curtis Edward McCarty, who was facing his third trial for a 1982 murder, was freed as the result of the improper handling and representation of hair evidence by Gilchrist, who apparently had tried to frame McCarty. The judge dismissed the charge despite her belief that McCarty was probably not completely innocent. This was merely the latest in a series of episodes involving Gilchrist.

Questions about the integrity of Gilchrist's work began as early as January, 1987, when a Kansas City colleague, John Wilson, complained about her to the Southwestern Association of Forensic Scientists, without result. In 1998, Robert Miller was exonerated after he had been convicted a decade earlier based in part on Gilchrist's testimony regarding blood, semen, and hair evidence. In 1999, Gilchrist was criticized by a judge for having given false testimony (regarding semen evidence) in the rape/murder trial of Alfred Brian Mitchell in 1992. In the spring of 2000, Jeffrey Todd Pierce was ordered released after he had served a decade and a half for a rape he did not commit; he had been convicted based on Gilchrist's testimony. In January, 2001, Gilchrist was criticized for the various judicial reprimands and professional critiques her work had received. In August, 2001, doubts were raised about the guilt of Malcolm Rent Johnson, who had been executed for a 1981 rape and murder; Johnson was convicted based on Gilchrist's testimony.

A month later, in September, 2001, Gilchrist was finally fired, after years of reputedly shoddy forensics work, including both mishandling and misrepresentation of evidence, on many cases in addition to those noted above. The world of criminal justice contains innumerable isolated instances of perverse idealism, self-serving cynicism, and simple incompetence, but Gilchrist is one of the most striking cases of flagrant disregard for ethics in the forensics community. Was she genuinely convinced of the guilt of those against whom she testified? (She was certainly persuasive to juries.) Was she cynically distorting her testimony, and the evidence, to help prosecutors gain convictions, or was she just incompetent?

Ethics of Competence

One may well agree with forensics ethicist Peter D. Barnett's remark that "there is a certain baseline level of competence that every criminalist is expected to understand, and there are certain procedures and protocols that are so fundamental to the practice of criminalistics that failure to follow them is evidence of gross incompetence or malfeasance, which is unethical." As Barnett himself notes, however, "in the practice of forensic science, the disparate educational and experiential backgrounds of workers in the field make determination of a baseline level of competence relatively difficult."

This is a problem throughout the American criminal justice system. In June, 2007, all sergeants in the New Orleans Police Department were required to attend a four-day seminar to learn how to improve their (and their subordinates') writing of police reports. This was part of an attempt to smooth out conflicts between the department and the New Orleans district attorney's office, which claimed that part of its difficulty in prosecuting criminals stemmed from "incomplete or vague reports" by officers. More generally, criminalists frequently lament that frontline officers are not more skilled in observing, protecting, collecting, and preserving crime scene evidence.

One certainly can (in theory) impose reasonable expectations about competence and development in forensic science. However, that is not made easy by the variety of educational backgrounds and practical experience of the people who actually work in the field. In an unflattering assessment published in 2005, Jane Campbell Moriarty and Michael J. Saks bluntly asserted that "in the forensic sciences . . . 96 percent of practitioners hold bachelor's degrees or less." They went on to note:

> Most forensic "scientists" have little understanding of scientific methodology, do not design or conduct research (and do not know how to), often have not read the serious scientific literature beginning to emerge in their fields. . . . Scientific findings relevant to a given forensic science often are ignored in the conduct of everyday casework.

Moreover, as with the difficulty in defining the qualifications for expert testimony, the fact that crime fighting is not a natural kind of expertise has an impact. Almost any expert might be relevant to a criminal case, depending on circumstances. Given the diverse forms of knowledge relevant to the application of science to crime solving, and to the providing of suitable expert testimony, it may be that the only truly unifying factor is the application of the so-called scientific method, broadly understood as intellectual integrity—the determined effort, as physicist Richard P. Feynman put it, not to fool oneself (or others).

What is impressive about the case of William Tobin is his determination to ensure that his colleagues (or former colleagues) not testify to more than the data warrant, both out of scientific integrity and out of fairness to those whose lives are affected by what scientists say. What is appalling about the case of Joyce Gilchrist is the stubbornness of her effort to resist correction by colleagues or even by the seemingly obvious limits of the evidence itself. Sometimes the individual needs to correct the group, by exposing a bogus or complacent consensus; sometimes the group needs to correct the individual, by identifying willful deception or self-centered fantasy. Unfortunately, no formula exists to guarantee the right result, and that is why ethics remains a constant challenge to conscientious souls.

Edward Johnson

Further Reading

Barnett, Peter D. *Ethics in Forensic Science: Professional Standards for the Practice of Criminalistics*. Boca Raton, Fla.: CRC Press, 2001. Includes an examination of various ethical scenarios in the light of the codes of ethics of the American Academy of Forensic Sciences, the California Association of Criminalists, the American Society of Crime Laboratory Directors, and other forensic organizations.

Inman, Keith, and Norah Rudin. *Principles and Practice of Criminalistics: The Profession of Forensic Science*. Boca Raton, Fla.: CRC Press, 2001. Provides an introduction to "good practices" (including ethics) in the forensic science profession.

Lucas, Douglas M. "The Ethical Responsibilities of the Forensic Scientist: Exploring the Limits." *Journal of Forensic Sciences* 34 (May, 1989): 719-729. Discusses the tension between the ethos of science and the ethos of the adversary system in criminal justice.

Macklin, Ruth. "Ethics and Value Bias in the Forensic Sciences." *Journal of Forensic Sciences* 42 (November, 1997): 1203-1206. Addresses the tensions between the ethos of science and the claims of the forensic arena from the perspective of the author's experiences as a member of a National Research Council committee and as an expert witness.

Moriarty, Jane Campbell, and Michael J. Saks. "Forensic Science: Grand Goals, Tragic Flaws, and Judicial Gatekeeping." *Judges' Journal* 44, no. 4 (2005): 16-33. Offers a severe critique of the status quo in forensic science in the light of judicial decisions, such as *Daubert v. Merrell Dow Pharmaceuticals* (1993), that require expert testimony to meet high standards.

Peterson, Joseph L., and John E. Murdock. "Forensic Science Ethics: Developing an Integrated System of Support and Enforcement." *Journal of Forensic Sciences* 34 (May, 1989): 749-762. One of several essays the author has published in this leading forensics journal, which has given relatively extensive coverage to ethical issues.

See also: American Academy of Forensic Sciences; American Society of Crime Laboratory Directors; Brain-wave scanners; Criminal personality profiling; DNA database controversies; Ethics of DNA analysis; Expert witnesses; Innocence Project; Interrogation; Journalism; Training and licensing of forensic professionals; Truth serum; Wrongful convictions.

Ethics of DNA analysis

Definition: Principles of conduct, moral duty, and obligation that guide professionals involved in the analysis of DNA.

Significance: In its use as a powerful tool for identifying the perpetrators of crimes, DNA analysis has revolutionized the field of forensic science. Many ethical issues emerge from the use of DNA analysis, however, and forensic scientists must be aware of the potential for problems in the collection, use, and storage of DNA samples as well as the use of information gained from DNA analysis.

Because DNA (deoxyribonucleic acid) offers so much more information on individuals than either fingerprints or traditional serological evidence, serious concerns have been raised regarding the potential for abuses in the collection, storage, and analysis of DNA samples.

At the forefront of these concerns is the conflict between law-enforcement agencies' legal power to collect evidence and individuals' rights to privacy and autonomy. In addition, it has been noted that because DNA analysis can reveal many intimate aspects of individuals and their families—including paternity, susceptibility to diseases, and predisposition to genetic anomalies—the information gained through DNA analysis could be used in discriminatory fashion by employers, health care institutions, insurers, and government and educational institutions.

Relative to the use of DNA analysis by forensic scientists, some ethical concerns have been raised regarding quality control in the handling of DNA samples, the reliability of interpretations of DNA analysis results, and access to DNA analysis. Some observers have expressed fears that human error in the analysis of DNA may contribute to the wrongful conviction of persons accused of crimes; it has also been noted that some individuals who have been wrongfully convicted of crimes may be denied access to DNA analysis that could exonerate them.

Individual Rights and Privacy

Many of the concerns that have been expressed about DNA analysis, particularly in the United States, are related to individuals' desire for privacy and autonomy. Because the information provided by a person's DNA to a large extent defines that person's physical being, many people are more concerned about keeping their DNA information private than they are about keeping their general medical information private. Any mandatory legal provision for collecting DNA from the public pool in order to solve crimes is thus met with resistance. Many observers have voiced doubts regarding the ability of law-enforcement authorities to safeguard DNA samples, and many fear the possible misuse of information gained through DNA analysis.

Many objections have also been raised to the forced or coerced collection of DNA samples from all persons considered possible suspects in criminal investigations. It is vital to distinguish coerced or forced submissions of DNA from truly voluntary submissions. Law-enforcement agencies have at times justified the use of "DNA dragnets" in which samples are collected from hundreds or even thousands of "volunteers" in communities where serial crimes have been committed. Such police activities are troubling because they involve the collection of DNA samples from people who are not suspects and who do not provide the samples in a truly voluntary way. In addition, the DNA information obtained in this way is often poorly controlled, as generally no provisions exist for destroying these DNA samples after analyses have excluded innocent persons from suspicion.

In practice, law-enforcement investigators' collection of "voluntary" DNA samples can be questionable. No written provisions govern the consent process, and informed consent to provide DNA is possible only when the individual has a comprehensive understanding of the po-

DNA Testing and Privacy Rights

In early 2005, police in Truro, Massachusetts, tried to solve the case of the January, 2002, murder of fashion writer Christa Worthington by asking men in the town to submit to DNA testing voluntarily. Investigators hoped to find the murderer by matching a DNA sample with DNA extracted from semen collected from the body of Worthington, who had had sexual intercourse before she was killed. Hundreds of Truro residents complied with the request, allowing swabs to be taken from inside their mouths; however, the investigators' attempt to test the entire town alarmed civil libertarians, who were concerned with unwarranted intrusion into privacy rights. Particularly troubling was the fact that the police were recording the names of men who refused to comply with the request for DNA samples. The American Civil Liberties Union of Massachusetts sent letters to the Cape Cod County prosecutor and to Truro's chief of police, asking them to stop the DNA collection.

In 2003, police in Baton Rouge, Louisiana, collected DNA samples from about twelve hundred men in an effort to catch a serial killer. The authorities eventually arrested a suspect but did not reveal whether DNA evidence figured into the arrest.

tential implications associated with the DNA analysis and the ultimate disposal or storage of the sample. In addition, the consequences of declining to "volunteer" a DNA sample when the police are collecting from a particular population can be too great for many people to bear; those who refuse may face social stigmatization or ostracization. In many cases, individuals who are unwilling to volunteer DNA samples may be forced to give them through search warrants.

Potential Misuses of DNA

The United States maintains the largest DNA database in the world, the Combined DNA Index System (CODIS). The rapid growth of CODIS has prompted many concerns over civil liberties. At first, the DNA profiles of convicted sex offenders constituted the bulk of the material in the local, state, and federal databases that make up CODIS, but many states then expanded to include all felons; some even take DNA samples from all persons arrested, even those who are not convicted. CODIS has expanded over the years to include the DNA profiles of suspects, victims, and many other people who were not originally intended to be included.

Although DNA databases play vital roles in criminal investigations and postconviction reviews, the necessity of solving crimes must be weighed against respect for civil liberties. Observers have noted that the sweeping expansion of DNA databases may lead to dangers of privacy invasion and even racial discrimination. Given that no effective policy or legal provisions are in place in the United States to ensure genetic privacy for those who have never been convicted of any crime, concerns about privacy issues in relation to DNA are legitimate. After a person's DNA makes its way into CODIS, it remains in that system whether the person is a model citizen or a violent criminal. For this reason, many have argued that the contents of DNA databases must be as limited as possible and that only those who have been convicted of crimes should be included.

Another ethical dilemma revolves around the potential for racial discrimination associated with the uses of these databases. The DNA analysis technique using short tandem repeats (STRs) was initially developed to enable the matching of a sample of unknown origin with a sample of known origin. The same kind of analysis, however, has been used to create suspect pools based on the linking of STR patterns with physical characteristics of certain races or ethnic groups. Given that numbers of arrests are already biased toward some racial and ethnic minorities, the increased inclusion of individuals from these groups in DNA databases raises the probability for future "identification" of members of these groups as seemingly established as perpetrators of crimes by what are actually probabilistic and scientifically evolving standards. It further compounds racial bias, given that many of the persons whose profiles are in the databases have never been convicted of any crime.

Quality Control and Equal Access

Some ethical concerns about DNA analysis center on quality control: in the collection of samples, in the isolation and analysis of DNA, and in the interpretation of results. For each of these stages to be accomplished properly, the persons involved—including detectives, lab technicians, forensic scientists, lawyers, and judges—must have a high level of professional competence. The contamination of a DNA sample, for example, could jeopardize an otherwise strong prosecution case. The miscalculation of the probability of a profile match between evidentiary DNA and that of a suspect may lead to a wrongful conviction. An expert witness's neglect in presenting laboratory error rate may mislead jurors in one direction or another. To ensure that DNA analyses are carried out and interpreted to a high degree of quality, guidelines must be in place to ensure a standard acceptable error rate in DNA analysis for all laboratories, periodic review and certification of laboratories for forensic DNA analysis, and proper training of personnel, including scientists, police officers, lawyers, and judges.

The issue of equal access to the technology of DNA analysis has been raised by many observers. They have argued that fairness demands that persons who were convicted of crimes before this technology became available should have the opportunity to submit evidence for

DNA analysis whenever circumstances warrant a review. The fair, just, and effective use of DNA analysis can aid in both convicting the guilty and exonerating the wrongfully accused.

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Further Reading

Kobilinsky, Lawrence F., Thomas F. Liotti, and Jamel Oeser-Sweat. *DNA: Forensic and Legal Applications*. Hoboken, N.J.: Wiley-Interscience, 2005. Presents an informative overview of the uses of DNA analysis.

Lazer, David, ed. *DNA and the Criminal Justice System: The Technology of Justice*. Cambridge, Mass.: MIT Press, 2004. Collection of essays explores the ethical and procedural issues related to DNA evidence.

Rudin, Norah, and Keith Inman. *An Introduction to Forensic DNA Analysis*. 2d ed. Boca Raton, Fla.: CRC Press, 2002. Provides a good introduction to the use of biological evidence in forensics as well as the history and application of DNA fingerprinting in forensic investigations.

Scheck, Barry, Peter Neufeld, and Jim Dwyer. *Actual Innocence: Five Days to Execution, and Other Dispatches from the Wrongly Convicted*. New York: Random House, 2000. Describes some of the most prominent and successful cases taken on by Scheck and Neufeld's Innocence Project, providing comprehensive data on cases of wrongful conviction.

Williams, Robin, and Paul Johnson. "Inclusiveness, Effectiveness, and Intrusiveness: Issues in the Developing Uses of DNA Profiling in Support of Criminal Investigations." *Journal of Law, Medicine, and Ethics* 33, no. 3 (2005): 545-558. Discusses the use of DNA databases in England and Wales and the ethical issues raised by uses such as familial searching.

See also: DNA analysis; DNA database controversies; DNA fingerprinting; DNA profiling; DNA typing; Ethics; Innocence Project; Paternity testing; Postconviction DNA analysis.

European Network of Forensic Science Institutes

Date: Founded on October 20, 1995

Identification: Association that brings together professionals from forensic laboratories across Europe to share their ideas, knowledge, and experiences.

Significance: The European Network of Forensic Science Institutes is devoted to encouraging and facilitating an arena that maintains credibility and quality within the forensic science field, establishes and preserves relationships with other organizations, and promotes best practices and international standards for all participating laboratories. This organization is widely acknowledged as an important contributor to the field of forensic science both in Europe and around the world.

In 1992, the directors of governmental forensic laboratories throughout Western Europe proposed that they should hold regular meetings in order to discuss matters related to the forensic sciences. Their first meeting, held in 1993, was attended by eleven laboratory representatives. The participants at that meeting agreed to open up membership in the new organization to forensic laboratories in all European countries, and the first official meeting of the European Network of Forensic Science Institutes (ENFSI) took place on October 20, 1995, in Rijswik, the Netherlands. Attendees signed a memorandum of agreement that laid out the structure and operation of the ENFSI; the first board was also elected, and the organization's logo was introduced.

The ENFSI's activities are governed by a constitution that was adopted at the organization's annual meeting in 1999, which was held in Moscow, Russia. The structure of the organization includes an elected board composed of a chairman, a chairman designate, and three members who serve three-year terms.

Three standing committees are responsible for different areas of the organization's work: the Expert Working Group Committee, the

Quality and Competence Committee, and the European Academy of Forensic Sciences. The Expert Working Group Committee coordinates and supports the activities of the ENFSI's sixteen Expert Working Groups, which are concerned with scientific knowledge in areas such as digital imaging, DNA (deoxyribonucleic acid), drugs, explosives, fingerprints, handwriting, and information technologies. The Quality and Competence Committee provides all ENFSI members with information on policies, accreditation, certification, and expert advice to ensure compliance with best practices and international standards, and the European Academy of Forensic Sciences facilitates dissemination of information about the activities of the ENFSI to a wider forum.

Among the most important activities of the ENFSI are its annual meeting, the meetings of the Expert Working Groups, and the publication of "best practice" manuals as well as newsletters on forensic science in various languages. In addition, the ENFSI sponsors collaborative studies and offers proficiency tests as well as one-day, one-issue seminars.

The ENFSI membership grew quickly, from eleven laboratories in 1993 to fifty-three labs in thirty-one countries by 2005. By providing a venue for the exchange of research findings, data, technology, experiences, best practices, and other knowledge within the international forensic community, the ENFSI has proved itself to be a vital part of the future of forensic science.

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Further Reading

Brickley, Megan B., and Roxana Ferllini. *Forensic Anthropology: Case Studies from Europe*. Springfield, Ill.: Charles C Thomas, 2007.

McCartney, Carole. *Forensic Identification and Criminal Justice: Forensic Science, Justice, and Risk*. Portland, Oreg.: Willan, 2006.

Nickell, Joe, and John F. Fischer. *Crime Science: Methods of Forensic Detection*. Lexington: University Press of Kentucky, 1999.

See also: American Academy of Forensic Sciences; American Society of Crime Laboratory Directors; Federal Bureau of Investigation Laboratory; Forensic Science Service; International Association for Identification; International Association of Forensic Sciences; Interpol.

Evidence processing

Definition: Procedures performed in the identification, evaluation, collection, and packaging of crime scene evidence.

Significance: Evidence processing is a vital procedural component of the crime scene investigation. Evidence and information obtained from crime scenes can assist investigators in identifying both victims and suspects, reconstructing sequences of events, and understanding motivations.

After a crime scene has been secured and thoroughly documented, the next step is to process the evidence. The primary steps in evidence processing are identification, evaluation, and collection of evidence. These procedures are most often the responsibility of crime scene technicians or specialists. Depending on the type of crime scene, specialists may be enlisted to collect particular types of evidence. For example, arson investigators may be brought in to process the evidence at scenes of suspected arson or at scenes where explosives are found.

Evidence Identification and Collection

The types of evidence identified and the techniques utilized to collect the evidence fully depend on the nature of the crime. For example, the evidence processing at a crime scene involving a homicide is quite different from that conducted at a crime scene involving a burglary or a drug bust. At a typical crime scene, evidence is initially identified during the search process. This very methodical process can take different forms; for example, a crime scene may be searched in a spiral, grid, parallel, or zone pattern. The objective of all crime scene search patterns is the same, however: to facilitate the identification and collection of evidence that may be helpful to investigators while minimizing the likelihood that searchers will contaminate any evidence.

After evidence is identified, it must be prioritized for collection, and the collection process must be thorough and methodical. Crime scene technicians have one chance to get it right—if evidence is overlooked, the strength of the criminal case may be significantly affected. Fragile evidence takes priority and is often collected as quickly as possible. Such evidence may include perishable evidence, fingerprint evidence, or evidence that may be easily lost. The typical types of evidence collected at crime scenes include but are not limited to trace evidence (such as gunshot residue), body fluids (such as blood), impressions (including fingerprints and tool marks), hair, fibers, weapons, clothing, tools, controlled substances, electronic data, questioned documents, and explosives.

Crime scene technicians may not always be able to identify evidence with the naked eye. After a visual inspection is conducted to identify evidence, specific lighting techniques or chemical enhancement techniques may be utilized to identify additional evidence. Trace evidence, impression evidence, biological evidence, and latent print evidence are just a few examples of the kinds of evidence that may be visible only with the aid of lighting and chemical techniques.

A number of different techniques are used in the collection of evidence. Decisions regarding which collection techniques to use often depend on the unique demands of particular crime scenes. Trace evidence, for example, may be collected manually, using lifting tape or tweezers, or with a vacuum. Trace evidence samples may also be scraped off of surfaces. Impression evidence may be collected through casting, photography, or both. After latent prints have been identified, they may be collected photographically or through the use of techniques involving

Some of the products used in the gathering of evidence at crime scenes include (from left) sprays to preserve footprints, chemicals for testing unknown substances, numbered tags used to identify items of evidence in photographs and sketches, and fingerprint dusting equipment. *(AP/Wide World Photos)* chemical or powder enhancement. In addition to collecting evidence, crime scene technicians must collect reference, control, or elimination samples of materials at the scene for forensic scientists to use in comparisons in the laboratory.

Packaging and Labeling

The final steps of evidence processing entail the packaging and labeling of evidence samples in preparation for their transport to the crime laboratory for analysis. It is important that crime scene technicians follow established guidelines in packaging evidence so that the samples are properly preserved. Most often, evidence samples are placed individually into various sizes and types of paper bags. Individual items must be kept separate to prevent cross-contamination. Plastic bags and other plastic containers are avoided because they facilitate the deterioration of evidence. Not all types of evidence are packaged in paper bags, however; for example, unstable liquids, such as gasoline, are typically collected in glass jars.

The general process for packaging and preserving biological evidence samples involves allowing each sample to air-dry, packaging it in a paper bag, and then refrigerating or freezing it. For example, a bloodstained shirt would be allowed to dry completely before it is packaged in a paper bag, refrigerated or frozen, and transported to the crime laboratory. When this is not possible, the evidence must be packaged at the crime scene and quickly transported to the crime laboratory, where it is then completely dried and properly packaged. In situations like this, a time limit (often a matter of hours) is usually placed on how long the evidence can be packaged while wet before it is considered useless for forensic analysis. Evidence that has not been allowed to dry completely is at risk of becoming degraded or contaminated.

After each item of evidence is collected and packaged in the proper manner, it must be labeled with important identifying information. Typically, this information includes the name of the person who collected the evidence, a brief description of the evidence, and the date, time, and location of the collection. This initial identification of the evidence begins the chain of custody. From this point on, every time the piece of evidence changes hands, the name of the individual who handles it is added to the identifying information. This detailed labeling process is intended both to prevent contamination and to prevent tampering with evidence.

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Further Reading

Bennett, Wayne W., and Kären M. Hess. *Criminal Investigation*. 8th ed. Belmont, Calif.: Wadsworth/Thomson Learning, 2007. Provides comprehensive discussion of the procedures and techniques used by investigators at crime scenes.

Fisher, Barry A. J. *Techniques of Crime Scene Investigation*. 7th ed. Boca Raton, Fla.: CRC Press, 2004. Presents detailed information on the methods used in the collection and preservation of evidence found at crime scenes.

Gardner, Ross M. *Practical Crime Scene Processing and Investigation*. Boca Raton, Fla.: CRC Press, 2005. Describes the practical application of methods and procedures of crime scene processing.

Lyman, Michael D. *Criminal Investigation: The Art and the Science*. 5th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2008. Textbook discusses the fundamentals of crime scene investigation and relevant technological advances. Also explores the roles and responsibilities of police officers and criminal investigators.

National Institute of Justice. *Crime Scene Investigation: A Guide for Law Enforcement*. Washington, D.C.: U.S. Department of Justice, 2000. Report intended for law-enforcement administrators and trainers of crime scene investigators addresses the general procedures and methods to be followed at crime scenes, including initial response, documentation, and the evaluation and processing of evidence.

_______. *Crime Scene Investigation: A Reference for Law Enforcement Training*. Washington, D.C.: U.S. Department of Justice, 2004. General reference guide created to assist trainers in developing programs for law-enforcement and crime scene investigators. Intended as a complement to the 2000 report cited above.

See also: Chain of custody; Computer forensics; Courts and forensic evidence; Crime scene documentation; Crime scene investigation; Crime scene measurement; Crime scene reconstruction and staging; Crime scene screening tests; Crime scene search patterns; Crime scene sketching and diagramming; Cross-contamination of evidence; Direct versus circumstantial evidence; Disturbed evidence; Imaging; Physical evidence; Quality control of evidence.

Exhumation

Definition: Excavation and removal of a previously buried human body for purposes of analysis, legal investigation, or reburial in another location.

Significance: Bodies are sometimes exhumed from formal, marked graves during the investigation of suspicious deaths, and exhumation is a common activity in the investigation of forensic scenes where bodies have been concealed by burial. In the latter cases, recovery not only of the remains but also of associated physical evidence (artifacts, soil, and insects) can assist investigators in determining manner and time since death. The exhumation of executed victims from mass graves has provided vital evidence for the prosecution of individuals accused of war crimes and crimes against humanity.

In most cultures, it is considered disrespectful to disturb the resting places of the dead. Exhumation of human remains may be required under legal mandate, however, if the remains need to be examined for a variety of reasons or if they need to be moved to new locations to avoid the impacts of changes in land use.

Reasons for Exhumation

Apart from the requirement to exhume remains from a criminal covert burial, exhumation from a formal, marked grave may legally occur in the investigation of a suspicious death when new evidence is required from the remains. In addition, with advances in DNA (deoxyribonucleic acid) analysis, the bodies of previously unidentified individuals from battlefields or accident locations such as airplane crash sites are sometimes exhumed for sampling and identification. Famous individuals, such as U.S. president Zachary Taylor, have been exhumed so that forensic scientists could attempt to answer historical questions with the latest technologies and methods. In cases in which recently buried individuals or relatively recently established cemeteries are being moved, judges may issue permits for exhumation and removal. Exhumation in all cases concerning formal graves can proceed only after legal authority is granted.

Human remains in prehistoric burial sites and centuries-old cemeteries must sometimes be exhumed when these sites are threatened by government-funded projects such as highway or reservoir construction. In the United States, excavation of such sites—especially if they are on federal land—requires both federal and state permission and public notification to identify any descendants of the persons buried there. The State Historic Preservation Office of the state where the cemetery is located must be involved in a discussion with all interested parties to develop a plan for the exhumation, analysis, and reburial of remains from cemeteries that are considered historically significant. If there is no way for the planned project to avoid disturbing the cemetery, exhumation is conducted by a team of professional archaeologists and the remains are usually analyzed by physical anthropologists before reburial.

Mass Graves

Mass graves constitute special settings for exhumation because they contain the closely associated remains of multiple persons. Remains may have been placed in these large burial pits or trenches in an organized or a disorganized (jumbled) manner. Generally, the remains found in mass graves are those of persons who shared one or more common traits—ethnic, political, or religious—that led them to be executed and placed in the graves together. International law provides the legal justification for

Calcasieu Parish coroner Zeb Johnson (right) oversees the exhumation of a body in Lake Charles, Louisiana, in May, 2004. The exhumation was ordered so that a forensic anthropologist could examine the body in an attempt to establish the cause of death, which was not satisfactorily determined at the time when the body was discovered on the roof of an elementary school in 1993. *(AP/Wide World Photos)*

exhumation of such graves as a means of collecting evidence to use in the prosecution of war criminals.

The presence of numerous clustered, disorganized bodies makes the documentation and removal of remains from mass graves particularly challenging. In some cases, the complex mixture includes remains exhibiting various stages of decay, particularly if some of the bodies are those of fairly recent victims.

Methods of Exhumation

The simplest and most destructive method of exhumation involves the use of a backhoe or other heavy machinery to simply scoop out the contents of a grave and place them in a new casket for reburial at another location. This may be a court-permitted procedure if the goal is simply to move remains to a new cemetery.

In contrast, in the case of a covert burial forming part of a forensic scene or a prehistorically or historically significant burial, exhumation follows standard archaeological methods. The top of the grave is first exposed and mapped, and then the site is carefully excavated with trowel, brush, and wooden or bone tools (so as not to damage bone) until the entire individual is exposed for recording. If the individual is skeletonized and bone preservation is poor, individual bones are labeled and bagged separately as they are removed to enhance later identification in the laboratory. Care is taken also to collect samples of the surrounding soil matrix, to record and collect any associated artifacts or coffin hardware, and to screen the excavated soil for small remains.

Similar basic archaeological methods of gridding the site area for mapping, screening excavated soil, and extensive photo documentation are used in the exhumation of unidentified military remains (usually from airplane crash sites) by the Joint POW-MIA Accounting Command (JPAC). In JPAC exhumations, however, less effort is made to record all the details and measurements than is the case in exhumation of historical sites, because the primary goal is the recovery of bone and other artifacts that can lead to the positive identification of the deceased service member.

Mass graves are crime scenes on a large scale, so the use of standard archaeological techniques is complicated by the sheer volume of remains and artifacts that must be documented. The leaders of such an excavation must take care to develop a standardized system of recording, ensure that all investigating personnel follow that system, and check data accuracy periodically so that they can build legally valid databases of information on the remains recovered.

Cliff Boyd

Further Reading

Dupras, Tosha L., John J. Schultz, Sandra M. Wheeler, and Lana J. Williams. *Forensic Re-*

covery of Human Remains: Archaeological Approaches. Boca Raton, Fla.: CRC Press, 2006. Provides detailed descriptions of search-and-recovery methods and the equipment used for such purposes in forensic scene investigations. Includes standardized recording forms and conversion tables in appendixes.

Haglund, William D. "Recent Mass Graves: An Introduction." In *Advances in Forensic Taphonomy: Method, Theory, and Archaeological Perspectives*, edited by William D. Haglund and Marcella H. Sorg. Boca Raton, Fla.: CRC Press, 2002. Presents a descriptive overview of exhumations from mass graves created as the result of human rights abuses.

Hoshower, Lisa M. "Forensic Archaeology and the Need for Flexible Excavation Strategies: A Case Study." *Journal of Forensic Sciences* 43, no. 1 (1999): 53-56. Discusses the different goals and methods used in the recovery of the remains of military personnel declared missing in action as opposed to criminal cases.

Schmitt, Stefan. "Mass Graves and the Collection of Forensic Evidence: Genocide, War Crimes, and Crimes Against Humanity." In *Advances in Forensic Taphonomy: Method, Theory, and Archaeological Perspectives*, edited by William D. Haglund and Marcella H. Sorg. Boca Raton, Fla.: CRC Press, 2002. Addresses the various methods of excavating mass graves containing victims of genocide and war crimes.

Sigler-Eisenberg, Brenda. "Forensic Research: Expanding the Concept of Applied Archaeology." *American Antiquity* 50 (1985): 650-655. Case study documents the use of archaeological excavation methods in the exhumation of the victims of a drug-related triple homicide.

See also: Anastasia remains identification; Columbus remains identification; Crime scene investigation; Croatian and Bosnian war victim identification; DNA analysis; DNA database controversies; Forensic anthropology; Forensic archaeology; Lincoln exhumation; Mass graves; Taylor exhumation.

Expert witnesses

Definition: Witnesses possessing specialized knowledge, training, or experience whose testimony is elicited to assist lay jurors in areas with which they are unfamiliar.

Significance: Expert witnesses are qualified by the court to guide the jury in determining a fact in issue (such as by explaining laboratory tests in drug or alcohol cases) or to present exculpatory evidence serving to prove that someone is blameless (such as evidence based on polygraph testing). Forensic scientists are often called upon to present expert testimony in court.

Every person is presumed to be a competent witness. So long as a witness has the ability to observe, recollect, communicate, and speak truthfully, the witness is declared competent. It is the role of the judge to determine a witness's competency to testify, but it is the role of jurors to determine what weight, if any, they will give to a witness's testimony. Diminished capacity goes to the weight rather than the admissibility of the testimony. The credibility of a witness's testimony can be impeached by evidence of dishonesty, conviction of a crime, prior inconsistent statements, or actions demonstrating bias or prejudice. The jury may determine that the testimony of a witness, while admissible, is not probative; alternatively, the testimony may be weakened in the eyes of the jury by one of the factors noted above.

Expert witnesses often work in scientific, technical, or other specialized fields; they are witnesses who have knowledge in particular subjects beyond that of the average person, sufficient that others may rely on their specialized opinions about evidence or matters at issue. Factors that judges consider in determining a witness's expert status include training and education, experience, familiarity with standard references and authorities in the field, membership in professional associations and societies, and publications. Judges also consider the relevance of the proffered testimony and whether it will actually aid the jury. Reasons for excluding proffered expert testimony include its lack of reliability and its likelihood to be more prejudicial than probative. Some experts are nontestifying; that is, both sides in a court case can hire experts to evaluate their case and determine its merit or lack of merit or to provide professional assessments based on the experts' areas of knowledge. This evaluation is privileged and not shared with the opponent. All other documentation used to prepare testimony must be available to all parties.

Areas of Expertise

Typically, both sides in civil disputes rely on experts for their opinions on matters such as the severity of an injury, its presumed effect on a person's life, and whether the injury is permanent; the cause of failure of a product or machine; and loss of future earning power. Experts can testify in any case in which their expertise is relevant. In criminal cases, forensic scientists or forensic psychologists are likely to provide expert testimony. Forensic experts who are employed at state crime labs or other public organizations with very high volume of cases requiring them to testify in court frequently prepare reports far in advance of their court appearances.

In 2000, the Federal Judicial Center published the results of a 1998 survey of federal judges and lead attorneys for both plaintiffs and defendants regarding the use of expert witnesses. This study found that medical and mental health cases used more than 40 percent of the experts presented overall. Physicians in all specialties accounted for approximately one-third of all expert witnesses, engineers and other safety personnel accounted for 24 percent, and law, business, and finance experts made up 22 percent of all experts, with economists being the largest type within this group. Scientific experts accounted for about 7 percent of all expert witnesses. When asked about the specific legal issues to which expert testimony had been directed, judges reported that the most frequent issues addressed were the existence, nature, or extent of injury or damage (68 percent of trials) and the cause of injury or damage (64 percent of trials). Other issues addressed by expert testimony involved amount of damages, reasonableness of a party's actions, industry standards (also called state of the art), professional standards of care, product design or testing, and knowledge or intent of a party.

Expert Opinion and Lay Opinion

Where jurors are competent to draw their own conclusions on an issue, the use of expert testimony is not proper. Examples are issues of innocence or guilt, fault, and negligence. Sometimes, lay witnesses as well as experts may testify on the same issue from various perspectives, such as the value of property (the owner may give an opinion), the cause of an accident or occurrence, and identity or likeness of handwriting (when a layperson is familiar with the evidence at issue).

Lay witnesses are permitted to offer their opinions about matters with which everyone is familiar: dimensions, including size (large, small), shape (round, flat), and length (short, long); color; weight; sound; time; sense recognition (heavy, bitter in taste); a person's appearance as it relates to condition (the witness appeared disheveled, elderly, strong, sloppy, wet, agitated, drunk, sober, sleepy, dizzy, irrational, in pain); apparent age; and matters of opinion based on perception or observation, such as the approximate speed of a vehicle (even a "glimpse" goes to the weight rather than the admissibility of the testimony). As long as the witness is not testifying as an expert, the witness's testimony in the form of opinions or inferences is limited to those opinions or inferences rationally based on the witness's perception that are helpful to an understanding of the witness's testimony or the determination of a fact in issue. Both expert and lay opinions may be admissible on issues such as mental competency.

Expert opinions do not necessarily have to be based on firsthand knowledge; they may be based on facts or data from personal observations, facts or data based on reports of others, facts or data made known during the trial (including the testimony of other witnesses), and facts that experts are asked to assume for purposes of hypothetical questions. Before the Federal Rules of Evidence were enacted in 1975, the hypothetical question was the traditional method used to elicit testimony from an expert who had no firsthand knowledge of the situation at issue and had made no investigation of the facts. The expert would be asked to assume certain facts and then to give opinions or inferences in view of those assumptions.

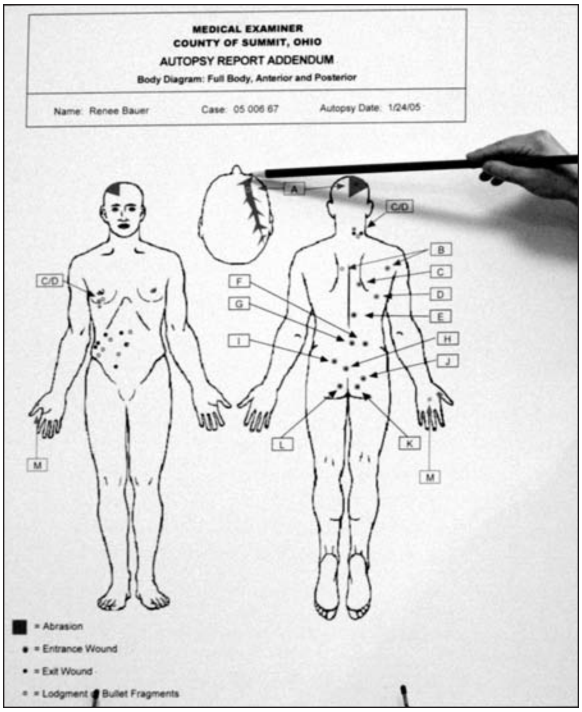
This form of questioning gave the examiner the opportunity to summarize all favorable evidence already produced and ask the expert to assume as true various facts that the examiner believed to have been proven. The expert was asked to state an opinion based on these assumed facts. Because the hypothetical question needed a proper foundation, evidence had to be admitted to support each assumed material fact. If no such evidence was presented, then the hypothetical question was improper. Hypothetical questions were usually very wordy because all relevant facts had to be restated, as allowing counsel to select only certain material facts to eliminate some of the verbosity led to a partisan and unbalanced presentation. Enactment of the Federal Rules of Evidence essentially eliminated use of the hypothetical question because its requirements were cumbersome and unnecessary.

Expert witnesses can testify about the ultimate issue in the case. The only exception to this concerns the issue of whether a criminal defendant had the requisite mental state at the time the crime was committed. Only the jury can decide whether the defendant possessed the *mens rea* (evil intent) to commit the offense. Expert testimony is not helpful in this instance because the jurors, having heard the evidence, are capable of forming their own opinions. Likewise, if an accident reconstruction expert in a personal injury case testifies to the conclusion that the defendant's car was on the wrong side of the road when it collided with the plaintiff's car, the expert should not be permitted to testify that the accident was the defendant's fault or that the defendant was negligent; these are questions of fact for the jury. In contrast, however, it is proper for a psychiatrist in a civil commitment proceeding to testify that the patient, a paranoid schizophrenic with organic brain damage, is a danger to herself and the community. The jury is not equipped to evaluate the patient without the expert's testimony.

The jury is not bound to accept the opinions of expert witnesses even if the opinions are uncontradicted, because the experts' opinions are no better than the reasons and facts on which they are based, and the jury may choose to disagree or disbelieve facts or the reasons stated. Jurors, however, may not arbitrarily disregard uncontradicted expert opinions and substitute their own on matters in which they are not qualified to render opinions. If they do so, their verdict must be set aside as being unsupported by evidence.

Relevant Case Law

Three court decisions in the 1990's set out and clarified guidelines for federal judges to use in determining whether and when a particular witness should be allowed to testify as an expert. *Daubert v. Merrell Dow Pharmaceuticals*, a 1993 U.S. Supreme Court case, established the "gatekeeper" function for judges, in which the judge acts as a filter and is empowered and charged with determining whether a particular expert is allowed to testify in a certain case. The



At an Ohio triple-murder trial in 2005, Dr. George Sterbenz presented diagrams of one of the murder victims showing thirteen different entry wounds and numerous exit wounds. As an expert witness, Sterbenz drew on his training and experience as a forensic pathologist to explain the significance of the wound patterns in the case against the defendant. *(AP/Wide World Photos)*

An Important Supreme Court Decision

In its decision in Kumho Tire Company v. Carmichael *(1999), the U.S. Supreme Court expanded the gatekeeping duties of the judge regarding the admissibility of expert testimony.*

In *Daubert*, this Court held that Federal Rule of Evidence 702 imposes a special obligation upon a trial judge to "ensure that any and all scientific testimony . . . is not only relevant, but reliable." . . . The initial question before us is whether this basic gatekeeping obligation applies only to "scientific" testimony or to all expert testimony. We . . . believe that it applies to all expert testimony. . . .

For one thing, Rule 702 itself says:

> "If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise."

This language makes no relevant distinction between "scientific" knowledge and "technical" or "other specialized" knowledge. It makes clear that any such knowledge might become the subject of expert testimony. In *Daubert*, the Court specified that it is the Rule's word "knowledge," not the words (like "scientific") that modify that word, that "establishes a standard of evidentiary reliability." . . . Hence, as a matter of language, the Rule applies its reliability standard to all "scientific," "technical," or "other specialized" matters within its scope.

judge can exclude unqualified experts as well as those who deliver unreliable and irrelevant opinions. Factors having a bearing in this area include whether the theory or technique has been tested, whether it has been subjected to peer review, the known or potential error rate, and whether the theory or technique has been generally accepted by the scientific community.

Until 1993, under the "*Frye* test" or "*Frye* standard," which was based on the court's decision in *Frye v. United States*, a 1923 D.C. Circuit case, expert testimony had to be based on scientific tests or principles "generally accepted" in the particular field in which the test or principles belonged. The attorneys introduced their chosen experts, and the jury decided what weight to give to the experts' opinions. Under *Frye*, therefore, the scientific community rather than the judge determined admissibility of expert testimony. With *Daubert*, the key inquiry centers on the reliability and relevance of expert testimony as determined by the trial judge. Because the judge is the gatekeeper, "*Daubert* hearings" are required so that the judge can make this determination in cases involving scientific tests and methods. The judge considers the competence of the expert as well as the relevance and reliability of that expert's theories and methods to determine whether to allow the expert's participation in the case.

First seen as a victory for plaintiffs who sought to introduce expert testimony based on new scientific tests and methods, such as plaintiffs in toxic tort and similar complex litigation, *Daubert* has instead been devastating to plaintiffs. Judges in federal district courts have rejected expert testimony on numerous occasions, and almost all of the rejected testimony has been offered by plaintiffs. In *General Electric v. Joiner*, a 1997 case, the U.S. Supreme Court emphasized the sweeping discretion of the judge in making gatekeeper decisions, making it difficult for appellate courts to overturn the trial judge's decision to exclude or admit expert testimony based on the gatekeeping criteria. In *Kumho Tire Company v. Carmichael*, a 1999 case, the Supreme Court expanded the judge's gatekeeper duties, holding that they are not limited to scientific methods cases but apply to all cases in which technical expertise is involved. All federal courts and many state courts are bound by the principles of these Supreme Court decisions.

Battles of the Experts

When two or more expert witnesses testify on opposite sides in a case, the jury understandably must decide which opinions to believe. The degree of confidence that jurors place in expert witnesses is related to the witnesses' experience, training, and credentials and whether the witnesses have performed all the tests necessary. Jurors sometimes feel that they are not qualified to make decisions in complex cases and are grateful to experts who explain technical issues simply and in ways that help the jurors with their task. When both sides bring in highly qualified experts who contradict each other, however, jurors tend to base their ultimate decisions on factors such as the perceived credibility, honesty, and forthrightness of the witnesses and how convincing their explanations are—factors collateral to the testimony.

Juries generally find experts intimidating because the experts have sophisticated and technical knowledge beyond that of the jury. Jurors understandably expect the testimony of expert witnesses to be complicated, confusing, and boring. At the same time, jurors wonder whether expert witnesses are biased because they are "hired guns" paid by the parties for whom they are testifying. In many cases, jurors think that expert witnesses are "too young" to have so much expertise and experience. Such doubts are usually resolved, however, when expert witnesses present their testimony to the jury in a likable manner, without condescension, and respectfully.

Challenging the Experts

Opposing attorneys often attempt to impeach the credibility of an expert witness on the other side by pointing out to the jury that the expert is being paid a fee to testify and a fee to prepare a report and that the expert testifies on a regular basis for the particular law firm. The attorney who called the expert witness to testify can often resolve this situation by affording the expert an opportunity to explain. If an expert has testified on behalf of both plaintiffs and defendants in the past, the expert is not necessarily "neutral." On cross-examination, opposing counsel may be able to establish that the expert finds favorably for whichever side pays the expert's fees. This type of inquiry can seriously undermine an expert's credibility in the eyes of jurors.

Potentially the most effective technique that attorneys use to discredit expert testimony is that of attacking the bases of the experts' opinions; this is a fundamental element in the cross-examination of opposing experts. If an attorney can convince the jury that an expert was either insufficiently informed or misled because of a failure to consider certain key facts or that key facts were withheld, this can produce a significant impact on the jury. Expert witnesses may also be impeached with prior testimony, prior inconsistent statements, or statements from other witnesses in the case. Inconsistencies place the credibility of expert testimony in doubt, and opposing attorneys often highlight such discrepancies on cross-examination.

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Further Reading

Broun, Kenneth S., ed. *McCormick on Evidence*. 6th ed. St. Paul, Minn.: Thomson/West, 2006. Considered the ultimate standard reference on evidence law. Contains detailed explanations and numerous references to case law.

Mauet, Thomas A. *Trial Techniques*. 7th ed. New York: Aspen, 2007. Handbook covering all aspects of the trial process includes extensive examples of patterns of questions that attorneys use in examining expert witnesses.

Rothstein, Paul F., Myrna S. Raeder, and David Crump. *Evidence in a Nutshell*. 5th ed. St. Paul, Minn.: West, 2007. Provides a succinct summary of the law of evidence. Useful for both students and practitioners.

Smith, Fred Chris, and Rebecca Gurley Bace. *A Guide to Forensic Testimony: The Art and Practice of Presenting Testimony as an Expert Technical Witness*. Boston: Addison-Wesley, 2003. Focuses in particular on the use of information technology by expert witnesses.

Stopp, Margaret T. *Evidence Law in the Trial Process*. Albany, N.Y.: West/Delmar, 1999. Undergraduate textbook intended primarily for paralegals discusses the principles of the law of evidence. A chapter on lay and expert witnesses includes cases and examples.

Wecht, Cyril H., ed. *Crime Scene Investigation: Crack the Case with Real-Life Experts*. Pleasantville, N.Y.: Reader's Digest Association, 2004. Accessible work provides a detailed look at forensic investigation.

See also: Crime laboratories; Crime scene reconstruction and staging; *Daubert v. Merrell Dow Pharmaceuticals*; DNA analysis; Ethics; Eyewitness testimony; Federal Rules of Evidence; *Frye v. United States*; Handwriting analysis; Insanity defense; Product liability cases; Training and licensing of forensic professionals; Trial consultants.

Eye scanners. *See* Biometric eye scanners; Iris recognition systems

Eyewitness testimony

Definition: Testimony of witnesses, including crime victims, who viewed events of interest to investigators.

Significance: Because eyewitness testimony has consistently been found to carry great weight with juries, the accuracy of such testimony is crucial. The presence of forensic evidence at a crime scene may confirm eyewitness testimony or cast serious doubt on its accuracy.

During crime scene interviews, investigators seek to gather reliable evidence from eyewitnesses, including the crime victims. The intent is to obtain high-quality evidence that will later enable juries or judges to be confident of the ability of the eyewitnesses to provide accurate information about what occurred.

Identification Procedures

Police investigators use standard procedures when interviewing victims and other eyewitnesses at crime scenes. They seek to obtain thorough and precise information, but at the same time they must be cautious to avoid suggestive questioning, which can lead witnesses to recall and describe events and persons incorrectly. Sometimes eyewitnesses are asked to describe the suspects they have seen to police sketch artists.

Following the initial witness interviews, police investigators use various identification procedures with eyewitnesses—such as photo arrays, lineups, and show-ups—to confirm the identities of suspects. For a photo array, the investigators assemble a number of photographs (usually six, sometimes more) of possible suspects based on the description given earlier by the witness. The witness is then presented with the full array of photos and is asked whether the suspect is pictured among them. Investigators should observe several simple rules when using photo arrays. Generally, this procedure should be conducted at the police agency or at the residence of the witness, and the witness should not be in the presence of any other witnesses when observing the photos. The different photos should, as much as possible, reflect the description of the suspect earlier provided by the witness, and black-and-white photos should not be mixed together with color photos. Most important, investigators should be certain that the witness does not feel compelled to select any one person out of the array as the offender.

In a lineup, the witness views live individuals, usually in a group of six, rather than photographs. This procedure typically takes place at the police agency in special rooms separated by a one-way mirror, so that the witness can see and hear the persons in the lineup but they cannot see or hear the witness. As with a photo array, the individuals in the lineup should reflect the description of the offender given by the witness during the initial interview. The participants in the lineup may be asked to speak for identification or to walk or gesture in a particular manner. The witness is asked to identify the offender if that person is present.

The show-up identification procedure (sometimes called an in-field identification) is not used as often as the photo array or lineup. In this procedure, a single suspect is brought before the witness for possible identification as the offender. Investigators use a show-up only when the crime has occurred very recently and a suspect is quickly apprehended based on immediate information provided by the witness. An example would be a convenience store robbery after which a suspect is taken into custody within fifteen minutes. The general thinking is that the offense is very fresh in the mind of the witness at that time, and therefore it would be prudent to get immediate confirmation from the witness that the correct person is in custody. Some legal observers have criticized this identification procedure as too suggestive and thus unfair to the alleged suspect.

U.S. Supreme Court Decisions

The U.S. Supreme Court has addressed the pretrial identification procedures that police use with witnesses in a number of cases. The Court has emphasized the need for reliable procedures that are not suggestive in nature—in other words, photo arrays, lineups, and show-ups that are fair to alleged suspects.

In *United States v. Wade* (1967), the Court held that a suspect has a Sixth Amendment right to legal representation at a postindictment lineup (a lineup held after formal charges have been brought against the accused) because, at this "critical stage" for the accused, the presence of an attorney may help to prevent police from conducting an unfair or suggestive lineup. An example of a suggestive lineup would be one in which all the lineup participants are young men except for one elderly participant, the accused, who matches the witness's description of the suspect. The attorney for the accused can bring the suggestive nature of the lineup to the attention of the police and can later argue to the trial court that the identification should be excluded from evidence because the lineup proceeding was unfair.

A suspect who has been arrested but has not yet been charged is not constitutionally entitled to an attorney at a lineup or show-up. The Supreme Court has never held that a suspect has a right to an attorney, under any circumstances, relative to a photo array.

In the later case of *Mansion v. Brathwaite* (1977), the U.S. Supreme Court decided that even a suggestive identification (in this case the result of an unfair photo array) could, if certain factors are present, still be admitted into evidence at trial. In its decision the Court relied on the five-factor test it had set forth in the case of *Neil v. Biggers* (1972). These five factors are the opportunity of the witness to view the criminal at the time of the crime, the witness's degree of attention, the accuracy of the witness's prior description of the criminal, the level of certainty demonstrated by the witness at the confrontation, and the length of time between the crime and the confrontation.

Therefore, even though a pretrial identification may be suggestive, the identification may nonetheless have indicators of reliability that eliminate any due process (fairness) argument. An example would be a case in which a witness identifies as the suspect someone the witness has worked with continuously for the past three years. The witness would easily recognize the suspect even if the photo array, lineup, or show-up in which he identified the person for the police was very suggestive in nature.

Reliability Issues

A substantial amount of research, particularly by experimental psychologists, has raised questions concerning the ways in which police conduct identification procedures with eyewitnesses and how accurate eyewitnesses are in

Eyewitness Testimony and a Wrongful Conviction

The1988 film *The Thin Blue Line* is a documentary about Randall Dale Adams, who was wrongly convicted of killing a police officer. As a result of public attention raised by this film as well as the evidence developed in the course of the film's production, a Texas criminal court ordered Adams released pending a new trial. Eventually, the state of Texas decided not to retry the case. The film meticulously documents the evidence in the case, suggesting that Adams was framed. Its depiction of why the key witnesses had reasons to lie helped to free Adams and provides a useful counter to the popular conception that eyewitness testimony is the most reliable testimony in criminal cases.

Timothy L. Hall

identifying suspects from photo arrays and lineups and during show-up procedures. It has been argued that mistaken eyewitness identifications are the most common reason for wrongful convictions.

Research findings suggest that investigators should be careful when giving instructions to witnesses before showing them photo arrays or lineups, and they should be cautious as well about making any comments to witnesses during or after these procedures. For example, at a lineup, an investigator should never imply that the actual offender is among the lineup participants, as this may cause the witness to select whichever person in the lineup is most like the person the witness remembers seeing at the crime scene. Likewise, investigators should not give positive feedback to a witness who has chosen someone from a photo array or lineup, such as "Good, you identified the right man," because it is possible that the witness's memories of the crime may be altered by this postevent information—that is, the witness may then be more likely to associate the person in the photograph with the crime, even if that is not the person who actually committed the crime. This can then affect the witness's testimony in court. In many wrongful conviction cases, witnesses have become "more certain" over time that the persons they selected during the identification process were the offenders, even though evidence that came out later proved that such was not the case.

Since the 1970's, defense attorneys have increasingly called on psychologists to testify in court as expert witnesses regarding the reliability, or unreliability, of eyewitness testimony. These experts generally explain to juries the fragile three-stage process through which eyewitnesses see, store, and later retrieve information. They note that many elements, including poor lighting, the stress of the crime event, and the witnesses' own attitudes, may have negative influences on eyewitnesses' ability to recall events clearly. For example, victims may be so distracted by the weapons offenders wield during crimes (so-called weapon focus) that they may later have difficulty recognizing or describing the offenders.

Additionally, expert witnesses sometimes discuss the well-documented phenomenon of cross-racial bias in memory—that is, research has shown that individuals have more accurate memories regarding the faces of people of their same race than they do for people of other races. Another issue related to eyewitness reliability is the phenomenon of "unconscious transference," in which eyewitnesses confuse persons they have seen in other situations for the perpetrators of the crimes they witnessed, and so select the wrong individuals from photo arrays or lineups.

In laboratory experiments, psychologists have found that high "confidence levels" in witnesses do not automatically equal accuracy. Many overturned cases of wrongful conviction have also shown this to be true.

Identification errors have been found to be more common in children than in adults, and child suggestibility is higher relative to interviewer comments. In addition, elderly persons are more likely to make identification errors than are young or middle-aged adults. In giving expert testimony on this topic, psychologists are fond of saying that the "eye is not a camera" and the "mind is not a videotape," and thus pretrial identifications should be examined closely for accuracy.

Efforts to Promote Accurate Eyewitness Identifications

An eyewitness identification may be the most crucial part of a criminal case. Traditionally, courts have relied on defense attorney cross-examination of eyewitnesses to reveal any potential inaccuracies in these witnesses' identifications. It has been suggested, however, that additional safeguards should be in place to ensure the accuracy of eyewitness accounts. A number of police departments have instituted the use of so-called cognitive interview techniques, which avoid the use of suggestive questions in interviews with victims and other witnesses. Just as physical evidence can be contaminated, the concern is that through improper, suggestive interviewing, contamination of eyewitnesses can occur. It has also become increasingly common for investigators to record—both in writing and on audio- or videotape—all pretrial identification procedures used, so that they can be reviewed later at trial.

Typically, pretrial identification procedures in a given case have been conducted by the investigator or investigators assigned to that case, but some observers have suggested that an alternative process might better ensure fair results. In this so-called double-blind process, the pretrial identification procedures are conducted by a police investigator who is not connected to the case under investigation. The assumption is that such a person would be unlikely to introduce any kind of bias or suggestion into the eyewitness's attempt to make an identification.

Another change in police procedure that has been recommended to reduce eyewitness identification error is the sequential display of photos or lineup participants rather than the commonly used simultaneous display. That is, instead of viewing all photos or lineup participants together as a group, witnesses look at each individual photo or lineup participant separately from the others. The thinking is that this procedure may be less likely to result in the identification of an innocent party and hence a potential miscarriage of justice.

Rick M. Steinmann

Further Reading

Brewer, Neil, and Kipling D. Williams, eds. *Psychology and Law: An Empirical Perspective*. New York: Guilford Press, 2005. Collection of essays includes discussion of eyewitness recall, testimony, and false memories.

Doyle, James M. *True Witness: Cops, Courts, Science, and the Battle Against Misidentification*. New York: Palgrave Macmillan, 2005. Explains the reasons that eyewitness accounts may lead to misidentifications.

Gilbert, James N. *Criminal Investigation*. 6th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2004. Comprehensive text includes an overview of how identification procedures are conducted.

Junkin, Tim. *Bloodsworth: The True Story of the First Death Row Inmate Exonerated by DNA*. Chapel Hill, N.C.: Algonquin Books, 2004. Relates the experiences of a man who was wrongfully convicted, in part because of eyewitness misidentification, and his subsequent release from prison.

Technical Working Group on Eyewitness Evidence. *Eyewitness Evidence: A Guide for Law Enforcement*. Washington, D.C.: National Institute of Justice, 1999. A panel of police officers, prosecutors, psychologists, and defense attorneys provide suggestions regarding the conduct of reliable, effective identification procedures.

See also: Cognitive interview techniques; Composite drawing; Direct versus circumstantial evidence; Expert witnesses; False memories; Forensic psychology; Innocence Project; *People v. Lee*; Pseudoscience in forensic practice; Trial consultants; Wrongful convictions.

F

Facial recognition technology

Definition: Computerized biometric identification technology that matches scans of facial features against images of faces stored in databases to identify individuals.

Significance: Facial recognition technology is an advanced tool used by law-enforcement agencies and security specialists to verify the identities of individuals and to conduct surveillance. Along with other biometric identification technologies, such as fingerprint- and eye-scanning systems, facial recognition systems are becoming increasingly important components of security measures in a number of environments.

Facial recognition technology (FRT), also known as face biometrics, is employed as a security measure in many public venues, particularly in airports, sporting arenas, and high-crime areas. Several countries—including Australia, the United Kingdom, and the United States—use digital cameras and closed-circuit television (CCTV) surveillance in strategically chosen public venues to capture images of faces, which are then reduced to digital codes and compared with images in databases of wanted persons. In addition to identifying and tracking known criminals, such surveillance along with FRT may act as a general deterrent to would-be criminals. Security specialists also use FRT in various business and government organizations to limit access to sensitive projects, technologies, and products.

After an FRT device captures an image of a face using digital camera or CCTV, the image is scanned and facial recognition software converts it to a face code, also known as a face print. Facial recognition software applies geometric and mathematical calculations based on a number of points identified on the facial image; these calculations vary depending on the software, the mathematical program implemented, and the number of points entered into the calculations. Generally, the face print is based on the angles of a face and the distances between the eyes, nose, and mouth. Some calculations are more resistant to errors because of changes in angle, lighting, or expression or because of changes in appearance such as a beard or glasses.

After a face print is established, the software interfaces with a database of stored facial images established by the Federal Bureau of Investigation (FBI) or with another database created by a security firm or by a state or local law-enforcement agency. For the FRT to identify an individual, a matching face print must exist in the database for comparison. In the case of FRT used for surveillance rather than to confirm identities for security purposes, some software is available that enables Internet-based searches for facial matches. When FRT is used for surveillance, after a face print is matched to a face in the database, the system alerts police or security personnel so that they can detain or track the person until his or her identity can be established.

One criticism of FRT is that all systems developed thus far have consistent error rates because of differences between the face prints in the databases and the face prints calculated based on the images captured by the systems' cameras. These differences are often caused by changes in the angles of people's faces as they pass surveillance points, by changes in facial expressions, and by facial disguises. The consequence of an error can be a false alarm or a miss. A false alarm identifies an individual as wanted when he or she is not, and a miss allows a person who is wanted (or banned or otherwise under excluded status) to avoid detection.

Supporters of the use of facial recognition systems note that FRT provides a relatively nonintrusive way to verify and authenticate a person's identity and assert that it is a valuable tool against terrorist attacks and other criminal activity. Opponents of the use of FRT point to evidence of high error rates and general ineffectiveness; they suggest that the technology in its current state is unacceptable given its potential for abuse and the threat that its use poses to individuals' privacy.

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Further Reading

Torr, James D., ed. *Homeland Security: Opposing Viewpoints*. San Diego: Thomson Gale, 2004.

Vacca, John R. *Biometric Technologies and Verification Systems*. Burlington, Mass.: Elsevier, 2007.

Woodward, John D., Jr., Christopher Horn, Julius Gatune, and Aryn Thomas. *Biometrics: A Look at Facial Recognition*. Santa Monica, Calif.: RAND, 2003.

See also: Airport security; Biometric eye scanners; Biometric identification systems; Closed-circuit television surveillance; Composite drawing; Forensic sculpture; Imaging; Integrated Automated Fingerprint Identification System; Iris recognition systems; Lasers.

Facial reconstruction. *See* Forensic sculpture

False memories

Definition: Thoughts about episodes seemingly from the past that the perceiver interprets as valid memories of personal experiences but that actually originate from the perceiver's own imagination or from the suggestions of others.

Significance: When the concept of false memories gained attention in the 1990's, it provided an alternative explanation for the phenomenon of "recovered memories," which usually involve themes of childhood sexual abuse. Whether memories of childhood abuse that emerge years later, and that are accepted by the perceivers as valid and factual, are indeed true has been the key issue in much civil and criminal litigation. Debates concerning the validity of the recovery of previously repressed memories continue.

The concept of false memories arose in the context of criticism of the alternative concept of repressed and recovered memories. Sigmund Freud originated the concept of repression around 1900, asserting that people react to disturbing thoughts, feelings, impulses, and experiences by removing them from conscious awareness, or repressing them. Such repressed materials continue to fester, however, and manifest themselves in anxiety and neurotic symptoms until the underlying conflicts are uncovered in psychotherapy.

In the last decades of the twentieth century, it became evident that instances of sexual abuse of children by parents and other caretakers are more common than earlier generations had believed. Whereas earlier psychoanalysts would have dismissed as fantasy patients' expressed thoughts involving themes of sexual interactions between children and parents, some psychotherapists in the late twentieth century, especially those most sensitive to women's issues, concluded that the expression of such thoughts reflected factual memories of abuse in childhood and that such abuse is a primary cause of emotional distress. Many psychotherapists worked with patients to "recover" memories of abuse that they believed the patients had repressed, as they believed this was important to relieve the patients' distress.

Those who accepted the memories of abuse recovered in therapy as valid memories often instigated civil lawsuits to seek damages against the parents or other caretakers they believed had perpetrated the abuse. In some cases, criminal indictments were sought. Because the recovery of such memories could occur many years after the alleged abuse, some states changed their laws to extend the statutes of limitations—the time limits placed on the instigation of legal action—for charges of child sexual abuse.

Contrasting Views

From the beginning, Dr. Elizabeth F. Loftus and other cognitive psychologists were skeptical of the validity of "recovered" memories. Much experimental work had already demonstrated that memory is vulnerable to distortion by suggestion and that a person's confidence in a memory and the vividness of a particular memory do not always correlate with its accuracy. Experimental work had documented how profoundly interviewers can alter the accounts of eyewitnesses through suggestions introduced unintentionally during questioning. The influence of new erroneous information slipped into interrogations by suggestive questioning had become widely known as the "misinformation effect."

Loftus and her colleagues attacked the concept of repressed and recovered memories with several types of arguments. First, they sought to produce evidence that would establish that such "memories" could be created through suggestion. Second, they sought to establish that such suggestions are often made in psychotherapy settings. Third, they showed that some so-called recovered memories contain themes that are wildly improbable. Finally, they attacked the basis of these memories in the concept of repression, which Loftus called a "myth."

Evidence for False Memories

Loftus and her colleagues first sought to gather evidence that fictitious events can be implanted as "memories" through suggestion. Beginning in 1994, these researchers successfully instilled such false memories in laboratory subjects. In a series of experiments, false memories were implanted by the subjects' cooperating family members. Each designated family member was given a written description of a plausible event that supposedly happened to the subject in childhood; the family member verified that the event had never occurred. The fictitious events included being lost in a shopping mall, being the victim of a vicious animal attack, almost drowning at the beach, and spilling punch on the parents of the bride at a wedding reception. In a session in which the subject and the family member "reminisced about childhood experiences," the fictional story and some true personal stories were discussed.

In these experiments, a significant minority of subjects, usually about a third, came to accept the fictitious stories as memories of "real" episodes from their own experience. In the most successful cases, the subjects embellished the false memories with descriptive details. In some cases, the "memories" were accompanied by appropriate emotional reactions; for example, subjects who accepted as memories contrived reports of bad childhood digestive upset caused by hard-boiled eggs later refused hard-boiled eggs when they were offered at a luncheon.

Loftus and her colleagues noted that the environment of psychotherapy is one in which suggestion can be influential. Techniques such as dream analysis, hypnosis, and free association encourage patients to mingle imaginative fantasies with reality. Therapy patients who are in distress tend to grasp at almost any explanatory certainty. Loftus and her colleagues found evidence that the suggestions made by some therapists are quite heavy-handed; disillusioned patients reported such strong suggestions from their therapists as "problems like yours generally originate from repressed sexual abuse in childhood." Some therapists advised patients to read *The Courage to Heal: A Guide for Women Survivors of Child Sexual Abuse* (1988), by Ellen Bass and Laura Davis; this book argues that the entire range of emotional problems experienced by women can be caused by repressed memories of childhood sexual victimization.

Loftus and her colleagues also pointed out that some so-called recovered memories seem so wildly improbable that they appear to be obvious products of imagination. The researchers found that some "victims" reported such memories as being kidnapped and impregnated by aliens, taking part in satanic rituals, and being stuck in the birth canal during the process of being born.

Repression, Forgetting, and Memory

The final contention made by Loftus and her colleagues is that the concept of repression behind the theory of "repressed trauma" is flawed. The thrust of modern research findings is that although certain implications of the concept of repression are valid, others are seriously misleading.

George Franklin holds a local newspaper with a headline announcing his release from jail in Redwood City, California. Franklin had been imprisoned for six years after he was convicted of murder based on the testimony of his adult daughter, who claimed she had suddenly remembered seeing him kill a friend of hers when the two girls were children. *(AP/Wide World Photos)*

The implication that forgetting is selective—for example, memories of happy and flattering experiences are retained in memory more easily, and unhappy and humiliating experiences are more easily dismissed from memory—is supported by much current research. Much forgetting seems to involve a sort of crowding of humiliating and painful experiences out of the focus of consciousness as people become involved in more reinforcing activities and roles. Most human beings like to interpret their pasts favorably; they dislike reminding themselves of painful experiences in the past, so they reinterpret those experiences to present themselves and their loved ones in more flattering ways. That such unpleasantness as sexual abuse can be dismissed from mind for periods of time is not, therefore, surprising.

For this reason, some recovered memories are likely to be valid memories of real episodes of abuse. In some documented cases, the original abuse has been confirmed by other evidence and the recovery of the memories occurred outside therapy. In many such cases, the confirmed abuse occurred for only a brief period of time or was ambiguous enough to permit a benign interpretation. In surveys of such cases, many subjects have reported that they "forgot" about the instances of abuse for a period of time; others reinterpreted the episodes benignly with such explanations as "playing tickling games." The sort of mechanisms that Freudians term "denial" and "rationalization" rather than "repression" seem to be at work in these cases in adjusting the harshness of the reality.

The most misleading implication of the concept of repression lies in its connection to the concept of "recovery." Although fragments of a memory may be accurate, no memory can ever return just as it was stored many years ago. Modern research suggests that memories are forever being reconstructed and modified by new information, insights, and values. Memory is more like a flowing stream, in which the composition of the water is constantly changing, than like a library, where fixed material is filed and cataloged. The notion that a childhood memory could return from repression unadulterated and with pristine clarity is based on the old card-catalog model. It is inconsistent with the view of memory implicit in modern cognitive psychology.

Legal Issues

People who recover memories of abuse and betrayal by caretakers they once respected and trusted typically feel angry and betrayed, and many seek redress through legal action. Litigation based on recovered memories, whether accurate or false, presents special challenges for the legal system, first, because any actual damages were inflicted years and perhaps decades before they were exposed, and second, because the legal system increasingly acknowledges that some recovered memories reflect real abuse and others are the misleading products of suggestion. Whether a memory is "recovered" or "false" can be decided with certainty only in cases confirmed by other evidence. The delay in initiating litigation in such cases was the easiest problem to solve: approximately three-fourths of U.S. states have adjusted their statutes of limitation on child sexual abuse charges to begin counting from the date of the memory recovery rather than from the date of the offense.

Since 1990, when George Franklin was sentenced to prison on the basis of the hypnotically refreshed memory of his daughter, courts have become increasingly aware of the fallibility of recovered memories. Criminal cases are rarely initiated based on uncorroborated recovered memories because "reasonable doubt" can easily be established. Even in civil cases, which have looser standards of proof, judges may be required to warn juries about the unreliability of such uncorroborated testimony. A number of therapy patients who as a result of "recovered memories" became estranged from their families have gone on to win malpractice suits against their therapists for using blatantly suggestive procedures that are considered to reflect the therapists' "failure to exercise the required standard of care."

In the early twenty-first century, the law in the United States generally recognizes the reality of both recovered and false memories. A few false memories are probably still treated as true, and some valid recovered memories of abuse are probably dismissed. In an increasing number of cases, the courts are admitting expert testimony by cognitive scientists to inform juries and judges about the science of memory.

Thomas E. DeWolfe

Further Reading

Bass, Ellen, and Laura Davis. *The Courage to Heal: A Guide for Women Survivors of Child Sexual Abuse*. 3d ed. New York: HarperPerennial, 1994. Argues that the sexual abuse of female children is pervasive, that this abuse is quite commonly repressed and forgotten, and that this is the primary cause of a variety of neurotic, interpersonal, and physical problems.

Conway, Martin, ed. *Recovered Memories and False Memories*. New York: Oxford University Press, 1997. Collection of papers taking a variety of views concerning the recovered versus false memory debate. Introduction orients the reader to each of the other ten papers. The last integrating chapter, titled "Taking the Middle Line," is valuable for the balanced perspective it offers.

Davies, Graham M., and Tim Dalgleish, eds. *Recovered Memories: Seeking the Middle Ground*. New York: John Wiley & Sons, 2001. Collection of papers that try to get beyond the polemics of the recovered versus false memory controversy of the 1990's. Strong first chapter describes the view of Freud, who considered such recovered material as fantasies symptomatic of emotional conflicts rather than memories of actual experiences. Subsequent chapters deal with the personal, social, and legal consequences of the issue.

Leavitt, Frank. "Iatrogenic Recovered Memories: Examining the Empirical Evidence." *American Journal of Forensic Psychology* 19 (2001): 21-32. Focuses on patients who have recovered their memories of being abused in childhood outside therapy and argues that it is unlikely that these recovered memories were created by therapist suggestions.

Loftus, Elizabeth F. "Make-Believe Memories." *American Psychologist* 58 (2003): 864-873. Summarizes several groundbreaking experiments that have established that suggestion can create, in vulnerable subjects, memories for entirely fictitious events that are accorded the validity of real memories.

Loftus, Elizabeth F., and Katherine Ketcham. *The Myth of Repressed Memory*. New York: St. Martin's Press, 1994. Describes the anguish, anger, and broken relationships that often follow from "false memories" of sexual abuse. Asserts that therapists' suggestions create such memories and attacks the concept of repression of memory as a "myth."

Wells, Gary L., and Elizabeth F. Loftus. "Eyewitness Memory for People and Events." In *Forensic Psychology*, edited by Alan M. Goldstein. Vol. 11 in *Handbook of Psychology*, edited by Irving B. Weiner. Hoboken, N.J.: John Wiley & Sons, 2003. Presents a discussion of false memories embedded in a more general discussion of the consequences of the fragility of memories and their vulnerability to suggestion.

See also: Child abuse; Cognitive interview techniques; Composite drawing; *Daubert v. Merrell Dow Pharmaceuticals*; Eyewitness testimony; Forensic psychiatry; Forensic psychology; Interrogation; Minnesota Multiphasic Personality Inventory; Parental alienation syndrome; *People v. Lee*; Postconviction DNA analysis; Wrongful convictions.

Fax machine, copier, and printer analysis

Definition: Examination of output from ink-jet and laser computer printers, electrostatic copiers, and fax machines to determine the origins or authenticity of printed documents.

Significance: Printer and copier analysis based on output is useful in two broad classes of cases: document authentication (generally in cases of suspected forgery), where the main aim is to demonstrate that a document could not have come from a specific source, and document tracing, where the aim is to connect an item with a specific printer and time frame. The latter is considerably more difficult. Document tracing is most likely to arise in criminal cases involving ransom notes, extortion, or blackmail. It may also provide key evidence in terrorism and espionage investigations.

Since the mid-1980's, high proportions of documents relevant to civil and criminal cases have been produced by fax machines, photocopiers, and printers connected to computers. Although they may appear indistinguishable under casual inspection, such documents have physical and chemical characteristics that enable forensic examiners to identify the equipment used to produce the pages and the approximate time frame in which they were generated. The techniques used rely on the extremely rapid rate of change in the printer industry and require sophisticated equipment linked to computer programs capable of discerning subtle differences in the patterns of complex digital signals.

Magnification

Examination under low magnification is usually sufficient to allow analysts to distinguish the outputs of different classes of printers. Ink-jet printers produce more blurred outlines than do laser printers and toner-based photocopiers. Older single-element printers leave indentations on the sheets of paper that pass through them that are similar to those made by electric typewriters. Also, paper may be marked by damaged or improperly aligned feeding machinery in printers. Incidental marks associated with dirty glass can originate either at input (scanner/fax) or at the time of printing. Printer output of any description can be distinguished from typewritten originals by the complete absence of erasures and strikeovers.

In an authentication case, the key question is usually whether two documents were produced on the same equipment. For example, if a questioned contract, originally filled in by typewriter on a printed form, contains substituted pages made by a forger who has scanned the originals, made changes to the text electronically, and printed the altered pages on a laser printer, the differences between original typewritten copy and the scanned forgery would be evident on close examination. If visual inspection under low magnification fails to detect any useful information on a questioned document, analysts may apply a wide array of more sophisticated techniques, such as those described below, but unless large sums of money are involved or the case is politically charged, these are seldom employed.

Electronic and Chemical Analysis Methods

When low-volume laser and ink-jet printers and copiers first hit the mass market, forensic specialists assumed that this would make tracing documents to individual printers virtually impossible. In fact, every brand and model of printer (including photocopiers that scan input prior to printing) has a distinctive electronic signature that can be "read" from the output using a scanner and appropriate software. One brand of higher-end color copier invisibly attaches the serial number of the machine to copies, a practice that may well expand. Computer analysis can also reveal banding and other flaws resulting from machine malfunction.

The most powerful tools for tracing printer and copier output, however, rely on the chemical compositions of dyes and toners, both the pigments themselves and the compounds used to bind them to the paper. The exact formulation of each dye and toner is specific not only to the manufacturer but also to a narrow time frame, measured in months.

Different tools provide analysts with complementary information. Scanning electron microscopy (SEM) produces a high-resolution image of surface features, including the drying patterns of inks. As an adjunct to SEM, energy-dispersive spectroscopy (EDS; also known as energy-dispersive X-ray spectroscopy, or EDX) measures the X-ray emission spectra of compounds bombarded by electrons. An EDS reading indicates which atomic elements are present in a sample and in what proportions. X-ray fluorescence spectroscopy detects the presence of certain compounds based on the visible or ultraviolet light they emit when bombarded by X rays.

Infrared absorption spectrometry detects specific types of chemical bonds in organic molecules. This technique is useful for distinguishing between chemically similar bonding agents. Thin-layer chromatography and pyrolysis gas chromatography depend on the rate of diffusion of compounds and are useful for distinguishing mixtures of complex organic chemicals, such as those in dye-based inks.

All of these spectrographic and chromatographic methods require extensive costly equipment, most of it, however, not specific to forensic science. Most techniques involve sample destruction, but only very small amounts of material are required. After a reading is obtained, the examiner uses a computer program to compare that reading either to a sample of known origin or to a library of chemical signatures. Such libraries are maintained both by leading national forensic laboratories and by toner and ink manufacturers.

One California investigation into fraud and insider trading focused on a company executive who denied ever having seen a certain set of privileged documents. By analyzing ink and printer characteristics, forensic scientists were able to demonstrate with a high degree of probability that the papers in question were printed on the executive's home computer system.

Chemical analysis of inks and toners does not even require intact documents. In a 2006 Japanese blackmail investigation, the suspect burned critical documents. Scientists were able to analyze the toner found on the charred fragments and ashes; it matched that of the blackmail letters, strengthening the prosecution's case.

In the future, the most persistent and organized criminals will undoubtedly become more adept at circumventing techniques now in place for detecting fraudulent and extortionist uses of printers and photocopiers. Forensic document examiners must thus stay abreast of the rapidly evolving technology in this area.

Martha Sherwood

Further Reading

Dines, Jess E. *Document Examiner Textbook*. Irvine, Calif.: Pantex International, 1998. Practical manual for forensic document examiners presents lengthy discussion of typewriter analysis but relatively little on the analysis of the output of computer printers.

Eckert, William G., ed. *Introduction to Forensic Sciences*. 2d ed. Boca Raton, Fla.: CRC Press, 1997. Text aimed at students considering a career in the forensic sciences includes a chapter on questioned documents.

Houck, Max M. *Forensic Science: Modern Methods of Solving Crime*. Westport, Conn.: Praeger, 2007. Highly readable volume provides a rigorous overview of many aspects of forensic science, with numerous examples. Includes brief coverage of document analysis.

Kaye, Brian H. *Science and the Detective. Selected Reading in Forensic Science*. New York: VCH, 1995. Presents clear descriptions of the manufacturing processes used in making toners and of the mechanics of laser and ink-jet printers.

Nickell, Joe. *Detecting Forgery: Forensic Investigation of Documents*. 1996. Reprint. Lexington: University Press of Kentucky, 2005. A leading expert in the investigation of paranormal phenomena presents a lively and thorough treatment of the topic of forgery. Discusses several famous cases.

White, Peter, ed. *Crime Scene to Court: The Essentials of Forensic Science*. 2d ed. Cambridge, England: Royal Society of Chemistry, 2004. Good general text includes a section on printer and typewriter analysis.

See also: Check alteration and washing; Computer crimes; Counterfeiting; Document examination; Energy-dispersive spectroscopy; Federal Bureau of Investigation Laboratory; Forgery; Questioned document analysis; Scanning electron microscopy; Typewriter analysis; Writing instrument analysis; X-ray diffraction.

Federal Bureau of Investigation

Date: Established as the Bureau of Investigation in 1908; renamed the Federal Bureau of Investigation in 1935

Identification: Main law-enforcement agency of the U.S. Department of Justice.

Significance: The Federal Bureau of Investigation has long been the leading agency in the development and use of forensic science in crime investigation and prevention in the United States, if not the world.

The Federal Bureau of Investigation (FBI) serves as both a federal criminal investigative body and a domestic intelligence organ within the United States. With jurisdiction over more than two hundred federal crimes, the FBI is the principal federal law-enforcement organization, with an annual budget of more than six billion dollars and more than thirty thousand employees as of 2007. In addition to its headquarters in Washington, D.C., the FBI maintains fifty-six field offices and more than four hundred resident agencies in the United States as well as sixty foreign offices in U.S. embassies around the globe.

The FBI has a broad mandate to protect the United States from terrorist attacks, foreign spying, cybercrime, public corruption at any level, violation of civil rights, organized crime, and any large-scale or otherwise significant violent crime. The agency also assists other federal, state, local, and international crime-fighting agencies and develops technologies to further these objectives. Forensic science has played an important role throughout the history of the FBI, and the agency provides many forensic science services free to U.S. state and local governments.

Early History

The legal authority for federal law enforcement developed very slowly in U.S. history. Although one of the first four officials appointed to the cabinet of President George Washington in 1789 was the attorney general of the United States, the first attorney general, Edmund Randolph, was not given a department to run. The U.S. Department of Justice was not created until 1870, and even then the department was not given many law-enforcement duties. Under the federal system, states and localities were expected to provide for basic law enforcement. The role of federal law enforcement changed gradually with the passage of various federal laws, such as the Interstate Commerce Act of 1887. When violations of federal laws needed to be investigated, the U.S. attorney general informally hired or borrowed personnel from other agencies.

By 1908, near the end of President Theodore Roosevelt's term in office, various political and legal struggles made this situation untenable, and the Bureau of Investigation was created. This precursor to the FBI exhibited the same pattern of success and failure that later marked the FBI, but the scale of the agency's activities was limited until J. Edgar Hoover was appointed BOI director in 1924.

Hoover, a consummate bureaucrat, led the agency for forty-eight years, until his death in 1972, and molded it into the paradoxical phe-

J. Edgar Hoover in 1924, the year he was appointed director of the Bureau of Investigation, which later was renamed the Federal Bureau of Investigation. *(Library of Congress)* nomenon it became. One of his first steps was to create the national registry of fingerprints, which became one of the hallmarks of forensic science, although the agency's first laboratory was not established until 1932 (when the agency's name was changed to the U.S. Bureau of Investigation). The FBI crime lab started with basic forensic science analyses, such as firearms identification and the examination of disputed or questioned documents. Gradually, it became one of the best forensic facilities in the world, pioneering a wide range of forensic techniques, including the development of the use of DNA (deoxyribonucleic acid) analysis as a tool for identifying individuals.

The Stated Mission and Priorities of the FBI

Our Mission

To protect and defend the United States against terrorist and foreign intelligence threats, to uphold and enforce the criminal laws of the United States, and to provide leadership and criminal justice services to federal, state, municipal, and international agencies and partners.

Our Priorities

In executing the following priorities, we will produce and use intelligence to protect the nation from threats and to bring to justice those who violate the law.

1. Protect the United States from terrorist attack
2. Protect the United States against foreign intelligence operations and espionage
3. Protect the United States against cyber-based attacks and high-technology crimes
4. Combat public corruption at all levels
5. Protect civil rights
6. Combat transnational/national criminal organizations and enterprises
7. Combat major white-collar crime
8. Combat significant violent crime
9. Support federal, state, local and international partners
10. Upgrade technology to successfully perform the FBI's mission

Since 1935

In 1935, the U.S. Bureau of Investigation was renamed the Federal Bureau of Investigation. Hoover undertook a campaign to make the FBI one of the most powerful federal law-enforcement agencies through an expansion of the agency's responsibilities, but he took great care to ensure that the FBI did not overreach. Critics have charged that much of the positive public perception of the FBI in its early years came about as the result of Hoover's intentional attack on "glamorous" crime problems that led to comparatively easy successes. In the 1920's, Hoover had pursued powerless left-wing radicals through such actions as the so-called Palmer raids (named for A. Mitchell Palmer, the U.S. attorney general who oversaw the raids). As FBI director, Hoover focused on bank robbers, a small part of national crime, creating the illusion of a 1930's crime wave that he could easily solve.

When World War II broke out, Hoover changed his focus to capturing the relatively small numbers of German and Japanese agents in the United States; the FBI caught enough of them that these activities were deemed a success. During the Cold War, Hoover again focused on left-wing radicals. At one time it was estimated that one-fifth of the members of the American Communist Party were "undercover" FBI agents. Despite all of the agency's public relations success, the FBI caught relatively few communist spies. The FBI compiled a successful statistical record, but the real crime fighting remained in the hands of local law enforcement.

This pattern of giving high priority to successful public relations seemed brilliant for a long time, but it also led to extensive criticism of Hoover and the FBI. By the end of Hoover's career, the FBI's reputation for success began to be a burden as the agency was asked to take on more and more responsibilities. With the passage of the Controlled Substances Act of 1970, Hoover managed to avoid having the FBI carry the sole responsibility for the thankless job of fighting drug trafficking—that responsibility was placed primarily with the newly established Drug Enforcement Administration. In the same year, however, the passage of the Racketeer Influenced and Corrupt Organizations (RICO) Act gave the FBI a prime role in fighting organized crime.

After Hoover's death in 1972, those who succeeded him as FBI director were unable to stop the federal government from assigning the agency new responsibilities, and the FBI, some critics have asserted, became overextended. Throughout the Hoover era, forensic science was among the most glamorous of the FBI's activities, and the FBI Laboratory Division represented one of the agency's greatest successes. Each new responsibility assigned to the agency presented new opportunities for uses of forensic science, and the FBI's forensic science capabilities were augmented even if the popular focus was on other aspects of the agency's law-enforcement work.

The FBI and Forensic Science

The many different kinds of forensic science conducted at the FBI Laboratory reflect the full range of the uses of forensic science in the areas of law enforcement and intelligence gathering. The FBI lab performs a wide variety of chemical, biological, and technological services, which are offered to many state, local, and international agencies free of charge. The FBI also publishes a number of different kinds of reports on the lab's work; both news media outlets and law-enforcement agencies rely on these reports for information on the state of forensics in law enforcement in the United States.

The FBI has achieved some great successes in using forensic science to solve crimes and support successful prosecutions. By analyzing the debris of the 1993 World Trade Center bombing, FBI scientists were able to identify the vehicle used in the explosion within just a few hours of the attack; they achieved the same shortly after the 1995 bombing of the Alfred P. Murrah Federal Building in Oklahoma City. In both cases, the evidence gathered and analyzed by the FBI resulted in successful prosecutions of the perpetrators. The FBI investigation of the Unabomber case took longer, but ultimately the forensic evidence gathered resulted in the successful prosecution of Theodore Kaczynski.

Among the forensic science tools developed at the FBI is the use of criminal personality profiling—that is, the study of the psychological profiles associated with various types of criminals. Closely related to such profiling is the creation of the FBI's Hostage Rescue Team (HRT) in 1983; the hostage negotiators on the HRT are trained to seek peaceful outcomes to a wide range of hostage situations.

Richard L. Wilson

Further Reading

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005. Provides an excellent summary of forensic science for the general reader as well as a wealth of additional material.

Kessler, Ronald. *The Bureau: The Secret History of the FBI*. New York: St. Martin's Press, 2002. Readable work by a prominent journalist covers the entire history of the FBI. Comments negatively on FBI directors William Sessions and Louis Freeh.

Powers, Richard Gid. *Broken: The Troubled Past and Uncertain Future of the FBI*. New York: Free Press, 2004. Historical study of the FBI by a leading historian of national security and law enforcement. Asserts that the weaknesses of the FBI go back to the agency's beginnings.

Romerstein, Herbert, and Eric Breindel. *The Verona Secrets: Exposing Soviet Espionage and America's Traitors*. Washington, D.C.: Regnery, 2001. Uncritical work tells the story of the FBI's great success at breaking the Soviet Union's secret codes from a bygone era.

Theoharis, Athan G. *The FBI and American Democracy: A Brief Critical History*. Lawrence: University Press of Kansas, 2004. Presents a careful academic examination of the decline and failures of the FBI, especially in the era following the September 11, 2001, terrorist attacks on the United States.

Tonry, Michael, ed. *The Handbook of Crime and Punishment*. New York: Oxford University Press, 1998. Collection of essays on criminology and criminal justice policy issues includes extensive discussion of the FBI.

Zegart, Amy B. *Spying Blind: The CIA, the FBI, and the Origins of 9/11*. Princeton, N.J.: Princeton University Press, 2007. Criticizes the FBI's performance in the period leading up to the terrorist attacks of September 11, 2001, and argues that the agency's failures in fighting terrorism are the result of deeply institutionalized opposition to that role for the FBI.

See also: Criminology; Drug Enforcement Administration, U.S.; Federal Bureau of Investigation DNA Analysis Units; Federal Bureau of Investigation Forensic Science Research and Training Center; Federal Bureau of Investigation Laboratory; Integrated Ballistics Identification System; Interpol, U.S. National Central Bureau of; Kennedy assassination; National Crime Information Center; National DNA Index System; Oklahoma City bombing; World Trade Center bombing.

Federal Bureau of Investigation DNA Analysis Units

Date: Formed in 1998

Identification: Special units of the FBI Laboratory formed to provide DNA testing and related services to all federal, state, and local law-enforcement agencies, military tribunals, and U.S. attorneys in the United States and abroad.

Significance: By providing comprehensive forensic examinations, scientific research, technological advancements, training, expert witness testimony, and maintenance and creation of national DNA database programs, the FBI's DNA Analysis Units have contributed to the effectiveness of the use of DNA evidence in criminal investigations and in the identification of missing and unidentified persons.

The Federal Bureau of Investigation (FBI) operates one of the world's largest forensic laboratories. The FBI Laboratory, commonly referred to as the FBI crime lab, comprises branches and sections that are further divided into special units. In 1988, the DNA Unit was established as part of the lab's Scientific Analysis Section. The new unit included biologists, forensic examiners, specialists in DNA (deoxyribonucleic acid) analysis, and management and program analysts. In 1998, the DNA Unit was divided into two more specialized units: the DNA Analysis Unit I (DNAAU-1) and the DNA Analysis Unit II (DNAAU-2).

DNAAU-1 examines evidence from a variety of crimes and provides serological and nuclear DNA testing services. Serological techniques assist in DNA analysis by identifying whether biological stains are blood, semen, or other body fluids. DNA samples may also be obtained from a variety of other sources, such as saliva left on cigarette butts, envelopes, or beverage bottles and from sweat deposited inside hats. Nuclear DNA testing is performed on the evidence, and the findings are compared with the DNA found in reference samples obtained from crime victims or suspects.

In accordance with the Federal Convicted Offender Program, DNAAU-1 also conducts DNA analysis on all individuals convicted of federal felonies. The resulting DNA profiles are entered into the National DNA Index System (NDIS). Additionally, DNAAU-1 offers specialized training on DNA technology for forensic scientists and examiners, law-enforcement agencies, and members of the legal community, such as prosecutors and judges.

DNAAU-2 analyzes the mitochondrial DNA (mtDNA) sequences in biological evidence from crime scenes, such as hair, teeth, and bones. Nuclear DNA analysis may not be appropriate for such evidential materials, as the DNA may be degraded, so sensitive mtDNA analysis techniques are used. Forensic information attained through these techniques has proved to be especially useful in cold cases and in cases with only small pieces of biological evidence available.

Unique identification—that is, identification of a specific individual—is not possible using

The FBI's Adoption of DNA Analysis Techniques

1985	Alec Jeffreys develops restriction fragment length polymorphism (RFLP) probes.
1988	FBI establishes DNA Unit and begins RFLP casework.
1990	FBI establishes Combined DNA Index System (CODIS).
1993	FBI begins polymerase chain reaction (PCR) short tandem repeat (STR) casework.
1998	FBI creates DNA Analysis Units.
1998	CODIS's national database becomes operational.
1999	FBI and other labs stop RFLP casework.
2002	FBI initiates mitochondrial DNA (mtDNA) casework.
2004	FBI initiates mtDNA regional labs.

mtDNA analysis, as all maternal relatives inherit the same mtDNA type. DNAAU-2 scientists compare the mtDNA from biological evidence to reference samples of qualifying relatives, such as the mother or siblings, of the person of interest.

The work of DNAAU-2 is also integral to the National Missing Person DNA Database (NMPDD) program. The NMPDD contains available DNA profiles from missing persons, biological relatives of missing persons, and unidentified human remains. Like NDIS, the NMPDD is part of the Combined DNA Index System (CODIS). DNAAU-2 also works in partnership with the Regional Mitochondrial DNA Laboratory Program and maintains the Scientific Working Group DNA Analysis Methods mtDNA Population Database.

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Further Reading

Buckleton, John, Christopher M. Triggs, and Simon J. Walsh, eds. *Forensic DNA Evidence Interpretation*. Boca Raton, Fla.: CRC Press, 2005.

Butler, John M. *Forensic DNA Typing: Biology, Technology, and Genetics of STR Markers*. 2d ed. Burlington, Mass.: Elsevier Academic Press, 2005.

Kirby, Lorne T. *DNA Fingerprinting: An Introduction*. New York: Oxford University Press, 1992.

Rudin, Norah, and Keith Inman. *An Introduction to Forensic DNA Analysis*. 2d ed. Boca Raton, Fla.: CRC Press, 2002.

See also: CODIS; DNA analysis; DNA database controversies; DNA fingerprinting; DNA isolation methods; DNA profiling; Federal Bureau of Investigation; Federal Bureau of Investigation Forensic Science Research and Training Center; Federal Bureau of Investigation Laboratory.

Federal Bureau of Investigation Forensic Science Research and Training Center

Date: Established in 1981

Identification: Section of the Federal Bureau of Investigation Laboratory Division responsible for developing new and improved forensic science techniques and for providing training in the forensic sciences to local, state, and federal law-enforcement and criminal justice system personnel.

Significance: The Forensic Science Research and Training Center makes important contributions to the field of forensic science by supporting researchers as they develop new methods and technologies and improve existing techniques for gathering, examining, and analyzing forensic evidence. The work done at the center influences the work of law-enforcement agencies around the world.

The Federal Bureau of Investigation (FBI) Forensic Science and Research Training Center (FSRTC), a section of the FBI Laboratory Division, is located on the grounds of the FBI Academy in Quantico, Virginia. One of the primary purposes of the FSRTC is to engage in research in the ever-changing field of forensic science. The center works to develop new methods as well as to improve existing techniques for the analysis of forensic evidence. Using the most advanced equipment available, scientists at the FSRTC study a vast range of forensic subjects, including the analysis of fingerprints and footprints, tire impressions, explosives, documents, fibers, and DNA (deoxyribonucleic acid).

The scientists who work at the FSRTC are among the best in their fields. Researchers at the FSRTC work in partnership with researchers from all over the United States, including scientists in university laboratories, governmental and nongovernmental labs, and private-sector labs. In addition, the FSRTC provides support to the FBI Laboratory in the areas of forensic science research and quality assurance.

Research findings of the FSRTC are widely disseminated to forensic scientists through a number of outlets, including the quarterly journal *Forensic Science Communications*, which is published by FBI Laboratory personnel. In addition, the FSRTC regularly holds widely respected conferences that attract the participation of criminal justice professionals from all over the world.

Another important function of the FSRTC is to provide training in the forensic sciences for new FBI and Drug Enforcement Administration agents as well as continuing education courses for FBI special agents, laboratory examiners, and laboratory technicians. The center also offers training to local, state, and other federal law-enforcement agencies. In addition to teaching the theoretical aspects of forensic science, the FSRTC provides substantial hands-on training to ensure that trainees are comfortable with the actual handling of equipment, chemical solutions, and physical evidence. Among the topics covered by FSRTC courses are the collection and preservation of physical evidence, photographic techniques, laboratory management, fingerprint analysis, and DNA technology.

The FSRTC is also involved in raising awareness among young people of the increasing importance of forensic science professions. As part of this effort, the FBI's Honors Internship Program creates opportunities for college science students to work alongside some of the nation's leading geneticists, biochemists, and other scientists at the FSRTC.

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Further Reading

Federal Bureau of Investigation. *Handbook of Forensic Services*. Washington, D.C.: U.S. Department of Justice, 2003.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005.

National Institute of Justice. *The Future of Forensic DNA Testing: Predictions of the Research and Development Working Group*. Honolulu: University Press of the Pacific, 2005.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007.

See also: American Academy of Forensic Sciences; DNA analysis; Federal Bureau of Investigation; Federal Bureau of Investigation DNA Analysis Units; Federal Bureau of Investigation Laboratory; Federal Law Enforcement Training Center; Forensic Science Service; International Association of Forensic Sciences.

Federal Bureau of Investigation Laboratory

Date: Established on November 24, 1932

Identification: Central forensic science unit of the Federal Bureau of Investigation.

Significance: The Technical Laboratory established by the FBI in 1932 subsequently evolved into one of the world's leading organizations in the development of the forensic sciences. The FBI Laboratory provides forensic services in support of federal, state, and local law-enforcement agencies across the United States as well as agencies in other nations.

The Federal Bureau of Investigation (FBI) is the leading federal agency for both crime investigation and domestic intelligence within the United States, and the FBI Laboratory (commonly referred to as the FBI crime lab) is one of the agency's most successful divisions. In addition to its law-enforcement responsibilities, the FBI assists federal, state, local, and international crime-fighting agencies, in large part through the services of its crime lab. Many state, local, and international agencies use the services of the FBI Laboratory free of charge. Long-term FBI director J. Edgar Hoover was responsible for inaugurating the practice of fingerprint analysis by the agency in 1924 and later for the founding of the Technical Laboratory, precursor to the modern FBI Laboratory, in 1932.

Development of Early Techniques

One of the earliest forensic science techniques employed by the FBI was fingerprint analysis. At the modern FBI crime lab, the Latent Print Operations Unit (LPOU) conducts friction ridge analysis, including the development and comparison of latent fingerprints, palm prints, and footprints. The LPOU reports its findings, provides expert testimony, and trains national and international law-enforcement personnel. The lab uses prints from a large database known as the Integrated Automated Fingerprint Identification System (IAFIS) for comparison; IAFIS is maintained by the FBI's Criminal Justice Information Services Division. The Counterterrorism and Forensic Science Research Unit (CFSRU) of the lab conducts research into techniques that might improve fingerprint identification.

Another unit of the FBI crime lab that was established relatively early in the lab's history is the Questioned Document Unit (QDU), which examines and compares evidence samples involving paper, including handwriting, typewriting, printing, erasures, alterations, indented writing, and obliterations. The work of the QDU includes matching torn or perforated edges of items (such as paper and postage stamps) and analyzing typewriter ribbons, images made by photocopiers and fax machines, works of graphic art, and plastic bags. The unit maintains an electronic database of images of ransom notes, extortion letters, and other anonymous communications to assist analysts in comparing questioned documents from different cases with a common source. In addition, the duties of the unit have been expanded to include footprint and shoe print analysis, and it maintains an electronic database of sole and heel designs from shoe manufacturers to compare with prints and impressions left at crime scenes.

Other Forensic Services

Many of the forensic services conducted by the FBI crime lab concern the analysis of firearms, tool marks, and explosives. The Firearms-Toolmarks Unit (FTU) focuses on the forensic examination of firearms, ammunition components, tool marks, gunshot residue on victim or suspect clothing, bullet trajectories, and other physical evidence related to firearms and tool marks. FTU scientists compare lead and other metal fragments, shot wads, shot cups, and bullets removed from corpses at autopsy to each other and to firearms to establish links or exclude possible weapons. Scientists in this unit also compare the marks found at crime scenes and on victims' bodies made by screwdrivers, knives, crowbars, saws, chains, human bone or cartilage, locks, bolts, and screens to try to determine the specific tools that made the marks. The Explosives Unit conducts chemical analyses to determine the types of explosives used in explosive or incendiary devices; this unit is also concerned with determining whether accelerants are present in the debris left by fires of suspicious origins.

Among the most important forensic science services conducted at the FBI lab are those involving DNA (deoxyribonucleic acid) analysis. One of the lab's two specialized DNA Analysis Units (DNAAU-1) examines DNA samples taken from evidence collected in various counterterrorism efforts as well as from crime scenes and victims of murders, sexual assaults, bank robberies, and other crimes. Samples of biological materials—such as blood, semen, and other body fluids—are subjected to DNA typing, and the results are compared with DNA analysis results from known samples from victims or potential suspects. This unit also processes DNA samples from convicted federal offenders, whose DNA profiles are then added to the database known as the Combined DNA Index System (CODIS), which enables state and local law-enforcement agencies to search for possible matches to DNA profiles obtained locally.

Additional areas of forensic science practiced at the FBI crime lab include computer analysis and response, evidence response, forensic audio, forensic video, image analysis, investigative and prospective graphics, special photographic analysis, and analysis of structural design. The lab also conducts research into various areas of the forensic sciences and engages in training forensic scientists.

The FBI crime lab sometimes works in cooperation with other federal agencies, such as the U.S. Coast Guard and Customs and Border Patrol. If criminal activity is suspected in aviation disasters or other transportation incidents, the FBI lab works with the National Transportation Safety Board. The FBI lab also provides services to U.S. Immigration and Customs Enforcement, which has its own investigative power.

Successes and Failures

One of the early successes attributed to FBI forensic scientists was their role in establishing the evidence to convict Bruno Hauptmann, who was arrested in 1934 for the 1932 kidnapping and murder of the infant son of American pioneer aviator Charles A. Lindbergh. This high-profile case dramatized the efforts of the FBI lab to solve crimes through crime scene analysis and led to the passage of federal legislation that

The FBI Lab's Evidence Response Team Unit

The Federal Bureau of Investigation provides this description of its Laboratory Division's Evidence Response Team Unit.

Mission

The Evidence Response Team Unit (ERTU) enables FBI field office Evidence Response Teams (ERTs) to collect evidence supporting FBI priority investigations in a professional, competent, and systematic manner by providing ERTs with training, equipment, and forensic expertise.

The Program

The program consists of ERTs in all 56 FBI field offices. These highly trained and equipped teams, totaling about 1,200 personnel, operate at a high level of competence to ensure evidence is collected in such a manner that it can be introduced in courts throughout the U.S. and the world. ERTs strive to be the model for crime scene processing from the standpoint of safety, expertise, training, equipment, and ability.

The Work

- Provide training, crime scene equipment and supplies, and on-scene support to field ERTs and coordination for response at national and international special events.
- Provide basic forensic evidence instruction to new agents training classes and to the National Academy, as well as advanced forensic training for all field ERT personnel.
- Provide canine/handler teams to assist federal, state, and local law enforcement agencies.
- Develop new ERT software to collect and record information and print records relating to the crime scene for use in court proceedings.
- Oversee the FBI's Underwater Search and Evidence Response Team (USERT) program and the FBI's Human Scent Evidence Team (HSET). USERTs in several FBI field offices provide an underwater search capability with trained divers and sophisticated equipment to assist underwater search and recovery for evidence and human remains. The HSET is based at the ERTU and provides capability to track persons associated with certain items of evidence through the use of specially trained canines.

Lab workers perform the early stages of mitochondrial DNA extraction in the FBI's crime lab in Quantico, Virginia, in 2003, soon after the laboratory opened this $155 million forensics and evidence facility. *(AP/Wide World Photos)*

gave the FBI jurisdiction over kidnap cases that cross state lines.

During World War II, the FBI crime lab played a key role in the joint code-breaking effort of the United States and Great Britain (the Venona project), which cracked Soviet diplomatic and intelligence codes. This participation led to the FBI's pursuit of Americans operating as Soviet spies within the United States.

In 1963, when President John F. Kennedy was assassinated in Dallas, Texas, the local police department originally had jurisdiction over the investigation because no federal statute was in place that criminalized the killing of a president. The newly sworn-in president, Lyndon B. Johnson, directed the FBI to take over investigation of the assassination, however, and the FBI lab became involved in forensic examination of the evidence. Controversy regarding assertions that evidence in that case was altered or destroyed tarnished the FBI in the eyes of many and led to a number of conspiracy theories.

Despite the FBI lab's obvious successes, the pursuit of forensic science has at times suffered within the FBI because those who conduct forensic science for the agency are not considered special agents. For most of its history, the FBI has tended to favor special agents—the armed personnel who make arrests—heavily over other employees. Forensic science seemed likely to get a boost within the FBI in the late 1980's and early 1990's, as the apparent end of the Cold War reduced the threat of Soviet-inspired terrorism. During this period more than three hundred special agents transferred from counterintelligence work to work as adjuncts to local police departments, catching criminals who had crossed state lines to avoid capture—a federal offense. The post-Cold War decline in funding, however, limited the FBI's work in forensic science. The FBI lab contributed a great deal to the development of the use of DNA analysis, but the lab's fingerprint unit declined in quality. After numerous errors in fingerprint analysis were exposed and criminal cases had to be reopened, the lab faced the task of repairing its reputation for excellence.

Richard L. Wilson

Further Reading

Benedict, Jeff. *No Bone Unturned: Inside the World of a Top Forensic Scientist and His Work on America's Most Notorious Crimes and Disasters*. New York: HarperCollins, 2003. Details the diversity of the forensic science done by Dr. Douglas Owsley, who contributed to a number of FBI investigations.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005. Provides an excellent summary of forensic science for the general reader as well as a wealth of additional material.

Powers, Richard Gid. *Broken: The Troubled Past and Uncertain Future of the FBI*. New York: Free Press, 2004. Historical study of the FBI by a leading historian of national security and law enforcement. Asserts that the weaknesses of the FBI go back to the agency's beginnings.

Romerstein, Herbert, and Eric Breindel. *The Venona Secrets: Exposing Soviet Espionage and America's Traitors*. Washington, D.C.: Regnery, 2001. Uncritical work tells the story of the FBI's great success at breaking the Soviet Union's secret codes from a bygone era.

Theoharis, Athan G. *The FBI and American Democracy: A Brief Critical History*. Lawrence: University Press of Kansas, 2004. Presents a careful academic examination of the decline and failures of the FBI, especially in the era following the September 11, 2001, terrorist attacks on the United States.

Tonry, Michael, ed. *The Handbook of Crime and Punishment*. New York: Oxford University Press, 1998. Collection of essays on criminology and criminal justice policy issues includes extensive discussion of the FBI.

See also: Bullet-lead analysis; CODIS; European Network of Forensic Science Institutes; Federal Bureau of Investigation; Federal Bureau of Investigation DNA Analysis Units; Federal Bureau of Investigation Forensic Science Research and Training Center; Integrated Ballistics Identification System; Lindbergh baby kidnapping; National DNA Index System.

Federal Law Enforcement Training Center

Date: Founded on March 2, 1970

Identification: Law-enforcement partnership funded by the U.S. government and operated under the auspices of the U.S. Department of the Treasury.

Significance: The mission of the Federal Law Enforcement Training Center is to offer high-quality professional law-enforcement training at cost-efficient prices. This training center provides federal law-enforcement officers (excluding officers and agents of the Federal Bureau of Investigation) and state, local, and international police officers with a host of training courses on a variety of basic and specialty law-enforcement topics.

The Federal Law Enforcement Training Center (FLETC) was officially established on March 2, 1970. It began its operations in Washington, D.C., and in 1975 was relocated to its current headquarters in the small town of Glynco, Georgia. The creation of FLETC was the outcome of a 1968 study conducted by a federal law-enforcement interagency task force. The results of the study indicated that federal law-enforcement officers had no consistency in their formal law-enforcement training. According to the study's findings, most federal law-enforcement officers lacked the appropriate training, knowledge, and specific skill sets to do their jobs at even a minimum operational standard. In fact, until 1970, most federal law-enforcement training was conducted by part-time instructors working in dilapidated facilities; no consistent schedule of training courses was set, and no particular subject material was covered.

FLETC was created to serve as a high-quality training center for federal law-enforcement officers. Since its inception, the center has expanded its mission to include law-enforcement officers at various levels throughout the United States and abroad. FLETC has grown to offer more than two hundred training programs ranging from basic to advanced policing and investigative techniques to international courses regarding global terrorism. The center continually evaluates all of these programs through curriculum meetings and student evaluation reports to ensure that the quality of instruction remains extremely high, professional, and efficient. FLETC also offers a unique selection of courses in technical, clerical, and managerial support services to enhance the overall functioning of participating agencies.

FLETC instructors are experienced and highly trained professionals who have at least five years of law-enforcement or investigative experience. They include federal officers and investigators on assignment from their respective agencies, state and local police officers who have specialized skills in particular areas (such as fingerprint analysis or forensic investigation), and civil instructors who have training in particular fields related to law enforcement (such as hand-to-hand combat, behavioral profiling, or fraud investigation). The work of both full- and part-time faculty members is complemented by that of full-time support staff.

Events such as the 1995 bombing of the Alfred P. Murrah Federal Building in Oklahoma City and the terrorist attacks on New York City and the Pentagon of September 11, 2001, have resulted in tremendous demand at FLETC for training involving the prevention and investigation of terrorist activities. The center has thus created specific courses that focus on international and domestic terrorism.

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Further Reading

Bennett, Wayne W., and Kären M. Hess. *Criminal Investigation*. 8th ed. Belmont, Calif.: Wadsworth/Thomson Learning, 2007.

_______. *Management and Supervision in Law Enforcement*. 5th ed. Belmont, Calif.: Wadsworth/Thomson Learning, 2007.

Greene, Jack R., ed. *The Encyclopedia of Police Science*. 3d ed. New York: Routledge, 2007.

See also: Crime scene investigation; Crime scene search patterns; Criminalistics; Federal Bureau of Investigation; Federal Bureau of Investigation Forensic Science Research and Training Center; Police psychology; Training and licensing of forensic professionals.

Federal Rules of Evidence

Definition: Rules governing the admission in federal courts of the facts that litigants may use to prove their cases.

Significance: Designed to ensure that trials proceed in an orderly and predictable manner, the Federal Rules of Evidence provide guidelines for gauging the validity of scientific evidence and its admission at trial.

The rules of evidence used in U.S. courts have evolved with the jury system. Until 1975, when they were codified under the Federal Rules of Evidence, these rules existed independently in the form of judicial decisions, mandates, and separate statutes. The Federal Rules of Evidence govern procedures in the federal courts, but they are not applicable to state court proceedings. Each U.S. state has its own rules of evidence, although many states have used the federal rules as models or prototypes.

The general purpose of rules of evidence is to regulate the evidence that juries may use to reach their verdicts. The rules address some basic concepts, such as relevance, eliminating unfair surprise, efficiency, reliability, and overall fairness in the adversary process, and they also permit judges broad discretion to admit evidence or exclude evidence within certain parameters, ensuring that juries have a broad spectrum of evidence before them, but not so much that the evidence becomes cumulative, repetitive, inflammatory, or confusing.

Types of Evidence

Two basic types of evidence are recognized: direct and circumstantial. Direct evidence tends to establish the fact in question without additional proof. A fact is established based on the credibility or value of the evidence, without the need for further inference. Circumstantial evidence requires the fact finder (the jury in a jury trial, the judge in a bench trial) to make inferences or draw conclusions. For example, a person wakes up find to snow on the ground in the morning when it was clear and dry the night before; the observer did not personally see the snow falling but can infer that it snowed during the night.

Testimonial evidence is based on the testimony of witnesses; nontestimonial evidence (also called real or tangible evidence) is based on physical objects or items designed to assist the fact finder (called demonstrative evidence) such as maps or diagrams of crime scenes.

The admissibility of evidence at trial depends on the rules. The fact finder is permitted to evaluate only admissible evidence. All relevant evidence is admissible only if it is competent (legally adequate). Relevant evidence tends to prove or disprove a disputed issue. Irrelevant evidence wastes time and is often prejudicial. It may also confuse the jury. Sometimes, however, even relevant evidence can be inadmissible because its probative value is outweighed by the danger of unfair prejudice or confusion. Probative evidence tends to prove something of importance to the case. Relevant evidence that has little probative value is immaterial and should be excluded. Materiality is part of the concept of relevance under the federal rules, but it is defined as evidence that tends to make the existence of a fact more probable or less probable than it would be without the evidence.

Evidence must also be competent to be admissible. Competent witnesses must take an oath or affirm that they will testify truthfully. Nonexpert witnesses are limited to testimony about what they saw or heard personally; the opinions and conclusions of such witnesses are "incompetent." Witnesses who are experts—owing to special training, knowledge, or experience—may offer opinions and conclusions. It is for the fact finder to determine the value, if any, to be placed on the testimony of competent witnesses, lay or expert.

Admissibility of Scientific Evidence

The landmark case for the admissibility of scientific procedures and their results is *Frye v. United States* (1923). The *Frye* standard requires the trial court to determine whether the scientific theory or scientific method used to generate evidence is generally accepted as reliable in the scientific community. This has become known as the *Frye* test. After the Federal Rules of Evidence were adopted in 1975, Rule 702 stated that expert witnesses may testify in the form of opinion if their specialized knowledge will help the jury to understand the evidence or determine a disputed fact. Although Rule 702 relaxed the stringent *Frye* standard, it gave little guidance as to what would be helpful to the fact finder.

In its 1993 decision in the case of *Daubert v. Merrell Dow Pharmaceuticals*, the U.S. Supreme Court agreed that the trial court has a gatekeeper function: to make sure that admitted scientific evidence and expert testimony are reliable and relevant. *Daubert* set out a checklist for trial courts to use in assessing the reliability of scientific expert testimony, suggesting factors such as standards and controls, testing, peer review, error rate, and acceptability that could be helpful in determining the reliability of a scientific theory or technique. During the early twenty-first century, more state courts use the *Daubert* test for admissibility of scientific evidence; federal courts use both Rule 702 and *Daubert*.

In 2000, Rule 702 was amended in response to *Daubert* and *Kumho Tire Company v. Carmichael*, a 1999 Supreme Court decision. The amendment affirms the trial court's role as gatekeeper and provides general standards that the trial court must use to assess the reliability and helpfulness of expert testimony.

Character Evidence

Character is a collection of traits and features that make up a person's disposition or nature, evidenced by a consistent pattern of behavior. Character traits include honesty,

Federal Rules of Evidence, Rule 702: Testimony by Experts

If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise, if (1) the testimony is based upon sufficient facts or data, (2) the testimony is the product of reliable principles and methods, and (3) the witness has applied the principles and methods reliably to the facts of the case.

courage, and integrity as well as such negative traits as dishonesty, violence, and recklessness. In criminal cases, character evidence is generally inadmissible to prove conduct to show that a person acted in conformity with a particular character trait on a particular occasion. The prosecution is not permitted to introduce evidence of the defendant's bad character, such as violent tendencies, but the defense has the option to introduce evidence of good character, such as honesty.

If the defense elects to introduce a character witness to testify about the defendant's good character, this is said to "open the door" for the prosecution to provide rebuttal evidence. If the defense does not choose to introduce a character witness, the prosecution may not comment on that fact to the jury.

Hearsay Evidence

Hearsay is defined in rule 801(c) of the Federal Rules of Evidence as "a statement, other than one made by the declarant while testifying at the trial or hearing, offered in evidence to prove the truth of the matter asserted." It is excluded because the witness is not testifying from personal knowledge but from repetition of what was said or written outside court by another person who is not present, offered for the purpose of establishing the truth. The out-of-court declarant may have been lying, joking, or speaking carelessly, and the opposing side has no opportunity to cross-examine the declarant to impeach or test that person's credibility. Additionally, given that the statement was made out of court, the demeanor of the declarant could not be observed by the fact finder. Alternatively, the testifying witness may have a faulty memory, poor hearing, or another infirmity. The exclusion of hearsay testimony prevents unreliable evidence from being considered. It should be noted that statements that otherwise would qualify as hearsay are admissible if they are introduced not to prove the truth of the matter asserted but merely to show that a statement was made.

Numerous exceptions to the hearsay rule exist, making otherwise inadmissible hearsay evidence reliable and admissible. These exceptions often involve surrounding circumstances that ensure the reliability of the evidence.

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Further Reading

Broun, Kenneth S., ed. *McCormick on Evidence*. 6th ed. St. Paul, Minn.: Thomson/West, 2006. Considered to be the bible of the law of evidence. Contains detailed explanations and case references.

Graham, Michael H. *Federal Rules of Evidence in a Nutshell*. 7th ed. St. Paul, Minn.: West, 2007. Provides a concise summary of the Federal Rules of Evidence; useful as a reference tool.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005. Illustrated introductory text presents a clear overview of the subject. Includes several chapters devoted to legal issues in forensic science.

Pellicciotti, Joseph M. *Handbook of Basic Trial Evidence: A College Introduction*. Bristol, Ind.: Wyndham Hall Press, 1992. Comprehensive yet concise text outlines the rules of evidence and provides examples.

Stopp, Margaret T. *Evidence Law in the Trial Process*. Albany, N.Y.: West/Delmar, 1999. Discusses the rules of evidence and clarifies them with examples, explanations, and case excerpts.

See also: Chain of custody; Courts and forensic evidence; *Daubert v. Merrell Dow Pharmaceuticals*; Direct versus circumstantial evidence; Drug and alcohol evidence rules; Expert witnesses; *Frye v. United States*; Legal competency.

Fibers and filaments

Definition: Threads and threadlike textile materials of natural or human-made origins.

Significance: Fibers and filaments are often among the trace evidence samples collected at crime scenes and from crime victims and potential suspects. Because fibers and filaments are easily transferred from objects to persons, from persons to objects, and from persons to persons, the analysis of such materials found in relation to crimes can provide investigators with important information.

The forensic analysis of fibers and filaments has been practiced for more than a century. Forensic scientists define a fiber as the smallest unit of a textile material that has a large length-to-diameter ratio. Based on length, fibers may be classified as either staple fibers or filaments. "Filament" is the term used to refer to a fiber with indefinite or extreme length; many synthetic fibers and some wool fibers are classified as filaments.

Fibers and filaments can be left at crime scenes in a variety of ways. In sexual assault and homicide cases, for example, cross-transfer of fibers often occurs through personal contact between suspect and victim. In a burglary, fibers from the perpetrator's clothes may be caught on window screens, furniture, or broken glass. When fibers recovered from a crime scene are analyzed, they can often place particular persons at the scene and serve to corroborate other evidence gathered during the course of the investigation.

Plant Fiber Identification

Forensic investigators collect fibers at crime scenes using tape, forceps, and vacuums. The sources of the fibers collected may be such items as clothing, blankets, carpeting, wigs, and furniture upholstery. The fibers are then separated in the laboratory into natural, manufactured, and mixed types.

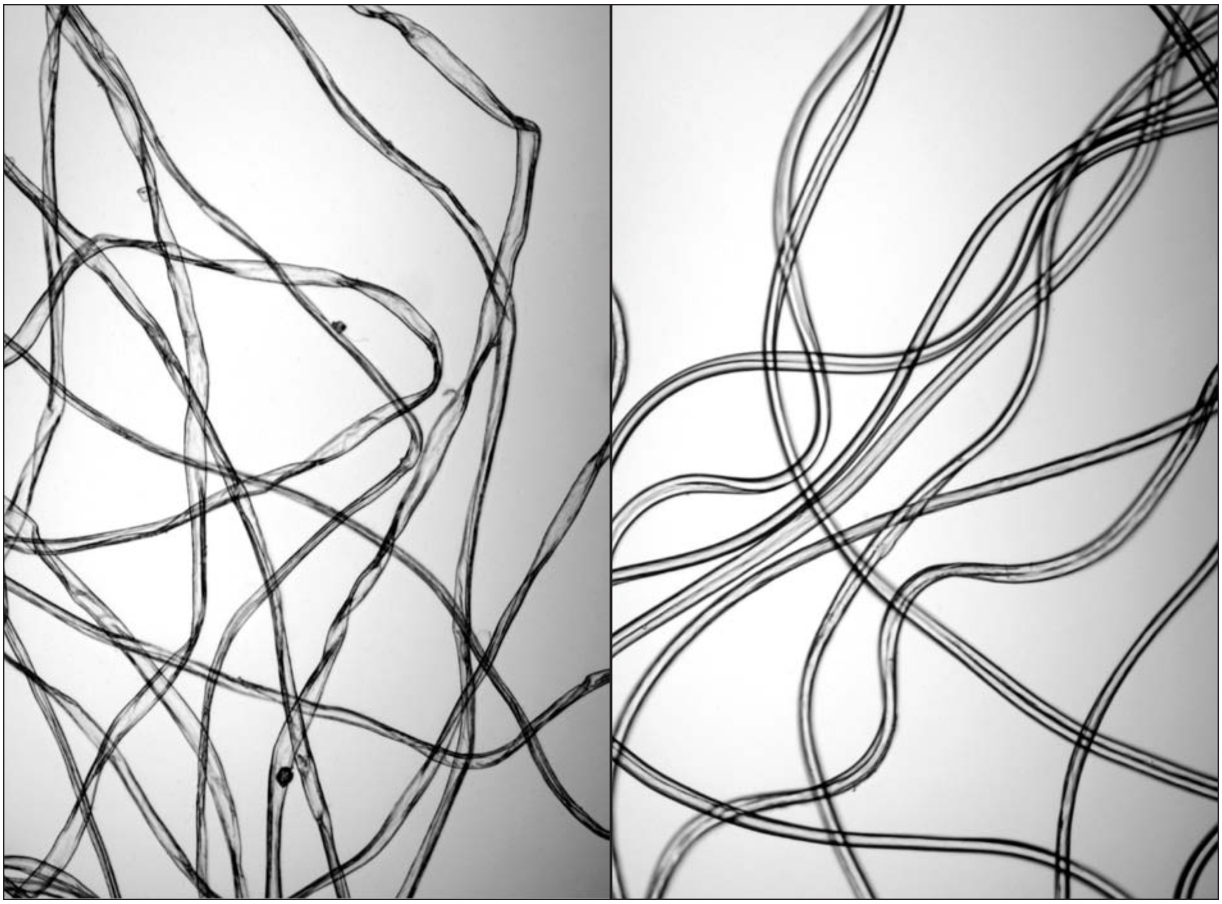
Natural fibers are those that have their origins in plants (such as cotton), animals (such as wool), or minerals (such as asbestos). During the analysis of natural fibers, the scientist seeks to distinguish the materials' plant, animal, or mineral origins. In general, microscopic examination is conducted; the scientist looks at both a cross section of each fiber and its outer length. When further analysis is needed to determine a fiber's origin and identity, burning and solubility tests are employed. Sometimes, color tests using special stains are also conducted. These color tests require the stripping of dyes and the use of differential stains; the instruments used to analyze the results are more sophisticated than those needed for other fiber tests.

Plant fibers are subdivided into three broad categories, depending on which part of the plant is the source of the fiber. Seed fibers include cotton, kapok, and coir; stem fibers, also called bast fibers, include flex and hemp; and leaf fibers include manila and sisal. Cotton fibers are by far the most common in the textile industry. Under a light microscope, cotton fibers look like twisted, flattened tubes, very irregular in appearance; these fibers remain bright in appearance in all orientations. Mercerized cotton appears somewhat featureless and less twisted, but the irregular form remains.

Less common plant fibers include flax (linen), ramie, sisal, jute, hemp, kapok, and coir. Each of these fibers has unique characteristics that are visible under the microscope; variations in size, directions of twist, ridges and striations, and other markings allow forensic scientists to identify individual types of fibers.

Animal Fiber Identification

Animal fibers, which are made up primarily of proteins, can be divided into three subgroups on the basis of protein composition and utilization: silk, wool, and hair fibers. Silk contains



Using a microscope, a forensic scientist can differentiate among different kinds of fibers. For example, cotton fibers (left) typically appear as twisted, flattened tubes, very irregular in appearance, whereas acrylic fibers (right), which are human-made, appear smooth and relatively uniform. *(© iStockphoto.com/Nancy Nehring)*

primarily fibroin and thus dissolves when placed in concentrated hydrochloric acid. When subjected to flame, silk fibers emit an odor similar to that of burning hair. Raw silk contains sericin, a globular protein, which is usually removed during the process through which silk yarn is produced for use in the textile industry. Like different kinds of plant fibers, various types of silk have different appearances under the microscope, enabling forensic scientists to distinguish among them.

The principal protein in wool is keratin. Raw wool typically contains substantial amounts of impurities, including soil, grease, sweat, and other organic matter. Clean wool, or pure keratin, is obtained through a scouring process by which raw wool is washed and the impurities removed. The most common wool fibers originate from sheep; other wool fibers come from goats (such as cashmere and mohair) and from camels. Each of these kinds of fibers displays unique characteristics of texture, color, and size under the microscope.

Human-Made Fibers

In the United States, more than 50 percent of the fibers used in fabrics are synthetic materials. Some human-made fibers are derived from natural materials, such as cotton and wood, whereas others originate exclusively from synthetic materials. In the manufacture of synthetic fibers, liquefied fiber-forming materials (natural or synthetic or a combination of the two) are forced through holes into the air so that they form threads. Whereas natural fibers viewed under the microscope often display rough external surfaces, human-made fibers appear smooth and more uniform, and some may have long extrusion lines on the surface.

Manufactured artificial fibers are traditionally made from cellulose of plant origin, whereas synthetic fibers are made exclusively from synthesized polymers. Widely used artificial fibers include viscose rayon and cellulose acetate. Viscose rayon is a cellulosic fiber regenerated through manufacturing processes to imitate the feel and texture of silk, wool, or cotton. Rayon fibers are naturally very bright and can be dyed easily; under the microscope, they display lengthwise striations and an indented circular cross section. Cellulose acetate is the acetate ester of cellulose made from cotton or tree pulp. The fiber has good draping qualities, dries fast, and resists shrinking, wrinkling, and mildew. Acetate fibers have a luxurious feel and appearance and range widely in color and luster.

The most common synthetic fibers are nylon and polyester. "Nylon" is a general term for a family of synthetic polymers designed originally as a synthetic replacement for silk. Nylon fibers are often used in fabrics, carpets, ropes, and even the strings of musical instruments. The cross sections of nylon fibers may be manufacturer-specific. Many forms of polyesters are in existence, including plant-based cutin and synthetic polyesters such as polycarbonate and polybutyrate. The term "polyester" is most commonly used to refer to polyethylene terephthalate. Polyester has been the most widely produced synthetic fiber since 1970.

Value of Fiber Evidence

The value of fiber evidence to criminal investigations varies widely, depending on the numbers, locations, and characteristics of the fibers recovered. Because of the diversity and considerable variations in fibers and filaments, they are considered "class" evidence—that is, identification using such evidence is based on probability, not certainty. As class evidence, fiber evidence alone is not enough for conviction. Identification of a suspect through such evidence must be corroborated by other evidence to present a strong prosecution case.

The amount of a particular fiber produced and included in end products determines the degree of rarity of that fiber and, often, its usefulness in a forensic investigation. The rarer the fiber, the higher the value if a match occurs between a crime scene sample and a sample taken from a suspect. The shape of a fiber can determine the value placed on that fiber as well, because the cross section of a fiber can be manufacturer-specific. Some cross sections are more common than others, and some shapes may be produced only in small quantities or for short periods of time. Unique or rare cross sections discovered in analysis can have increased significance for fiber association.

Other factors that affect the value of fiber evidence include color, the number of fibers collected, and the specific locations in which fibers are recovered. How stains are applied and absorbed along the length of a fiber provides an important characteristic for comparison during examination. The greater the number of fibers found on the victim or at the crime scene that match the suspect's clothing, the stronger the argument that physical contact occurred. The recovery of fibers from specific locations on a victim's body may be a significant indicator of the nature of a crime.

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Further Reading

Blackledge, Robert D., ed. *Forensic Analysis on the Cutting Edge: New Methods for Trace Evidence Analysis*. Hoboken, N.J.: John Wiley & Sons, 2007. Collection of essays on forensic methods focuses on advances in technology and includes discussion of fiber analysis.

Houck, Max M. *Forensic Science: Modern Methods of Solving Crime*. Westport, Conn.: Praeger, 2007. Includes a chapter on trace evidence that presents answers to many common questions about fiber analysis in criminal investigations.

Houck, Max M., and Jay A. Siegel. *Fundamentals of Forensic Science*. Burlington, Mass.: Elsevier Academic Press, 2006. Good general textbook includes chapters on hair examination and analysis of textile fibers.

Nickell, Joe, and John F. Fischer. *Crime Science: Methods of Forensic Detection*. Lexington: University Press of Kentucky, 1999. Comprehensive volume provides a practical and informative case study at the end of each chapter.

Robertson, James, and Michael Grieve, eds. *Forensic Examination of Fibres*. 2d ed. Philadelphia: Taylor & Francis, 1999. Presents a thorough, easily understood description of forensic fiber analysis.

Trimm, Harold H. *Forensics the Easy Way*. Hauppauge, N.Y.: Barron's, 2005. Includes a chapter that provides a good introduction to the topic of fiber analysis in clear language accessible to the general reader.

See also: Class versus individual evidence; Confocal microscopy; Crime scene investigation; Fracture matching; Hair analysis; Lasers; Micro-Fourier transform infrared spectrometry; Microscopes; Microspectrophotometry; Scanning electron microscopy; Tape; Trace and transfer evidence.

Fingerprints

Definition: Impressions made when fingertips come into contact with surfaces.

Significance: Because each person's fingerprints are unique, positive identification of unknown persons can be achieved through fingerprint analysis. Law-enforcement agencies often rely on fingerprinting to identify the persons involved in crimes, both victims and suspects.

The patterns of tiny ridges and valleys that appear on the fingertips and toes of human beings are unique to each individual. These fingerprints and toe prints are formed on a fetus around the fourth month of gestation and remain unchanged throughout the individual's lifetime. They do not change with age—the print patterns of a one-hundred-year-old person are identical to those that person had in the womb and at birth. Even identical twins do not share identical fingerprints and toe prints, although they may possess ones that are notably similar. If fingerprints are temporarily altered through some sort of accidental trauma or through calculated procedures intended to obliterate them, the body repairs them, and within a short time new prints identical to the original prints are formed. It is the uniqueness of such prints that makes them indispensable tools in law-enforcement investigations.

Immediately below the surface of the skin of the fingertips, on which patterns of ridges and valleys appear, are sweat glands from which small concentrations of skin oils are expelled through the pores. This sweat is composed mostly of water, but about 1.5 percent of it contains a combination of salts and various chemicals that the body produces. When a person's fingertips touch a surface, fingerprints formed by this sweat are left behind. The water in the sweat evaporates quickly, but a slight residue of salts and chemicals remains on whatever is touched. (It should be noted that, in contrast with the fingerprints of adults, those of young children often disappear almost instantly, for reasons that are not fully understood.)

Early Uses of Fingerprints

Fingerprints have been used as means of identification from the earliest recorded times. Egyptologists exploring artifacts dating back four thousand years, to the times of the pharaohs, have found that artisans working in clay often marked their work with their thumbprints before the clay was fired. On some occasions, an artisan would place an entire handprint on the soft surface of a pot about to be fired. Fingerprints and handprints were used as means of identification in China more than two thousand years ago, when a largely illiterate population accepted such marks as substitutes for written signatures on legal documents.

It was recognized in early cultures that no two people bore the same fingerprints, even though the classification of types of fingerprints probably did not occur until the late seventeenth or early eighteenth century, when an English plant morphologist, Nehemiah Grew, recognized the ridge patterns in fingerprints and announced his findings accompanied by remarkably detailed drawings of a variety of such patterns. In 1823, Jan Evangelista Pur-

The technique used to record human fingerprints has not changed much since this photograph was taken during the early 1930's. Ink is placed on the person's fingers and, with a rolling motion, an impression of each finger is made on a fingerprint card. *(Library of Congress)*

kyně, a Bohemian physiologist, wrote a lengthy paper in which he described in depth a number of friction ridge patterns found in a variety of fingerprints. A nineteenth century British book illustrator, Thomas Bewick, used finger- or thumbprints in works that he published as reliable means of identification.

William James Herschel, a British colonial working in India in the mid-nineteenth century, made extensive use of fingerprints to identify the people with whom he was working and to prevent them from receiving multiple benefits by simply appearing and claiming them. Once they signed in by providing their fingerprints, it was easily determined who they were and whether they had received what was due them. Henry Faulds, a Scottish physician working in India, became fascinated by fingerprints and corresponded with Charles Darwin, the evolutionist, about their uniqueness, suggesting that they might be used effectively in the investigation of crimes. A similar suggestion was made by Thomas Taylor of the U.S. Department of Agriculture, who published an article in which he contended that fingerprints and palm prints might be useful in identifying criminals.

After English scientist Francis Galton grew interested in the Faulds-Darwin correspondence about fingerprints, Herschel shared with Galton some of his material on fingerprints. In 1892, Galton published *Finger Prints*, which became a classic in its field. In this book, Galton presented exhaustive evidence that every fingerprint of every individual is unique and asserted that the ridge patterns on a person's fingers do not change throughout a lifetime.

Edward R. Henry, a British official who served as the inspector general of police for the Indian province of Bengal in the late nineteenth century, read Galton's book and soon began a correspondence with Galton, who shared with him much of the material he had obtained through his contacts with Herschel, Faulds, and Darwin. Henry devised a system of classifying and analyzing fingerprints that was widely used in colonial India and in Great Britain. Henry's book *Classification and Uses of Finger Prints*, published by the Indian government in 1897, became, like Galton's earlier book, a landmark in its field.

The earliest official use of fingerprints in the United States occurred in 1903, when New York City's civil service fingerprinted those taking civil service tests to ensure that those appearing to take the tests were the people they claimed to be. At about the same time, various law-enforcement agencies began using fingerprints to identify criminal suspects.

Three Major Types of Fingerprints

Law-enforcement investigators are generally concerned with three types of fingerprints found at crime scenes: latent, visible, and plas-

The AFIS Process

An automated fingerprint identification system (AFIS) enables the matching of fingerprints to those in a network's database. By using AFIS technology, fingerprint analysts can substantially reduce the amount of time involved in matching prints and also increase significantly the accuracy of such matches.

The AFIS process begins with the enlargement of the questioned fingerprint image; the enlarged image is then traced by hand in order to establish the minutiae/relational data that will serve as reference points used by the system to match prints. The image is then returned to its normal size and fed into the database, and the AFIS software compares it with the other fingerprints, often more than a million, on file in the database. Without automation, this process would take so long—days or weeks—that it would be impractical to employ it. Also, given the human fatigue factor, the results would be of questionable accuracy.

Using AFIS technology, the time it takes to match prints in a database with a given set of questioned prints is usually less than ten minutes, and the degree of accuracy in making a match is dramatically increased. The computer, which assigns a percentage of probability to each match generated by this process, usually registers upward of an 85 percent probability, making it almost certain that an accurate match has been made. At this stage in the process, a well-trained professional print examiner verifies what the computer has suggested, so that the final determination regarding a match is in the hands of someone trained specifically to make such a judgment.

tic prints. A latent print is one that is hardly visible. It may be incomplete—that is, only part of the finger has left behind an impression that can be lifted for purposes of identification. Although identifications are made most easily when full sets of fingerprints are available, many crime scenes do not provide investigators with that sort of evidence.

Visible prints are those that are easily seen without magnification because they are left on surfaces that are dusty or in such media as blood, damp paint, or grease with which the fingers have come into direct contact. Plastic prints are those left on soft surfaces such as unfired clay, putty, or cookie dough. Like visible prints, plastic prints are easily visible without magnification.

Latent fingerprints are the most difficult for crime scene technicians to collect for analysis. Just a little more than 98 percent of such prints is composed of water; the small amount that is not water, about 1.5 percent, consists of sugars, proteins, and fatty acids, the total mass of which is negligible, making the prints difficult to detect. With advances in forensic science, sophisticated lasers and chemical treatments have been developed to detect such prints, some of which may have undergone considerable degradation shortly after they were deposited on the surfaces where they are found. It is of the utmost importance that such prints be collected as quickly as possible, before they have degraded to the point that their validity is compromised.

In the United States, most law-enforcement crime scene units are now equipped with portable alternate light source (ALS) kits that are used to detect, through fluorescence, latent prints left at crime scenes. Many such prints are now recovered that in the past would have gone unnoticed.

Collecting Fingerprints

Fingerprints are most reliable when they have been gathered soon enough after their discovery that degradation has not advanced significantly. When latent prints are barely detectable on an object, such as a gun, the prints can sometimes be made much more visible in the crime lab through exposure to the vapors of chemical compounds generally called cyanoacrylates (the main ingredients in superglue). The object is placed in a sealed metal box and subjected to the fumes. This method is also used on objects that have no visible prints but may possibly have been touched by someone at the crime scene.

Crime scene technicians also collect latent prints by brushing surfaces with powders containing chemicals that stick to the surface and present sharp contrasts between the ridges and valleys of the prints. Such prints are then lifted with a specially designed tape and placed on cards for transportation to the lab for analysis.

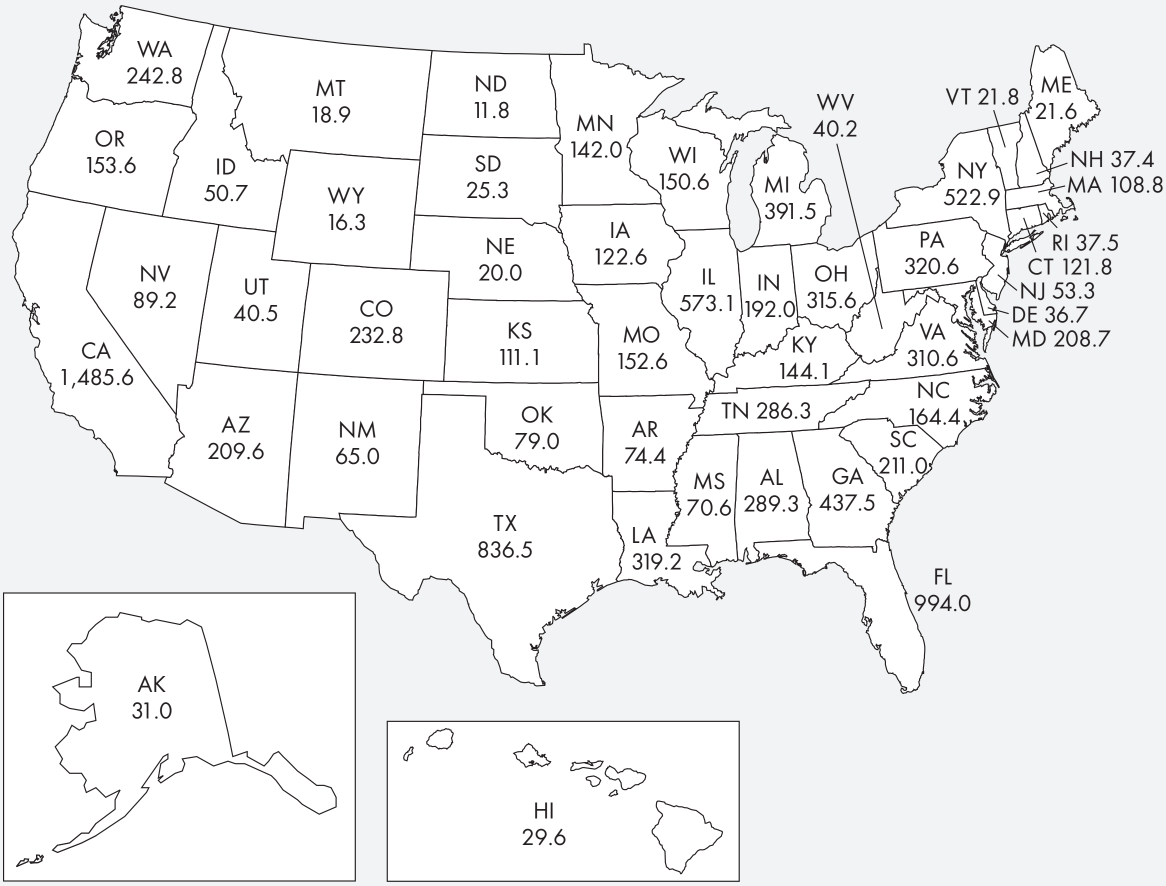
In cases where latent prints are wet, they are often treated with a small particle reagent (SPR) that clings to the lipid residues of salts and chemicals found in fingerprints. Iodine, slightly heated, produces vapors that can make latent prints visible, but this technique is not used very widely because the resulting prints disappear quickly. If they are not photographed at once, they become unusable.

Prints visible to the naked eye are generally photographed and then entered into computerized databases, where they are compared with existing prints that are on file and are then stored for future reference. Plastic prints, which are similarly easy to see without magnification or special chemical treatment, are also photographed for analysis.

Major Classifications and Distribution of Fingerprints

Most of the fingerprints on record fall into the three different categories that Henry identified toward the end of the nineteenth century: the arch, the loop, and the whorl. To these three general classifications, which Henry divided into subgroups such as the plain or tented arch, the plain loop, the central pocket loop, and the double loop, Henry added a fourth classification, the composite, which has the combined

Arrestee Fingerprint Cards Recorded in 2003 (in thousands)



Source: U.S. Bureau of Justice Statistics, *Survey of State Criminal History Information Systems, 2003*, 2006.

features of all of the other types. The most common of the patterns is the loop. The prints of between 60 and 65 percent of people fall into this category, with another 30 to 35 percent having the whorl pattern. The least common pattern, the arch, is found in approximately 5 percent of the world's population.

For purposes of classification, Henry devised a system that is still in general use by law-enforcement agencies. In a set of ten prints from one person, each print is designated as being from the right or left hand, using the letters *R* and *L*, and is further designated using the letter *p* to identify the small or pinky finger (*Rp* or *Lp*), *r* to identify the ring finger, *m* to identify the middle finger, *i* to identify the index finger, and *t* to identify the thumb.

Examining Minutiae

The uniqueness of fingerprints is attributable to varying ridge characteristics. Fingerprint analysts note the number and types of these characteristics as well as their positions relative to other ridge characteristics. Through careful study of these characteristics, referred to as minutiae, analysts determine what makes individual fingerprints unique and differentiate among prints that closely resemble one another.

Particular types of minutiae that analysts observe include bifurcations, or ridges that divide at some point; delta or triangulated ridges, which resemble the Greek letter for which they are named; lakes, or groups of ridges that divide and then rejoin to form what resemble lakes in their centers; spurs, or ridges that jut out from the main ridge line; and crossovers, or ridges that connect to other ridge lines.

Fingerprint Identification

Law-enforcement investigators often identify individuals based on archived sets of fingerprints that have been obtained previously by law-enforcement or other authorities. In making such a set of fingerprints—ten prints, five from each hand—ink is placed on the person's fingers and, with a rolling motion, an impression of each finger is made on a fingerprint card. Various law-enforcement agencies and other organizations maintain massive databases of such archived fingerprints for purposes of identification. In criminal cases, fingerprints from crime scenes, suspects, and victims are compared against the prints in these databases. Anyone who is arrested in the United States is fingerprinted, and sets of all arrestees' prints are added to the Integrated Automated Fingerprint Identification System (IAFIS), the national fingerprint database maintained by the Federal Bureau of Investigation (FBI). Sometimes just part of a single print is available, but even such a minimal impression can be compared with the millions of archived sets in the FBI database. The FBI has estimated that approximately three thousand fugitives are identified each month through IAFIS.

In addition to the routine use of fingerprint identification by law-enforcement agencies in criminal cases, fingerprint comparisons are increasingly being employed to screen persons seeking entry to areas where security is essential. Fingerprints are also used to identify victims of highway and airplane accidents, in which sometimes only fragmentary remains are available for examination.

Training

With advances in technology and increasing emphasis on national security, given the rise in terrorism worldwide, the need for fingerprint analysts in the United States has soared in both the private and public sectors. In addition to the need for trained analysts, police officers in jurisdictions ranging from small towns and villages to huge metropolitan areas need special training in the detection, collection, and preservation of fingerprints.

The FBI is a major provider of training in all areas related to fingerprints. Local police officers who are trained at the FBI Laboratory or similar venues generally become instructors in fingerprinting techniques when they return to their local police departments. They are trained specifically not only in how to preserve crime scenes so that viable fingerprint evidence can be collected but also in how best to obtain fingerprints, particularly the latent prints that are so important in building legal cases against criminal suspects. Police officers must be able to determine the most effective means of gathering fingerprints that will allow prosecutors to introduce the prints as evidence in courts of law.

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Further Reading

Baden, Michael, and Marion Roach. *Dead Reckoning: The New Science of Catching Killers*. New York: Simon & Schuster, 2001. Presents detailed information on the modern forensic methods used to track down criminals, including fingerprint verification through the use of sophisticated electronic identification document readers.

Bell, Suzanne. *Encyclopedia of Forensic Science*. New York: Facts On File, 2004. Comprehensive, well-illustrated overview of all the significant components of forensic science includes discussion of fingerprinting.

Cole, Simon A. *Suspect Identities: A History of Fingerprinting and Criminal Identification*. Cambridge, Mass.: Harvard University Press, 2001. Excellent resource provides thorough information on the historical aspects of the uses and validity of fingerprints in the criminal justice system.

Conklin, Barbara Gardner, Robert Gardner, and Dennis Shortelle. *Encyclopedia of Forensic Science: A Compendium of Detective Fact and Fiction*. Westport, Conn.: Oryx Press, 2002. Presents one of the best succinct discussions of the topic of fingerprinting available. Includes excellent illustrations.

Lee, Henry C., and R. E. Gaensslen, eds. *Advances in Fingerprint Technology*. 2d ed. Boca Raton, Fla.: CRC Press, 2001. Collection of essays by experts in the field covers every aspect of fingerprint technology. Includes informative illustrations.

Pentland, Peter, and Pennie Stoyles. *Forensic Science*. Philadelphia: Chelsea House Publishers, 2003. Presents a brief discussion of fingerprinting with informative illustrations. Intended for young adult readers.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007. Textbook provides good coverage of the topic of fingerprinting, including the various methods of collecting prints.

See also: Ballistic fingerprints; Biometric identification systems; DNA fingerprinting; Ear prints; Integrated Automated Fingerprint Identification System; Prints; September 11, 2001, victim identification; Sinus prints; Superglue fuming.

Fire debris

Definition: Materials that have been partially or completely burned in fires.

Significance: Fire debris is often the most valuable evidence at a fire scene. The analysis of fire debris evidence is used in fire investigations to help determine the causes and origins of fires. The results of the analysis of fire debris may indicate whether a fire was intentionally set or accidental.

Enormous amounts of debris are typically found at fire scenes. In an intense fire, the bulk of a structure can be reduced to soot and ashes. Sifting through such debris is a daunting task for fire investigators, but the work is worth the effort because the results of fire debris analysis often play a critical role in determining the cause and origin of a fire.

At the Fire Scene

One of the primary goals of a fire investigation is to identify exactly how the fire started. In many cases, fires are accidental, caused by electrical problems, gas leaks, or even lightning damage. In other cases, however, fires are set intentionally by people with malicious intent. Often the presence of an accelerant (a substance used intentionally to increase the rate and spread of a fire) indicates that a fire was purposely set. Accelerant residue is most likely to be found in the area where the fire started, or the origin.

A visual examination of the fire debris is typically the first step the investigator takes. By assessing the direction and intensity of the burn patterns, the investigator can identify the fire's origin. A classic V-shaped pattern is often seen, as fires tend to burn in a tight area at the base and then spread as they move upward or away from the source. The V points back to the source of ignition, potentially an accelerant pool. Another typical burn pattern is known as a "trailer" or pour pattern. Arsonists often pour accelerant in a constant stream from room to room in an attempt to guarantee that the fire will spread throughout the entire structure.

Visual examinations of fire debris, however, are subjective in nature, as they rely primarily on the experience of individual fire investigators. Also, the damage may be too extreme for an investigator to identify burn patterns, or the patterns that are present may be misleading. Tools are available to assist investigators in the analysis of debris at a fire scene. Portable "sniffer" instruments are commercially available for the detection of hydrocarbon and organic vapors in the air. The air around the area suspected to contain an accelerant is drawn into the instrument, where any accelerant vapors are detected. These sniffers are sensitive but not selective. Many common household items emit hydrocarbon vapors when burned, and these may be identified by the sniffer. Another method of accelerant detection that is becoming increasingly popular is the use of trained dogs to sniff out accelerant odors. These dogs, known as accelerant-detection canines, undergo rigorous training and are less prone to incorrect identifications than are sniffing instruments.

Evidence Collection

After the origin of a fire has been determined, investigators can begin to collect evidence to be taken to the forensics laboratory for further analysis. Debris is typically collected from several locations within the fire scene using everyday garden tools. If an area of heavy accelerant use has been identified, multiple types of debris from that area are collected. Most likely to contain traces of accelerant are porous surfaces, because accelerants can soak into them and be protected from the heat of the fire.

Different types of debris should be collected separately, even if they are from the same area. If several points of origin or areas of accelerant use are identified, representative debris samples should be collected from each area. In addition to debris from the areas suspected to contain accelerant residue, similar samples of debris that are not suspected to contain accelerant residue should be taken. These control samples are necessary to prove that any accelerant residue detected is not an inherent component in the debris material itself.

Fire debris evidence should be collected and stored in airtight containers. The majority of accelerants that may be present contain volatile components that may be lost in an unsealed environment. The preferred collection receptacle is an unused metal paint can with a friction lid. Glass jars are also acceptable, but only if they have airtight lids. Plastic containers should be avoided. As debris samples are collected, each container should be filled only about halfway,

A Pennsylvania State Police fire investigator collects debris for laboratory analysis near a mobile home destroyed by a suspicious fire in South Connellsville. *(AP/Wide World Photos)* leaving an area above the sample empty. This space, known as the headspace, is needed for some extraction techniques used in the laboratory. Samples that are too large for the available containers should be cut and placed in several different containers. After the evidence has been collected, the containers should be stored in a temperature-regulated area to ensure that no volatile components evaporate.

Laboratory Analysis

In the laboratory, the samples are subjected to the standard procedures in place for fire debris analysis. Conventional techniques are used to extract residual accelerants from the debris. The choice of extraction procedure depends on the type of debris and on the potential accelerant used. Gas chromatography coupled with mass spectrometry (GC-MS) is the standard analytical technique used for fire debris. The pattern of peaks present in the chromatogram and the chemical information available from the mass spectrum will help investigators to determine whether an accelerant, or any other significant component, is present in the fire debris.

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Further Reading

Almirall, José R., and Kenneth G. Furton, eds. *Analysis and Interpretation of Fire Scene Evidence*. Boca Raton, Fla.: CRC Press, 2004. Provides information about fire scene investigation and the chemical analysis of fire debris.

DeHaan, John D. *Kirk's Fire Investigation*. 6th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007. Covers the physical nature and chemistry of fire and also discusses the various types of fires.

Nic Daéid, Niamh, ed. *Fire Investigation*. Boca Raton, Fla.: CRC Press, 2004. Compilation of material on the basics of fire investigation includes discussion of laboratory reconstruction and analytical techniques.

Redsicker, David R., and John J. O'Connor. *Practical Fire and Arson Investigation*. 2d ed. Boca Raton, Fla.: CRC Press, 1997. Details the various undertakings of fire investigators, from scene investigation to courtroom testimony.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007. Textbook discusses all subdisciplines within forensic science, including fire investigation.

See also: Accelerants; Arson; Bureau of Alcohol, Tobacco, Firearms and Explosives; Burn pattern analysis; Gas chromatography; Mass spectrometry; National Church Arson Task Force; Quality control of evidence; Spectroscopy.

Firearms analysis

Definition: Examination of bullets, cartridge cases, and firearms marks as well as identification and functionality testing of firearms.

Significance: Firearms may be used in crimes in a wide variety of ways, and law-enforcement investigations involving firearms must examine a wide range of forensic evidence. Because the use of firearms varies so much from crime to crime, methods of firearms analysis also vary, with investigators and forensic experts relying on a mixture of chemistry, physics, and technology to conduct their examinations.

The field of forensic firearms analysis has grown from the traditional study of ballistics to include detailed analysis relying on the fields of chemistry, physics, engineering, mathematics, and other traditional disciplines. The very nature of modern firearms, along with the varied ways in which firearms are used in criminal activities, means that firearms analysis requires a high level of expertise.

Early firearms analysis focused primarily on the identification of bullets, cartridge cases, and firearms marks. One of the more famous cases that relied on bullet identification took place during the U.S. Civil War, after Confederate general Stonewall Jackson was shot returning to his camp after a battle. The wound resulted in Jackson's death a little more than a week later.

The director of the Los Angeles County Sheriff's Department crime lab looks at his lab's new state-of-the-art bullet recovery tank in early 2007. Analysts discharge firearms into the water-filled tank, from which undamaged bullets can be recovered for comparisons with bullets fired at crime scenes. *(AP/Wide World Photos)*

Experts were called to examine the recovered projectile and, after careful analysis, determined that the bullet—based on its size and shape—was not the same as the type used by the Union Army. This likely meant that Jackson was shot not by an enemy soldier but instead by one of his own troops.

Ballistics and Firearms Identification

The term "ballistics" refers to the study of the motion, behavior, and effects of projectiles. This includes bullets, aerial bombs, rockets, and other projectiles. Most commonly, the term is applied to the science and art of accurately sending a projectile through the air to achieve a desired performance. As used by forensic analysts, "ballistics" refers to the study of projectiles to determine their origin as well as their use and implementation.

Firearms identification is closely associated with ballistics, as both focus on the nature of the projectile as well as the method for sending it through the air. The major categories in firearms identification include types of firearms, manufacturing techniques, design, construction, and function. A common task for law-enforcement investigators following a criminal act involving a firearm is the recovery of the projectiles fired, with the aim of matching them to the firearm that fired them.

Firearms Types and Ammunition

The type of firearm and the specific ammunition chosen for a criminal act are often important factors in the investigation. Certain firearms, such as pistols, can be easily concealed and are used when stealth or convenience is required. Rifles and shotguns present very different usage parameters and so are typically related to specific types of crimes. The identification of the types of firearms used is important in the investigation of crimes such as robbery and murder.

"Ammunition" generally refers to the method and type of projectile in question. Modern firearms rely on a cartridge system, which brings bullet, gunpowder, and sparking mechanism together into a single unit that can be easily loaded for quick use. Firearms analysis focuses on the individual components as well as their use. Experts in bullet and cartridge case identification focus on size, shape, weight, and manufacturer marks to help identify evidence related to crime involving firearms.

Collection and Analysis of Firearms Evidence

Crime scene technicians are responsible for the location and recovery of projectiles used in firearms-related cases. The methods for recovering both fired bullets and spent cartridges vary depending on the nature of the crime and crime scene conditions. The focus in recovering a fired bullet is often on recovering the evidence in a manner that will least affect its condition.

Forensic analysts traditionally work in laboratories or other secured facilities when examining firearms, bullets, cartridges, and other firearms-related evidence. A common task is the comparison of bullets or firearm parts to determine the likelihood of match with a suspect firearm. Modern pistols and rifles have grooves cut inside their barrels to help control the accuracy of fired projectiles. This means that for many modern firearms, the interaction of a fired bullet with the barrel of the gun often leaves distinct markings that can be used to match the bullet with the gun.

Another matching technique uses the impression left on the cartridge from the firing pin or other parts. The firing pin strikes the end of the cartridge, causing a chemically ignited spark that ignites the gunpowder. A great deal of force is necessary to cause the firing pin to strike the cartridge, which in turn ignites the gunpowder. This force leaves an impression of the firing pin on the cartridge that can be matched in many instances.

The matching of a bullet with barrel grooves and the matching of a firing pin to the impression on a cartridge rely on similar techniques. Known commonly as impression comparison, these techniques focus on similarities between the bullet or cartridge in question and the potential source of the impression.

Firearms analysis has advanced to the point that detailed databases exist to help forensic scientists in impression comparison and identification. Both firearms and ammunition manufacturers and investigative agencies maintain such databases, often in cooperation with one another. Such databases are especially useful in the establishment of baseline identification methods.

Trajectory and Other Firearms Analysis

The term "trajectory" commonly refers to the path a bullet or other projectile takes in flight or after contact with an object. Both forces of nature (such as wind) and manufacturing characteristics can affect the way a bullet is propelled through the air. Analysis of a bullet's trajectory may help establish where the shooter was in relation to the victim as well as the degree and type of injury sustained.

In complex cases involving firearms, especially those in which multiple shots were fired or multiple shooters were involved, forensic scientists determine the angles and paths of the bullets through trajectory analysis. This method of analysis relies heavily on known characteristics of guns and ammunition as well as on the science of physics.

Firearms analysis may also involve questions of injury and nature of use. The type of bullet as well as the type of firearm can affect dramatically the type of injury to the victim and the damage to any property or physical item struck by the bullet. The analysis of such injury or damage can help determine the relationship between shooter and victim as well as answer potential questions of conduct during the shooting. For example, the presence of gunpowder residue on a victim's skin generally indicates that the weapon was close to the victim at the time it was fired; this information may support or disprove witness statements regarding the events that took place.

Carl Franklin

Further Reading

Heard, Brian J. *Handbook of Firearms and Ballistics: Examining and Interpreting Forensic Evidence*. New York: John Wiley & Sons, 1997. Comprehensive volume provides a thorough survey of the subject of firearms analysis.

Hueske, Edward E. *Practical Analysis and Reconstruction of Shooting Incidents*. Boca Raton, Fla.: CRC Press, 2006. Focuses on the management and reconstruction techniques used by forensic investigators in crimes involving firearms.

Schwoeble, A. J., and David L. Exline. *Current Methods in Forensic Gunshot Residue Analysis*. Boca Raton, Fla.: CRC Press, 2000. Discusses all aspects of gunshot residue analysis, including collection techniques, interpretation, testimony, and report writing.

Sharma, B. R. *Firearms in Criminal Investigations and Trials*. New York: Universal Law Publishing, 2004. Provides basic information on the firearms analysis techniques used in traditional criminal investigations.

See also: Ballistic fingerprints; Ballistics; Bloody Sunday; Bullet-lead analysis; Bureau of Alcohol, Tobacco, Firearms and Explosives; Gunshot residue; Gunshot wounds; Integrated Ballistics Identification System; Sacco and Vanzetti case; Silencers for firearms.

First responders

Definition: Specifically trained persons who are first to arrive at emergency or disaster scenes, including military personnel, law-enforcement personnel, firefighters, emergency medical technicians and paramedics, health care professionals, public works officials, and professionals who work with animals trained in search and rescue.

Significance: First responders not only carry out search-and-rescue missions but also preserve forensic evidence at emergency and disaster scenes to enable investigators to identify the dead, determine the causes of the events, and conduct related criminal investigations.

The many different kinds of professionals classified as first responders work for private, public, and governmental agencies—federal, state, and local governments; the private sector; and nongovernmental entities and organizations. As first responders, they are usually certified to carry out specific emergency management tasks. First responders in the United States receive training concerning the National Incident Management System (NIMS), which uses the Incident Command System to ensure coordinated responses at scenes of emergencies or disasters. Some states, such as California, mandate by law that all first responders have a certain level of emergency medical training. The federal government, especially the Department of Homeland Security, provides much of the funding for such training and for the equipment necessary to respond to emergencies and disasters.

First responders can be found at the scenes of crimes, terrorist attacks, fires, vehicle accidents, hazardous spills at manufacturing plants, contagious disease outbreaks, downed utility lines, and natural or human-made disasters involving thousands of people. Not all persons who are the first to arrive at emergency scenes are traditional first responders, however. Nontraditional first responders might include flight attendants, sports coaches, lifeguards, and teachers, who may have no training in any emergency procedures beyond simple first aid. After the terrorist attacks on the World Trade Center in New York City and on the Pentagon on September 11, 2001, lay rescuers became increasingly involved in early responses to emergencies in the United States. The enormity of the response and recovery needs experienced as a result of Hurricane Katrina in 2005 added to this trend, and many people in positions to become lay responders began to receive training in fire safety, first aid, the Heimlich maneuver, cardiopulmonary resuscitation (CPR), and the use of automated external defibrillators (AEDs).

Roles and Responsibilities

Although first responders can be found around the globe, the public became more aware of the roles of first responders in the United States after the 2001 terrorist attacks that caused the collapse of the World Trade Center towers in New York City. In 2003, in response to the aftermath of these attacks, U.S. president George W. Bush issued a presidential directive that defined first responders as those skilled individuals involved in the first stages of an incident who carry out many roles for the purposes of protecting and preserving people and property, evidence, and the environment. The foremost objective of first responders is to protect humans from injury and death. First responders also protect animals. In addition, first responders play major roles in protecting property from damage and destruction and in preserving forensic evidence.

First responders participate in the multiple phases of the disaster management cycle, which include planning, prevention and mitigation, response, and recovery. First responders take specific actions depending on the types of emergencies or disasters that have taken place, whether natural or human-made. The duties of first responders are usually established in the federal, state, local, and private emergency response plans adopted by the governmental or nongovernmental entities that engage the services of the responders or volunteers. The National Response Plan in the United States describes fifteen emergency support functions (ESFs); these further delineate the roles of first responders at the various levels of government when the president declares a national emergency.

Second Responders

First responders may become overwhelmed during serious disasters and may need to call on others for assistance. These others, sometimes known as second responders, include people from charitable organizations such as the Red Cross. In 2002, President Bush encouraged all Americans to volunteer service through the USA Freedom Corps during times of emergencies and disasters. Some of the newest emergency response volunteer organizations in the United States are part of the Citizen Corps, which was established after the September 11, 2001, attacks. Other organizations, such as faith-based and secular service organizations, also stepped up in greater numbers after the 2001 attacks to offer their services in assisting first responders.

Because first responders may need to rely on second responders, the U.S. Department of Homeland Security works with state and local governments and nongovernmental entities to provide training and certification for persons who are likely to participate in emergency and disaster response before they partner with first responders. Such training and certification enable second responders to partner effectively with first responders and to follow the Incident Command System. Moreover, second responders who receive this training learn how to protect victims and property, thus ensuring the preservation of forensic evidence at emergency and disaster scenes.

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Further Reading

Alexander, David. *Principles of Emergency Planning and Management*. New York: Oxford University Press, 2002. Basic text focuses on the planning aspects of emergency management. Analyzes case studies to reinforce the discussion of emergency management practices.

Bergeron, J. David, Gloria Bizjak, George W. Krause, and Christopher Le Baudour. *First Responder*. 7th ed. Upper Saddle River, N.J.: Prentice Hall, 2004. Workbook, part of an emergency management series, is intended as a training tool for first responders. Includes instruction on cardiopulmonary resuscitation (CPR) and first aid training.

Bullock, Jane, and George Haddow. *Introduction to Emergency Management*. 2d ed. Boston: Butterworth-Heinemann, 2005. Provides a good overview of emergency management and the roles and responsibilities of first responders.

______. *Introduction to Homeland Security*. 2d ed. Boston: Butterworth-Heinemann, 2006. Presents an informative overview of homeland security measures in the United States and first responders' use of the Incident Command System. Includes discussion of the emergency responses to the terrorist attacks on September 11, 2001, and the hurricanes of 2005.

Limmer, Daniel, Keith J. Karren, and Brent Q. Hafen. *First Responder: A Skills Approach*. 7th ed. Upper Saddle Rivier, N.J.: Prentice Hall, 2006. Covers the various kinds of incidents in which first responders are involved, including terrorist attacks and medical and industrial emergencies. Intended for both students and emergency management professionals.

See also: Asian tsunami victim identification; Buried body locating; Cadaver dogs; Chemical Biological Incident Response Force, U.S.; Crime scene investigation; Disturbed evidence; Nerve agents; Oklahoma City bombing; September 11, 2001, victim identification; ValuJet Flight 592 crash investigation; World Trade Center bombing.

This flight data recorder came from ValuJet Flight 592, which crashed in Florida in May, 1996. The device was retrieved from the crash site and displayed by the National Transportation Safety Board a few days after the accident. *(AP/Wide World Photos)*

Flight data recorders

Definition: Devices carried on aircraft that record information about flight paths and the actions of crew members.

Significance: The presence of flight data recorders on aircraft has significantly improved the ability of investigators to determine the causes of airplane crashes. These devices have allowed investigators to provide the families of crash victims with clearer information about their loved ones' deaths and have also enabled the agencies concerned with air travel to take corrective actions that have decreased the incidence of crashes and kept consumer confidence in air travel high.

The idea of placing devices on aircraft to record flight data originated in the 1940's, but it was not until 1957 that David Warren, an aeronautical researcher in Australia, created a flight data recorder (FDR) that could record all of an aircraft's basic operating systems, including heading, altitude, time, airspeed, and vertical accelerations. The FDR was called the "red egg" at the time because of its bright reddish-orange color; it later, strangely, became known as the "black box." This now-common term has been reported to have come into use after a journalist called the device a "wonderful black box," but many also believe that the black box name came about because some of the original FDRs were painted black or because after an airplane crash the box is typically charred black.

The first patent issued for an FDR in the United States was granted to James Ryan in 1963. In 1965, all commercial airlines were required to install cockpit voice recorders that could capture the last thirty minutes of crew voice communications and noise on any flight. By the 1970's, major airlines began replacing these basic FDRs with more advanced systems, including magnetic tape recorders to replace the original foil recorders and more fire- and crash-resistant technology. As planes became larger and more technologically advanced, FDRs were developed to record increasing amounts of information, including data on engines and flaps.

During the 1990's, with the rapid advancement of computer technology, airlines began replacing magnetic tape recorders with solid-state FDRs that could store information on integrated circuits involving memory chips. Compared with earlier FDRs, these solid-state systems allowed for the recording of much longer intervals of data, required less overhaul and maintenance time, and enabled much faster retrieval of the information stored.

In the United States, regulations regarding FDRs are established and enforced by the Federal Aviation Administration (FAA); in Europe, these duties are fulfilled by the European Organization for Civil Aviation Equipment. In 1997, the FAA required that all FDRs on U.S. planes must be capable of recording at least eighty-eight flight parameters. Modern FDRs record a much greater volume of information than their predecessors, including data on fuel flow, magnetic heading, control column, wheel position, and horizontal stabilizers.

How FDRs Work

The memory boards inside FDRs are protected by sheets of aluminum housing and dry silica insulation contained within stainless-steel shells. FDRs are typically placed in the tails of planes because this positioning provides them the most protection during crashes. The bright orange color and fluorescent tape on FDRs aids in their location after crashes. In addition, FDRs are equipped with underwater location beacons that send out ultrasonic pulses that can be detected by sonar. These beacons are activated when the devices touch water, and the pulses are sent out continuously for thirty days.

FDRs must go through rigorous survivability testing, including pressure tests, crash impact tests (which often involve shooting the devices from cannons), and trauma tests (which involve the dropping of heavy steel pins on the devices). Finally, FDRs are fire tested; they must be able to survive one hour at 1,100 degrees Celsius and another ten hours at 260 degrees Celsius.

Following an airplane crash in the United States, the FDR is located and then turned over to investigators of the National Transportation Safety Board (NTSB), who take it apart and download the data. When an FDR is badly damaged, its memory boards have to be removed and connected to special software that retrieves the data. Typically, experts are brought in to interpret the data, a process in which they compare movements of the plane and its instruments with the cockpit voice re-

Cockpit Voice Recorders

In an aircraft accident investigation, the data from the flight data recorder are examined in conjunction with the information provided by the cockpit voice recorder. On its Web site, the National Transportation Safety Board (NTSB) provides this description of the role of the CVR.

The CVR records the flight crew's voices, as well as other sounds inside the cockpit. The recorder's "cockpit area microphone" is usually located on the overhead instrument panel between the two pilots. Sounds of interest to an investigator could be engine noise, stall warnings, landing gear extension and retraction, and other clicks and pops. From these sounds, parameters such as engine rpm, system failures, speed, and the time at which certain events occur can often be determined. Communications with Air Traffic Control, automated radio weather briefings, and conversation between the pilots and ground or cabin crew are also recorded.

A CVR committee usually consisting of members from the NTSB, FAA, operator of the aircraft, manufacturer of the airplane, manufacturer of the engines, and the pilots union, is formed to listen to the recording. This committee creates a written transcript of the CVR audio to be used during the investigation. FAA air traffic control tapes with their associated time codes are used to help determine the local standard time of one or more events during the accident sequence. These times are applied to the transcript, providing a local time for every event on the transcript. More precise timing for critical events can be obtained using sound spectrum software.

cordings. This process can take weeks or even months as investigators attempt to piece together failings in the operating system with the crew members' words as well as the damage to the aircraft.

Aeronautical researchers are always working to improve FDRs, and some now make video recordings of aircraft and their critical mechanical systems. Attempts are also constantly under way to increase the number of flight parameters recorded by FDRs in all aircraft, to improve the damage protection of FDRs themselves, and to place updated FDRs in small aircraft.

Some investigators have begun to view the FDR as a reactionary tool; they have suggested that it would be better to use satellite systems to provide instant access to information from aircraft that are having difficulty while they are in the air rather than after crashes have occurred. This is not likely to occur anytime in the near future, however; FDRs will probably remain critical in crash investigations rather than during in-flight emergencies.

Brion Sever

Further Reading

Bibel, George. *Beyond the Black Box: The Forensics of Airline Crashes*. Baltimore: The Johns Hopkins University Press, 2007. Attempts to diminish some of the myths surrounding flight data recorders and discusses their limitations in airline crash investigations, highlighting the value of investigative work.

Byrne, Gerry. *Flight 427: Anatomy of an Air Disaster*. New York: Springer, 2002. Provides a penetrating look at an airline crash investigation, focusing on the technology involved in the investigation, including the use of flight data recorders.

Faith, Nicholas. *Black Box: The Air-Crash Detectives—Why Air Safety Is No Accident*. Osceola, Wis.: Motorbooks International, 1997. Sheds light on the functioning of flight data recorders and the mechanics behind the devices. Also reviews the protocol in flight investigation, showing the role of FDRs in the investigations.

Witham, Janice. *Black Box: David Warren and the Creation of the Cockpit Recorder*. Sydney, N.S.W.: Lothian Books, 2006. Focuses on the development and history of cockpit voice recorders.

See also: Accident investigation and reconstruction; Airport security; National Transportation Safety Board; ValuJet Flight 592 crash investigation.

Food and Drug Administration, U.S.

Date: Established in 1906 as the Food, Drug, and Insecticide Administration within the U.S. Department of Agriculture

Identification: Federal agency that is responsible for the regulation of both drugs and foods in the United States.

Significance: The U.S. Food and Drug Administration, the first regulatory agency created in the United States to focus on consumer protection, has a more diverse and widespread jurisdiction than any other U.S. agency in the regulation of food products and drugs. The agency oversees the safety of foods, drugs, medical devices, cosmetics, and other products and services that may affect the public health.

The U.S. Food and Drug Administration (FDA) oversees a number of agencies that regulate foods and drugs. It is perhaps best known for its role in the process of the approval of new drugs seeking entry onto the market. The FDA closely monitors the research performed on drugs and the ways in which drugs are packaged and marketed once they are approved for sale. In addition, the FDA has a great deal of influence in regard to the preservatives and chemicals that are allowed in foods.

The FDA began as a watchdog agency focused on big businesses in the areas of commercial food and drug products. The pressure for the U.S. government to establish an agency to oversee the safety of foods and drugs began to mount in the early twentieth century, when newspapers and books publicized the unsanitary conditions under which many foods were processed and kept. The FDA originated as a wing of the Department of Agriculture's Bureau of Chemistry in 1906, when the Pure Food and Drug Act and the Meat Inspection Act were passed by the U.S. Congress. The FDA was originally focused on investigating potential existing food additives and drugs that were harmful to consumers, but its jurisdiction soon began to grow. In 1938, with the passage of the Federal Food, Drug, and Cosmetic Act, the FDA extended its jurisdiction to cosmetics and the marketing of new drugs and also took on the inspection of factories.

The FDA continued to expand its regulatory jurisdiction with the development of new technologies. For instance, the agency oversees cell and tissue products, vaccines, gene therapy products, and other advanced biological products through the Center for Biologics Evaluation and Research, one of its many branch agencies. The Center for Devices and Radiological Health, another branch of the FDA, is responsible for approving medical instruments and overseeing their safety.

Critics of the amount of power given to the FDA have argued for decentralization of the agency. They contend that because the FDA's decisions have significant influence over the stock value of numerous companies, great potential exists for corruption and inappropriate influence on the agency by special interests.

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Further Reading

Hawthorne, Fran. *Inside the FDA: The Business and Politics Behind the Drugs We Take and the Food We Eat*. Hoboken, N.J.: John Wiley & Sons, 2005.

Hickmann, Meredith A., ed. *The Food and Drug Administration*. Commack, N.Y.: Nova Science, 2004.

Hilts, Philip. *Protecting America's Health: The FDA, Business, and One Hundred Years of Regulation*. New York: Random House, 2003.

See also: Air and water purity; Botulinum toxin; Drug classification; Drug Enforcement Administration, U.S.; Food supply protection; Product liability cases; Product tampering; Silicone breast implant cases; Thalidomide.

Food poisoning

Definition: Illness, sometimes fatal, caused by eating or drinking contaminated food or water.

Significance: Food poisoning incidents, both intentional and unintentional, are harmful to societies economically, psychologically, and politically. Microbial forensic analysis plays an important role in the detection and prevention of food poisoning.

Food-borne illnesses affect an estimated seventy-six million Americans every year. Although most victims recover quickly, some five thousand deaths from food poisoning occur in the United States annually. Approximately 75 percent of all food poisoning cases are caused by known pathogens; only a small percentage of food poisoning cases are caused by unknown sources or substances. Viruses, bacteria, parasites, toxins, metals, and prions that are consumed through contaminated foods and liquids, including water, cause food poisoning.

More than 250 different food-borne diseases have been identified, and the Centers for Disease Control and Prevention (CDC) estimates that 97 percent of food poisoning illnesses result from improper food handling; of these, 79 percent are caused by foods prepared in commercial kitchens and 21 percent are caused by foods prepared in home kitchens. Prepared foods left at unsafe temperatures, inadequate cooking or reheating, cross-contamination of foods, and infections in food handlers cause most food poisoning cases.

When contaminated food or water is consumed, the digestive system is usually able to destroy any harmful pathogens, but some pathogens can survive and cause illness. Usual symptoms include nausea, abdominal pain, vomiting, diarrhea, and headache; these occur normally within one to three days of ingestion of the contaminated food. Sometimes, however, a food-borne pathogen begins to multiply in the victim's stomach and intestine, producing toxins. These toxins then travel into the bloodstream, where they are transported to vital body organs and muscles, often with lethal results. Rare pathogens such as *Clostridium botulinum* (the bacterium that causes botulism), which grows in improperly canned foods, and harmful substances such as arsenic or pesticides cause severe symptoms that usually result in death.

Detection

When a serious case of food poisoning is diagnosed by a physician—after other illnesses that mimic food poisoning have been ruled out—it is confirmed by laboratory analysis of fecal and blood samples and oral history from the victim. The local health department and public health scientists are usually the first responders to a suspected case of food poisoning. Preservation of evidence is critical, and scientists carefully collect suspected food materials and samples of hair and stomach contents from the victim. Microbial forensic analysts must identify, collect, and preserve samples properly for transportation to the lab to avoid contamination of the samples.

A cluster of cases may be detected if several people connected by a common experience or event are suspected of having food poisoning. Scientists must determine whether the cases constitute more than the usual expected number

Food Poisoning Pathogens and Their Sources

Pathogen/Substance	*Sources*
Aeromonas	Untreated spring or well water
Arsenic	Pesticides and industrial chemicals
Bacillus cereus	Contaminated fried rice, meatballs
Clostridium botulinum	Improperly canned foods
Campylobacter jejuni	Contaminated meats (including beef, pork, lamb, goat, venison), poultry
Clostridium perfringens	Undercooked meats, poultry, legumes
Ciguatera	Carnivorous reef fish in Hawaii, Florida, the Caribbean
Entamoeba histolytica	Contaminated food, water
Enterohemorrhagic *Escherichia coli* (*E. coli* O157:H7)	Undercooked hamburger meat, contaminated leafy greens
Enteroinvasive *E. coli*	Contaminated imported cheeses
Enterotoxic *E. coli*	Contaminated water, foods
Giardia lamblia	Contaminated groundwater
Hepatitis A	Contaminated water, foods; person-to-person transmission
Listeria monocytogenes	Unpasteurized, raw milk; soft cheeses; contaminated raw vegetables, shrimp
Mercury	Inorganic mercuric salts
Mold	Fruits, grains, nuts, other foods past prime
Neurotoxic shellfish poison	Mollusks in coastal Florida
Norwalk virus	Contaminated water, shellfish; person-to-person transmission
Paralytic shellfish poison	Bivalve mollusks from temperate, coastal areas
Salmonella	Contaminated beef, poultry, eggs, dairy
Scombroid	Tuna, mahimahi, kingfish
Shigella	Contaminated potato salad, egg salad, lettuce, vegetables, ice cream, water, milk
Staphylococci	Improperly stored foods high in salt or sugar
Trichinella spiralis	Contaminated water, meats (pork, wild game)
Tetrodotoxin	Puffer fish from Japan
Vibrio cholerae	Contaminated water, foods
Vibrio parahaemolyticus	Raw, undercooked seafood
Vibrio vulnificus	Raw oysters
Yersinia	Contaminated milk, ice cream

A U.S. Department of Agriculture microbiologist examines the growth of microbes obtained from a hog carcass swab. Her work is part of the National Food Safety Initiative, which has as a major goal reducing food-borne pathogens on farms and in foods. *(U.S. Department of Agriculture/Keith Weller)*

of cases of a given food-borne illness or whether the reports constitute a false cluster (for example, backlogged cases reported all at one time).

Key components of a food poisoning investigation include the selection of investigatory method, analysis of samples, interpretation and validation of results, and quality assurance. If a food poisoning outbreak is identified in a particular area or in relation to a particular food, food distributors and vendors are notified immediately, and public recall notices are issued to prevent an epidemic.

Epidemiologists, forensic toxicologists and pathologists, microbiologists, and food safety and public health officials may all be called in to determine the source of a food-related contamination. Prior to 1996, many food poisoning cases went unreported to health authorities. The CDC established the Foodborne Diseases Active Surveillance Network (FoodNet) in 1996 to monitor food-borne illnesses. PulseNet, a branch of FoodNet, networks public health and food regulatory laboratories nationally and helps identify cases that are spread out over large geographic locations. PulseNet allows rapid analysis of suspected pathogens and identifies them through DNA (deoxyribonucleic acid) fingerprinting, enabling quick detection of specific contamination sources. By combining local and regional surveillance reports, PulseNet quickly identifies suspected cases and reduces epidemic outbreaks.

Alice C. Richer

Further Reading

Balkin, Karen F., ed. *Food-Borne Illnesses*. San Diego, Calif.: Greenhaven Press, 2004. Collection of essays presents a variety of perspectives on food safety issues.

National Center for Food Protection and Defense. *Food Defense Education: Post 9/11*. Minneapolis: Author, 2007. Report on a three-year study explores food safety education programs in the United States, with emphasis on the work of criminal justice professionals.

Scott, Elizabeth, and Paul Sockett. *How to Prevent Food Poisoning: A Practical Guide to Safe Cooking, Eating, and Food Handling*. Hoboken, N.J.: John Wiley & Sons, 1998. Provides thorough information on food poisoning's causes and symptoms. Includes a chapter devoted to the science of food poisoning.

Trestrail, John Harris, III. *Criminal Poisoning: Investigational Guide for Law Enforcement, Toxicologists, Forensic Scientists, and Attorneys*. 2d ed. Totowa, N.J.: Humana Press, 2007. Focuses on intentional poisonings and the techniques used to investigate poisoning crimes.

See also: Arsenic; Assassination; Biotoxins; Botulinum toxin; Centers for Disease Control and Prevention; *Escherichia coli*; Food supply protection; Forgery; International Association of Forensic Toxicologists; Mad cow disease investigation; Marsh test; Taylor exhumation.

Food supply protection

Definition: Regulations, laws, and policies intended to prevent the intentional or unintentional contamination of the food supply chain, from agriculture through food processing to retail food sellers.

Significance: Food and water supplies are critical components of a country's infrastructure. In the United States, increasing shipments of food products across regions and importation of foods from other nations, large food-processing operations, and terrorism threats have highlighted the risks of food contamination and the critical importance of protecting the food supply.

The food supply in the United States is considered one of the best protected in the world. Federal, state, and local agencies use science-based principles to implement the requirements of food safety legislation that is designed to ensure the availability of wholesome and safe foods. At the national level, the U.S. Department of Agriculture (USDA), the Environmental Protection Agency (EPA), the Centers for Disease Control and Prevention (CDC), the Department of Health and Human Services (HHS), and the Food and Drug Administration (FDA) all regulate and enforce food safety regulations. These agencies inspect and monitor many points along the food supply chain, respond to food poisoning outbreaks, educate the public, coordinate American food standards with international ones, and work toward preventing and responding to bioterrorism threats. At the local level, individual state and town public health departments also play a role in food protection, regulating supermarkets and restaurants. These local agencies are usually among the first responders to food contamination cases.

American Food Safety

In the United States, concern about food safety dates back to the first decade of the twentieth century. In 1906, two federal laws were enacted to ensure the safety of food products: the Meat Inspection Act and the Pure Food and Drug Act. The adulteration of foods and drugs prior to that time had been rampant. In his 1906 novel *The Jungle*, Upton Sinclair exposed the unsanitary conditions of the Chicago meatpacking plants and provided the impetus that led to the passage of the first American food safety laws. For the first time, inspections were required before meat could be sold to the public, and the U.S. Department of Agriculture's Bureau of Chemistry enforced food safety laws, penalizing those who did not comply.

Since 1906, many more food safety laws have been enacted to prevent harmful or toxic adulteration of foods in the United States. The various links in the food chain are overseen by different agencies. For example, the Animal and Plant Health Inspection Service (APHIS), a branch of the USDA, is responsible for protecting against plant and animal pests and diseases. Stringent food safety laws have become increasingly important as growth in food imports from other countries and shipment of foods across U.S. regions have significantly increased the potential of some foods to be exposed to pathogens, pesticides, and chemical residues.

U.S. Agencies and Programs

The Foodborne Diseases Active Surveillance Network, known as FoodNet, was established in 1996. This collaborative effort among the CDC, the USDA's Food Safety and Inspection Service (FSIS), the FDA, and state health departments actively tracks reported food poisoning cases and identifies patterns among these cases. Across the United States, 450 laboratories work with FoodNet scientists to simplify this process and make reporting quicker and easier.

PulseNet, a branch of FoodNet, was also set up to identify pathogens. PulseNet scientists maintain an electronic database of the DNA (deoxyribonucleic acid) profiles of different infecting pathogens that can link particular pathogens to their sources. For example, *Escherichia coli* O157:H7 (a specific food-borne pathogen) in ground beef has a DNA fingerprint that is different from an *E. coli* O157:H7 pathogen in a different food source. After individual pathogen DNA fingerprints are identified, they are published on the Electronic Foodborne Outbreak Reporting System. By identifying the sources of food poisoning cases, health authorities can prevent widespread outbreaks, even if victims are located in different states or countries. When PulseNet identifies a contaminant as the source of a food poisoning outbreak, FoodNet notifies food manufacturers and distributors and issues a recall. The public is then notified through press releases. Doctors, toxicologists, and public health department workers in the affected geographic area begin to investigate to determine the precise source of the contamination.

In 2000, the FDA implemented a system of protocols for the food service industry known as Hazardous Analysis and Critical Control Points (HACCP). The goal of HACCP is to analyze and monitor the entire production process of foods. During the production process, steps are implemented to reduce contamination as food goes from raw to finished state. HACCP also calls for the monitoring of farming procedures and animal feed to reduce food contamination risks. Farmers, ranchers, and the USDA regularly inspect feed and slaughter practices and the processing of any related food products. State and local public health officials inspect supermarkets and restaurants regularly to make sure that procedures are in place to decrease opportunities for the growth of food-borne pathogens; they examine the state of the water supply, facility cleanliness, storage and serving tempera-

The Making of Sausage

This description of packinghouse practices from Upton Sinclair's The Jungle *(1906) illustrates why many readers of the novel became vocal in their support of food safety in general and the passage of the federal Pure Food and Drug Act and the Meat Inspection Act in particular.*

There was never the least attention paid to what was cut up for sausage; there would come all the way back from Europe old sausage that had been rejected, and that was moldy and white—it would be dosed with borax and glycerine, and dumped into the hoppers, and made over again for home consumption. There would be meat that had tumbled out on the floor, in the dirt and sawdust, where the workers had tramped and spit uncounted billions of consumption germs. There would be meat stored in great piles in rooms; and the water from leaky roofs would drip over it, and thousands of rats would race about on it. It was too dark in these storage places to see well, but a man could run his hand over these piles of meat and sweep off handfuls of the dried dung of rats. These rats were nuisances, and the packers would put poisoned bread out for them, they would die, and then rats, bread, and meat would go into the hoppers together. This is no fairy story and no joke; the meat would be shoveled into carts, and the man who did the shoveling would not trouble to lift out a rat even when he saw one—there were things that went into the sausage in comparison with which a poisoned rat was a tidbit.

The owner of a food distribution company looks over bags of spinach in his warehouse in Columbus, Ohio, on September 15, 2006, after federal health officials quarantined the produce following an *Escherichia coli* outbreak in several states that killed one person and sickened dozens. *(AP/Wide World Photos)*

tures, and employee hand-washing procedures and training programs.

Following the terrorist attacks on New York City and the Pentagon of September 11, 2001, the possibility of threats of bioterrorism became a focus of those charged with protecting the American food supply. The U.S. Department of Homeland Security, EPA, FDA, USDA, Central Intelligence Agency, U.S. Customs Service, and HHS have increasingly worked together to implement policies to protect the food supply. Identifying weak areas in agriculture and food distribution systems has become a key priority, and increased emphasis has been placed on protecting farm animals, the water supply, and food products before public distribution. In addition, these agencies have formulated emergency procedures to be followed in the event of an outbreak of disease caused by food contamination.

In 2005, the FSIS established the Food Emergency Response Network (FERN) to handle widespread food emergencies rapidly. FERN comprises a network of state and federal laboratories that have committed their resources to the analysis of food samples in the event of any chemical, radiological, or biological terrorist attack in the United States.

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Further Reading

Balkin, Karen F., ed. *Food-Borne Illnesses*. San Diego, Calif.: Greenhaven Press, 2004. Collection of essays presents a variety of perspectives on food safety issues.

National Center for Food Protection and Defense. *Food Defense Education: Post 9/11*. Minneapolis: Author, 2007. Report on a three-year study explores food safety education programs in the United States, with emphasis on the work of criminal justice professionals.

Pampel, Fred C. *Threats to Food Safety*. New York: Facts On File, 2006. Discusses in detail all potential safety threats to the U.S. food supply.

Redman, Nina E. *Food Safety*. 2d ed. Santa Barbara, Calif.: ABC-CLIO, 2007. Comprehensive volume presents historical and current perspectives on U.S. food safety issues.

Roberts, Cynthia A. *The Food Safety Information Handbook*. Westport, Conn.: Oryx Press, 2001. Provides a full overview of food safety regulations and laws in the United States.

See also: Botulinum toxin; Centers for Disease Control and Prevention; Chemical terrorism; Food and Drug Administration, U.S.; Food poisoning; Mad cow disease investigation; Pathogen transmission; Product tampering.

Footprints and shoe prints

Definition: Impressions left by feet—wearing shoes or barefoot—in soft ground, blood, snow, or other surfaces.

Significance: Foot and shoe impressions that are found at crime scenes can be used to link specific individuals to such scenes based on foot size, sole patterns unique to particular brands and styles of shoes, specific wear patterns, and unique stray marks. In addition, forensic scientists can often estimate the height, weight, and gait patterns of persons from the footprints and shoe prints they leave behind.

At many crime scenes, shoes prints (and less frequently bare footprints) are present even if they are not always visible to the naked eye. Such prints provide a wealth of information that can link suspected perpetrators to the locations of crimes. Based on the correspondence of shoe type as well as individual characteristics, an alleged perpetrator's shoe may be positively identified as the specific shoe that made one or more impressions at a crime scene. Potential suspects may also be exculpated by the absence of their shoe prints at the scene. Footprints and shoe prints can sometimes provide evidence that links various crime scenes together in serial crime situations.

Types of Evidence

Footprints and shoe prints are also important because they provide information on indi-

When shoe prints are found at a crime scene, investigators can often ascertain information on the brand names and styles of the shoes by running comparisons of the prints with the contents of footwear databases, such as the database maintained by the Federal Bureau of Investigation crime lab that includes thousands of designs of shoe soles. *(©Mark Emge/Dreamstime.com)* viduals' points of entry into a crime scene and their points of exit. Such prints can also help investigators to determine the number of perpetrators involved in a crime. In addition, by tracking the impressions, investigators can often find other evidence, such as discarded firearms.

When shoe prints are found at a crime scene, investigators can often ascertain information on the brand names and styles of the shoes by running comparisons of the prints with the contents of a footwear database such as the one maintained by the Federal Bureau of Investigation (FBI) crime lab, which includes thousands of designs of shoe soles. If the producer of a particular kind of shoe is known, then the size of the footwear can be determined accurately. Even a partial shoe print can provide investigators with a general estimate of the wearer's size.

Such prints can also provide some evidence on the gait of the person who made the impressions, especially if the person has a medical condition that affects how he or she walks. In some cases, shoe prints can allow investigators to estimate the height, weight, and gender of the person who left them by measuring the stride, step length, and angle at which the feet contacted the ground. These elements can also indicate the rate of speed at which the person moved.

Forensic scientists use a variety of chemical techniques to enhance both wet and dry foot impressions to make them easier to analyze, and a variety of casting techniques allow them to preserve foot and shoe marks in three-dimensional form for analysis. When the shoe and foot impressions found at crime scenes cannot be captured in any other way, investigators take photographs of them.

Research on Footprints

Impressions of bare feet are found less often at crime scenes than are shoe prints, so forensic scientists spend less time examining footprints than they do analyzing shoe prints. Footprints have been the subject of some interesting research, however. It has been theorized that the ridges in the skin on the soles of human feet are as unique to individuals as fingerprints, but this has not been determined conclusively.

Other research in this area concerns the marks left by bare feet on the insides of shoes, including the marks left by the top of the foot on the inside upper surface of a shoe. If such marks are discovered to be distinctive, they may one day be used to connect particular persons to particular shoes, which may in turn be connected to crime scenes.

Richard L. Wilson

Shoes and the O. J. Simpson Trials

Perhaps the most spectacular uses of the application of forensic science in shoe print analysis to date occurred in the murder trial and wrongful death civil suit against the famous football player O. J. Simpson. Simpson was accused of murdering his ex-wife, Nicole Brown Simpson, and her friend Ronald Goldman. Investigators found shoe prints—stained with the victims' blood— leading away from the murder scene. It was determined that the prints had been made by someone wearing a relatively rare, imported Italian brand of shoes, and the size of the shoes matched the size Simpson wore. The shoes that made the prints were never found, and O. J. Simpson volunteered that he would never wear such ugly shoes. For a variety of reasons, including the failure of investigators to link Simpson to the pair of shoes that made the prints, Simpson was acquitted in the criminal trial.

After the criminal trial concluded, the victims' families brought a wrongful death civil suit against Simpson. Although the shoes still had not been located, photographs surfaced by the time of the civil trial showing Simpson wearing a pair of the exact type of shoes that made the prints found at the murder scene and that Simpson had denied ever wearing. The photos had been taken by dozens of different photographers months before the murders when Simpson appeared at a prominent public ceremony. Forensic analysis showed the photos to be authentic. After weighing all the evidence, including the photos, the civil jury found Simpson responsible for the wrongful death of Goldman and for battery against his ex-wife. Simpson was ordered to pay damages in excess of thirty million dollars.

Further Reading

Bodziak, William J. *Footwear Impression Evidence: Detection, Recovery, and Examination*. 2d ed. Boca Raton, Fla.: CRC Press, 2000. Comprehensive guide to handling footwear evidence includes information on the determination of gait from impressions.

Cassidy, Michael J. *Footwear Identification*. Ottawa, Ont.: Canadian Government Publishing Centre, 1980. Classic text on the topic remains an important resource for forensic scientists.

Hilderbrand, Dwane S. *Footwear, the Missed Evidence: A Field Guide to the Collection and Preservation of Forensic Footwear Impression Evidence*. 2d ed. Wildomar, Calif.: Staggs, 2005. Provides information about all aspects of preserving, collecting, and interpreting footwear impressions.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005. Easy-to-read introductory textbook covers all aspects of forensics, including the casting and analysis of footprint and shoe print impressions.

Whittle, Michael W. *Gait Analysis: An Introduction*. 4th ed. Boston: Butterworth-Heinemann, 2007. Leading text in the field provides good basic information on the study of how humans walk.

See also: Blood residue and bloodstains; Casting; Crime scene investigation; Crime scene measurement; Oblique lighting analysis; Physical evidence; Prints; Tire tracks.

Forensic accounting

Definition: Profession that interweaves accountancy, auditing, and other investigative skills to assist in criminal investigations and prosecutions, legal defenses, and valuation cases.

Significance: In the prosecution of white-collar crime, forensic accountants and auditors provide accounting analyses to courts. Practitioners of forensic accounting who serve as expert witnesses must be able to communicate complicated accounting data to judges and juries in a clear and concise manner. In addition to criminal fraud and embezzlement cases, forensic accounting is often important in divorce cases, business valuation disputes, insurance fraud cases, cases involving accusations of professional negligence, and partnership disputes.

Forensic accounting is accounting or auditing that provides results suitable for use in a courtroom. Forensic accounting is so thorough and so provable that in the accountant's or auditor's professional judgment, a conclusion can be reached regarding the accounts that would be sustainable in a court of law or within a judicial or administrative review (the latter would include events involving mediation or arbitration).

The findings of forensic accountants are based on the scientific evaluation and interpretation of the evidence in the books and records (such as journals and ledgers) of accounting systems. The usual objective of a forensic audit is to ascertain whether deception or fraud has been introduced into the accounting records. In a sense, all auditors and tax preparers are forensic accountants because they deal with either protecting the investment public or seeing that people pay their proper taxes. The formal phrase "forensic accounting," however, is usually reserved for accounting cases in which the accountants' work has to hold up to legal scrutiny. In such cases, the accountants seek a level of evidence that will be sustainable within the judicial framework. It has been said that accountants look at the numbers, whereas forensic accountants look behind the numbers. Forensic accountants combine accounting skills with investigative skills.

Forensic Accountants and Their Jobs

The work of forensic accountants is scientific and detailed; many practitioners find the work enjoyable in that it is like putting together a puzzle. Forensic accountants use their skills to determine whether accounting records mirror economic reality, and when the records do not match the events, the courts are interested. Forensic accountants are involved in both criminal and civil cases, but the criminal cases have tended to be those in the media spotlight.

Forensic accountants are typically certified public accountants (CPAs) in the United States and chartered accountants (CAs) in Canada and Great Britain. They also often hold another certification—that of certified fraud examiner (CFE). Such accountants specialize in those engagements where there is a need for evidence to support a case in court. Examples include investigating suspected embezzlements by employees, bankruptcy fraud, arguments in matrimonial divorce cases, and identification and valuation of assets in probate.

Falsifications and fraud in accounts or the valuation of inventories are also common engagements for forensic accountants. For example, a bank might hire a forensic accountant to determine whether a bankrupt debtor overstated personal inventories for purposes of getting a loan. One spouse seeking a divorce might hire a forensic accountant to determine whether the other spouse's business is worth more than the firm's accounting records indicate. Creditors will sometimes hire forensic accountants to reconstruct transactions to be sure that bankrupt individuals have not tried to hide assets or otherwise make fraudulent conveyances of assets. Occasionally, the owner of a shopping mall will hire an accountant to conduct a forensic investigation to determine whether tenants in the mall are paying the appropriate amount of rent, when such rents are based on each store's sales levels. Similarly, publishers sometimes undergo "royalty audits," in which forensic accountants determine whether the publishers are paying the proper royalties to their authors. Forensic accountants may also be involved when partnerships are dissolved or corporations are liquidated, as such situations often lead to disputes concerning the allocation of assets.

Sometimes forensic accountants provide litigation support services to quantify economic damages. For example, an accountant might testify in court regarding the calculation of economic loss resulting from a breach of contract or the economic loss from the breach of a noncompetition agreement. Loss quantification from professional negligence is also an area of practice for forensic accountants.

Basically, a forensic accounting engagement is any engagement that involves providing an accounting or auditing analysis that is suitable for presentation to a court and will provide the basis for debate and ultimate dispute resolution. The work of forensic accountants includes obtaining documentation needed to support or refute claims, reviewing documentation to identify areas of loss, assisting attorneys in formulating questions to be asked regarding financial evidence, evaluating the opposing expert's damages report to evaluate the weaknesses and strengths of the positions taken, assisting with negotiations, and providing assistance with cross-examination.

In addition to investigating and analyzing financial evidence, forensic accountants must be able to communicate their findings in the form of reports, exhibits, and collections of actual documents. Such findings are presented to courts or in other legal proceedings. Forensic accountants must thus be familiar not only with accounting and auditing techniques but also with legal concepts and procedures, including rules of evidence. The reports written by forensic accountants are designed to present evidence in a concise and professional manner.

Occupational Fraud and Forensic Accounting

Although occupational fraud, and the forensic investigation thereof, has been around for thousands of years, since the mid-1980's forensic accounting has become a growth area for accounting firms. Media attention has given forensic accounting a somewhat glamorous aspect that it did not previously have. Cases of corporate fraud—from those as small as embezzlement by single employees to organized attempts to defraud thousands of shareholders—have been uncovered by forensic auditors, and their work has been widely publicized in the popular media, leading increased numbers of people to pursue careers in the field. The media coverage reached a peak in 2002 when *Time* magazine named three forensic auditors as joint "Persons of the Year."

Occupational fraud falls into three categories: asset misappropriation, which usually involves employees stealing company assets; corruption and bribery, wherein employees use their positions within companies for personal gain (for example, a bank president might make a loan to a friend at a below-market interest rate and then accept a kickback from the friend); and fraudulent financial statements, wherein accounting records are manipulated to make companies look better financially than they really are. This last technique is sometimes employed by unscrupulous corporate executives who want to receive larger bonuses or who own stock in their companies and want the market price of their stock to increase. Cases of this type are among those that receive the most news coverage. For instance, the 2001 fraud at Enron Corporation and the 2002 fraud at WorldCom were uncovered by forensic accountants who observed that the corporations' accounting records did not seem to mirror economic reality. The auditors at these two companies were among those honored in 2002 by *Time*.

Corruption and bribery are among the most difficult types of crimes for forensic accountants to uncover because these are off-the-books crimes. In other words, the accounting records are accurate because the perpetrators are receiving bribes or kickbacks that never go through their companies. Such cases are usually solved only with the help of tips from outsiders. For instance, a person who has been paying kickbacks to a corrupt employee may get tired of making the payments and so may blow the whistle on the employee. Sometimes corruption can be as simple as conflict of interest, such as when employees have undisclosed financial interests in transactions that adversely affect the companies for which they work.

The HealthSouth Case

A prime example of the value of forensic accounting can be found in the case of HealthSouth Corporation, a giant health care company based in Birmingham, Alabama. Forensic accountants determined that the corporation's executives and others had committed massive accounting fraud. They discovered fraudulent entries made between 1992 and 2003 that overstated earnings by more than four billion dollars. As a result of their investigation and evidence, HealthSouth, its former investment bank, and its former audit company faced a class-action lawsuit from shareholders and bondholders. In addition, fifteen former executives pleaded guilty to taking part in the fraud scheme. HealthSouth founder Richard M. Scrushy faced criminal charges. Although five different former chief financial officers of HealthSouth pleaded guilty to fraud and implicated Scrushy in their wrongdoing, Scrushy himself was acquitted by an Alabama jury in June, 2005. Four months later, however, Scrushy was indicted on new charges of bribery and mail fraud. The following year he was convicted in a federal court. In June, 2007, he was heavily fined and sentenced to eighty-two months in a federal prison.

Red Flags

Forensic audits sometimes uncover clues—often referred to as red flags—in accounting records that indicate something is amiss. A red flag can be something as simple as a large discrepancy between what an employee earns and the amount of property that person owns. For example, if a company cashier earns $40,000 a year but lives in a million-dollar house and drives a $100,000 automobile, the auditor should be alert to the possibility that the cashier is stealing from the employer, although an alternative explanation may exist for how the employee can afford the high-priced home and car. That is the nature of a red flag: It does not necessarily indicate fraud, but it does alert the auditor to look at the situation more closely. In this example, a good auditor would try to determine where the cashier got the money for the house and car; perhaps it was from an inheritance or some other legitimate source. If no alternative explanation can be found, the auditor needs to examine the ledgers closely for fraudulent entries.

Another red flag arises for auditors when they become aware that employees are receiving visits or phone calls from bill collectors or collection agencies. Auditors become especially alert when employees are having trouble making ends meet because this can mean the employees may be tempted to embezzle. Auditors also may inquire as to which employees regularly visit casinos and racetracks. If employees are gambling, they are probably losing money, and if they are losing money, it may be the company's money they are losing. Forensic auditors sometimes visit gambling establishments simply for the purpose of looking for employees of the companies they are investigating, particularly those employees who deal with cash.

Other red flags include instances of missing documentation. When an auditor asks for a particular invoice and that invoice is not in the files, it indicates a problem—either someone is trying to hide that transaction or the company's filing system is inefficient. Given that mistakes happen, auditors always try to satisfy themselves by alternative means when documents turn up missing. Shortages of cash in cash drawers are often a sign of embezzlement, but auditors are also cautious when there is an overage in a cash drawer: Perhaps the cashier has figured out how to hide a theft (juggled the books) but has not yet stolen the money. An overage can be just as important a red flag as a shortage of cash.

One thing that forensic auditors always check is whether any vendors' addresses match any employees' addresses, because matches may indicate that employees have figured out ways to have company checks sent to themselves. Such comparisons are easy to make in computerized systems.

Another possible red flag is the refusal of employees to take vacations. Sometimes employees who are defrauding their companies must be at work every day to keep hiding their activities, so in some cases, employees who are praised because they never take sick time and never take vacations turn out to be their companies' biggest crooks. Similarly, employees who are always volunteering to work overtime may seem incredibly loyal to their companies, but in reality they may be working the extra hours to perpetuate their fraud schemes.

Sociological Aspects of Forensic Auditing

Forensic auditors must always consider the sociological aspects of fraud perpetrators' work. Employees typically need reasons to steal from their employers, for example. Sometimes they steal from employers after learning that coworkers are paid more than they are, justifying their theft as "equalizing" their salaries with those of others.

Psychologists say that most people who perpetrate fraud try to rationalize their actions. In many cases, the extended illness of a spouse or child is given as the reason for committing fraud. In other instances, addictions to drugs, gambling, or pornography can lead people to commit fraud. Some people who become involved in embezzlement rationalize that they are only borrowing the money and will pay it back in the future.

In some instances, the fraud perpetrated by employees is not financially based. Such cases are often the most difficult to discover because they do not raise the typical red flags that could indicate problems.

Bankruptcy and Divorce Cases

Although lacking the glamour of occupational fraud cases, bankruptcy and divorce cases have long been mainstays of the field of forensic accounting. Bankruptcy fraud results when a person filing for bankruptcy protection files false financial information on the bankruptcy petition. A similar kind of fraud also occurs in matrimonial divorce cases. In both types of proceedings, a person's assets are taken away and given to others, so an incentive exists for that person to commit fraud when preparing financial statements.

Because transferring assets to offshore bank accounts or to friends is a common ploy in both bankruptcy and divorce cases, bankruptcy trustees and creditor committees often hire forensic accountants to investigate for fraudulent transfers of assets. In fact, CPAs and CFEs may even serve as trustees or on creditor committees in bankruptcy cases.

In some cases, a bankruptcy is legitimate, but it was brought on by fraudulent activity. In other words, the bankrupt person may have stolen the assets long before bankruptcy was contemplated. In such a case, the forensic accountant would concentrate on the earlier period, whereas an accountant concerned with fraudulent transfers would normally look only at the period starting one year before the time of the court filing.

In divorce cases, the party alleging fraud will hire a forensic accountant to determine whether the other party made fraudulent transfers of assets prior to the divorce proceedings. The accountant then has to testify in court as to the nature of any hidden assets found in the audit. Divorce fraud cases are typically civil cases, but criminal charges can be filed if the fraudulent act is egregious.

Assets can be fraudulently transferred prior to a bankruptcy or divorce in many different ways. Inventory or other assets may be sold at greatly reduced prices, but with the agreement that the seller can buy back the assets after the court proceedings. Failing to record sales and receipts of cash can also hide assets. A debtor or divorcing party might make payments to fictitious individuals, writing checks that are in reality deposited in offshore bank accounts. Conspiring vendors may send fraudulent invoices and then credit the payments to the account of a debtor, with eventual repayment after the case has been closed.

In some cases of bankruptcy and divorce fraud, the perpetrators destroy all of the books and records to hide their fraudulent actions. In such instances, forensic accountants have to reproduce the original journals and ledgers as completely as possible.

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Further Reading

Albrecht, W. Steve, and Chad O. Albrecht. *Fraud Examination*. Mason, Ohio: Thomson South-Western, 2003. Textbook for upper-level courses in accountancy provides an excellent overview of forensic accounting and covers several fringe areas of the field, including bankruptcy and divorce fraud. Presents a good summary on the resolution of fraud, including elements of the court system and the civil and criminal litigation processes.

Biegelman, Martin T., and Joel T. Bartow. *Executive Roadmap to Fraud Prevention and Internal Control: Creating a Culture of Compliance*. Hoboken, N.J.: John Wiley & Sons, 2006. Covers audit techniques, applicable federal laws, and the fundamentals of providing legal testimony on forensic audits. Written by agents of the FBI and the U.S. Postal Inspection Service who have been involved in the prosecution of hundreds of cases of corporate crime, investment fraud, kickback schemes, international scams, and health care fraud, including violations of the Racketeer Influenced and Corrupt Organizations (RICO) Act.

Callahan, David. *The Cheating Culture: Why More Americans Are Doing Wrong to Get Ahead*. New York: Harcourt, 2004. Provides an overview of corporate fraud cases over the preceding twenty years and places the blame on the increasingly dog-eat-dog economic climate in the United States. Includes discussion of accounting scandals at Enron, WorldCom, Tyco, and Lincoln Savings and Loan.

Davia, Howard R., Patrick C. Coggins, John C. Wideman, and Joseph T. Kastantin. *Accountant's Guide to Fraud Detection and Control*. Hoboken, N.J.: John Wiley & Sons, 2000. Useful guide covers all aspects of fraud auditing. Includes many case studies as well as three chapters on prosecuting fraud that address the elements of the crime, procedures for discovery, and rules of evidence. Also discusses whistle-blower statutes in the United States.

Flesher, Dale L. *Internal Auditing Standards and Practices*. Altamonte Springs, Fla.: Institute of Internal Auditors, 1996. Textbook includes an overview of fraud investigation techniques and analysis of red flags in audits.

Silverstone, Howard, and Howard R. Davia. *Fraud 101: Techniques and Strategies for Detection*. 2d ed. Hoboken, N.J.: John Wiley & Sons, 2005. Excellent source of information on fraud auditing. A chapter devoted to evidence emphasizes the differences between indicative evidence and validating evidence—the latter of which is necessary in a court of law.

Silverstone, Howard, and Michael Sheetz. *Fo-*

rensic Accounting and Fraud Investigation for Non-Experts. Hoboken, N.J.: John Wiley & Sons, 2007. Presents a good overview of the field. Includes a section on interviewing financially sophisticated witnesses.

Wells, Joseph T. *Occupational Fraud and Abuse: How to Prevent and Detect Asset Misappropriation, Corruption, and Fraudulent Statements*. Austin, Tex.: Obsidian, 1997. One of the best resources available concerning what to look for during a fraud audit.

See also: Computer forensics; Computer Fraud and Abuse Act of 1984; Document examination; Fax machine, copier, and printer analysis; Federal Bureau of Investigation; Questioned document analysis.

Forensic anthropology

Definition: Profession in which skeletal analysis is performed for the purpose of gathering evidence to be used in legal contexts, such as criminal investigations and civil disputes.

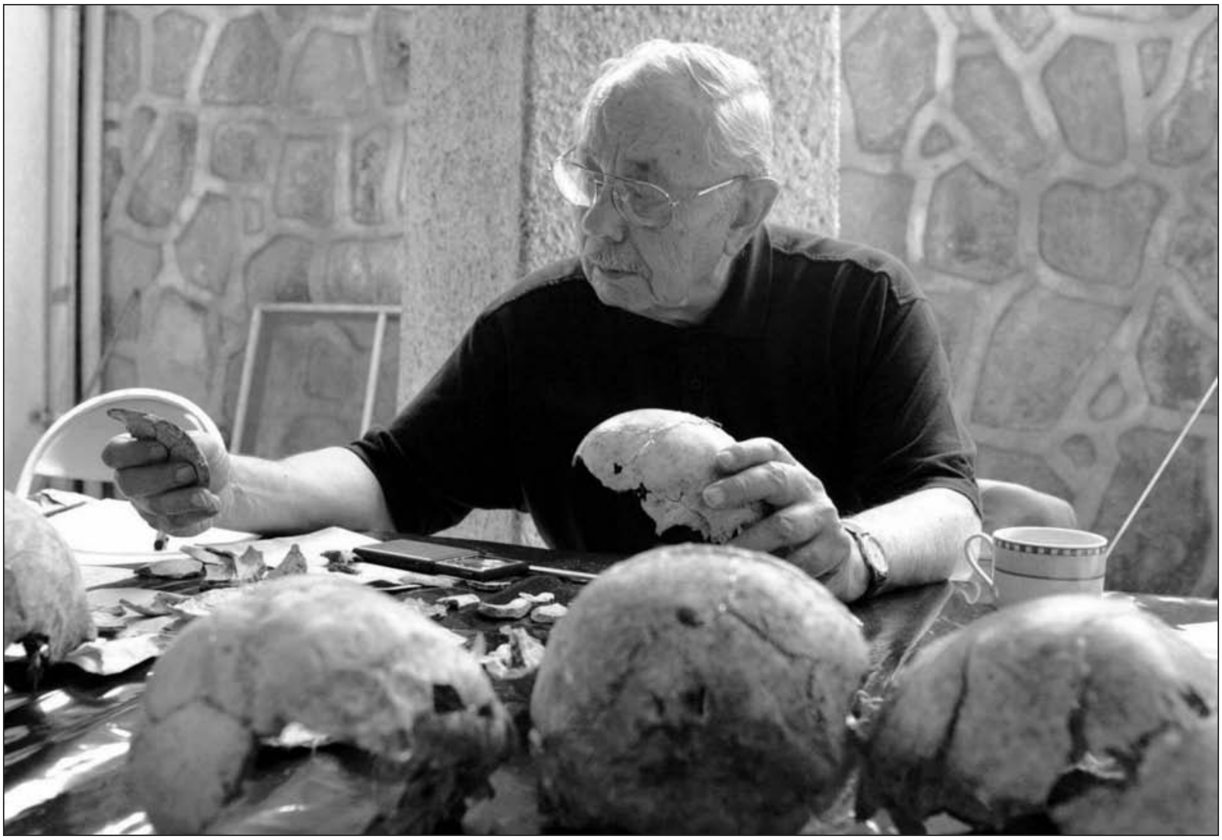
Significance: Because bones are resistant to the process of decay, human skeletal remains can provide primary evidence of the human form after death. Characteristics of humans' bones, and any marks preserved within, can reveal identity and causes of trauma. Such evidence is most frequently associated with homicide cases, but it can also be valuable in civil lawsuits, such as those involving the mishandling of remains. Forensic anthropologists are also sometimes employed to examine skeletal remains following mass disaster situations and cases of genocidal mass murder.

A subspecialty of physical anthropology, forensic anthropology came into being in 1878 when anatomist Thomas Dwight published an essay titled "Identification of the Human Skeleton: A Medico-legal Study." The field reached its modern era in 1939 with the publication of Wilton Marion Krogman's work "A Guide to the Identification of Human Skeletal Material," an article intended as a basic primer for law-enforcement personnel about the use of anthropology in the American legal system. This work garnered attention for the field and was expanded in 1962 into what many still consider to be the seminal text on skeletal identification, *The Human Skeleton in Forensic Medicine*. Forensic anthropology became an "established" area of study when the Physical Anthropology Section of the American Academy of Forensic Sciences (AAFS) was created in 1972. Within five years following creation of the section, the American Board of Forensic Anthropology was organized as a certifying body to ensure the competency of persons practicing in the field.

Two additional important developments occurred in the field of anthropology in the 1970's and the 1980's. First, the Anthropological Research Facility (ARF) was created in 1972 at the University of Tennessee under the vision and direction of well-known professor and forensic anthropologist Dr. William M. Bass. Second, the Physical Anthropology section of the AAFS developed the Forensic Anthropology Data Bank (FDB) in 1986. Both developments allowed researchers to gain significant insight into modern skeletal variation and analysis. The ARF, which is commonly known as the Body Farm, is an outdoor laboratory where corpses are left to decompose in various conditions, thus allowing for the study of decay, skeletal remains, and insect evidence. The FDB contains extensive demographic and skeletal information for more than two thousand sets of remains, both identified and unidentified.

Uses of Forensic Anthropology

The most common use of anthropological evidence is in the determination of the identities of deceased persons. Forensic anthropologists gather as much skeletal information as possible to create profiles of distinguishing traits. For example, an intact femur (thighbone) can be measured and mathematically analyzed to reveal height because the length of the femur has a linear relationship to human stature. This information can then be used to determine whether the remains in question are those of a specific human being, such as a particular miss-



Well-known forensic anthropologist Clyde Snow works on uniting parts of a skull after the remains of forty bodies were found in two mass graves near the site of the 1981 El Mozote Massacre in El Salvador. *(AP/Wide World Photos)*

ing person. Alternatively, the traits identified by forensic anthropologists can be assimilated into descriptions that can serve as the bases for facial reconstructions and drawings.

Anthropologists also use identifying characteristics to separate and identify individual victims of mass fatalities where remains are mixed. This often occurs in the context of natural disasters (such as the aftermath of Hurricane Katrina in 2005), airplane or train wrecks (such as the 1996 crash of Trans World Airlines Flight 800), terrorist attacks (including the World Trade Center attacks in 2001), and mass graves (as created during the genocide that accompanied Rwanda's 1994 civil war).

Anthropologists can also uncover details about the circumstances surrounding homicides. Signs of skeletal trauma can reveal what types of instruments or methods were used to cause fatal injuries. Knife marks preserved in bone, for example, imply that the victim was stabbed; a cracked hyoid bone suggests strangulation. In some cases, skeletal evidence may also reveal whether injuries were self-inflicted, accidental, or the result of criminal activity. For instance, evidence of repeated blows to the back of the head would seem to be indicative of assault rather than suicide.

Anthropological analysis may also shed light on the timing, or sequence, of trauma to a body. This is frequently seen in the case of gunshot wounds to the skull, wherein intersecting fissures allow the analyst to determine the order of bullet entry. Forensic anthropologists may also use bone evidence to estimate how much time has passed between a person's death and the discovery of the remains.

In a few rare instances, forensic anthropologists have been called upon to identify persons who are still living—specifically, criminal perpetrators. In these situations practitioners are asked to compare the anatomical features of suspects, such as their hands or feet, with crime scene evidence. This evidence can take many forms, including handprints, footprints, photographs, and surveillance videos.

The Process of Identification

The first step in any skeletal analysis is the recovery of the remains, which may have been discovered by accident or in the course of an investigation. Ideally, anthropologists examine the evidence at the site of discovery (in situ) and collect the skeletal material themselves. This is the preferred method because after the remains are disturbed, it is impossible to re-create the original relationship between the environment and the remains with complete accuracy. Many forensic anthropologists, however, work in an academic rather than governmental environments, and thus skeletal matter is frequently collected by evidence technicians. These technicians are trained to search for, photograph, recover, and label physical evidence. They may also map out key scene features, such as natural landmarks and bone location, sometimes using a grid pattern for reference. Recovery must be methodical and meticulous, as the very process itself is destructive to evidence. The ability to identify clandestine graves is often critical at this stage.

After anthropologists receive remains for examination, they must first determine whether the material in question is actually bone. This can usually be done with the naked eye, but the use of a microscope or chemical analysis may be necessary if the remains suffered severe damage such as burning or fragmentation. When the material has been positively identified as bone, the practitioners must determine whether the skeletal matter is from a human or a nonhuman. Again, this can normally be determined through visual inspection, especially if the anthropologists compare the questioned material against known animal specimens. If the remains are very small pieces or in very poor condition, however, examination of the microscopic structure of the bone maybe required.

Next, the examiners must determine whether the bone is of such an age as to be of forensic significance. Generally speaking, skeletal remains are of archaeological—not forensic—interest if they are from a person who has been dead at least fifty years. All available environmental factors, such as weather and burial conditions, are considered in this assessment, which is also referred to as the determination of the postmortem interval. Making such estimations is not an exact science, so anthropologists usually express their opinions on postmortem intervals in the form of ranges or approximations.

After these preliminary questions are answered in the affirmative, the process of personal identification can begin. First, the skeletal material is classified according to such general features as sex, ancestry, stature, and age at death. Practitioners distinguish these features by analyzing traits—particularly measurements—that correlate with particular subgroups of humans, such as female or adult humans. Although the discernment of some of these traits requires microscopic comparison, many traits are outwardly recognizable. For instance, most forensic anthropologists can determine the sex of adult remains simply by viewing the pelvic structure, which is designed to accommodate birth in female but not in male humans.

An Early Triumph for Forensic Anthropology

Forensic anthropology made one of its earliest appearances in 1897 at the trial of Adolph Luetgert in Germany. Luetgert stood accused of murdering his wife and then stewing her remains in a sausage vat until they were reduced to sludge. His attempt to hide this evil deed was thwarted when George A. Dorsey, who held a doctorate in anthropology from Harvard University, testified at trial that small bone fragments found in the vat came from a human; the defense had argued the fragments were animal bone. Although Dorsey's testimony was later criticized, the case stands as one of the earliest instances in which an anthropologist testified regarding skeletal evidence in a legal context.

All members of a subgroup do not exhibit identical features, however, so anthropologists must consider ranges of variation within each subgroup. The ranges they use are based on data gathered from collections of documented skeletons such as the Robert J. Terry Anatomical Skeletal Collection at the National Museum of Natural History in Washington, D.C., the Hamann-Todd Human Osteological Collection at the Cleveland Museum of Natural History, and the FDB. Anthropologists also use a specialized software package called FORDISC to interpret their measurements. Developed by researchers at the University of Tennessee, this interactive computer program allows practitioners to classify adults by sex or ancestry through any combination of standard dimensions.

The general characteristics determined through the examination are then assembled into a description that may in turn lead to a tentative identification. For example, the profile of a missing thirty-eight-year-old white man, approximately 6 feet 2 inches in height, may correspond with found skeletal material. A specific, positive identification is not possible, however, until features that are unique to an individual—not a subgroup—are matched to the remains. Practitioners start this process by gathering as many data as possible about the tentatively identified person. Often medical records will reveal key distinguishing features, such as healed fractures, bone disease, or surgical implants. Additionally, if facial portions of the skull are found, a reconstruction can be generated and compared with photographs of the person during life.

In addition to identifying the deceased, anthropologists can provide information about bone trauma, particularly as it relates to cause of death. Skeletal injury generally falls into one of three categories: gunshot wounds, blunt trauma, or sharp trauma. Practitioners use visual observation and three-dimensional digital reconstructions to detect and analyze evidence of skeletal injury.

In the case of gunshot wounds, anthropologists generally try to determine the direction of fire (the projectile's assumed path of travel), whether the marks on the bones are entrance or exit wounds, the caliber of the bullet, and, if multiple bullet marks are found, the sequence of shots fired. Fissure patterns and the appearance of individual wounds, especially whether the edges are beveled, are critical features in this analysis. In cases where persons have died from blunt force trauma, anthropologists examine the resulting unhealed fractures. In some instances these fractures may be depressed in shapes identical to those of the instruments used to inflict the injuries, allowing for identification of the weapons. In situations involving sharp force trauma, most commonly stabbings, knife marks are usually found in the rib cage or on adjacent bones. Cut marks may also be found at the ends of arm or leg bones, however; this suggests that the perpetrator dismembered or de-fleshed the body in an attempt to prevent discovery of the body or identification of the victim.

Forensic anthropologists are often asked to determine whether skeletal injuries were inflicted before death (antemortem), at the time of the death (perimortem), or after death (postmortem). Practitioners can readily identify whether certain artifacts, such as concretions or cracks, resulted from postmortem events such as chemical erosion, animal activity, or intentional displacement. The key feature in this analysis, however, the trademark sign of antemortem trauma, is evidence that the injury has healed. Antemortem trauma, although not always indicative of the cause of death, is still important in criminal investigations because it may suggest that the victim was tortured or otherwise abused prior to death.

The accuracy of skeletal analysis, whether it is used to determine identity or cause of trauma, depends on the quantity and quality of skeletal remnants available for examination. Anthropologists frequently work alongside other forensic specialists who can confirm or support their conclusions, including odontologists and pathologists.

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Further Reading

Bass, Bill, and Jon Jefferson. *Death's Acre: Inside the Legendary Forensic Lab the Body Farm Where the Dead Do Tell Tales*. New York: G. P. Putnam's Sons, 2003. Offers a firsthand explanation of the fascinating research performed at the University of Tennessee's Body Farm.

Byers, Steven N. *Introduction to Forensic Anthropology*. 3d ed. Boston: Pearson/Allyn & Bacon, 2008. Comprehensive textbook addresses the subject in a manner that is both thorough and accessible.

Krogman, Wilton Marion, and Mehmet Yasar Iscan. *The Human Skeleton in Forensic Medicine*. 2d ed. Springfield, Ill.: Charles C Thomas, 1986. Updated and expanded version of Krogman's classic work, first published in 1962.

Reichs, Kathleen, ed. *Forensic Osteology: Advances in the Identification of Human Remains*. 2d ed. Springfield, Ill.: Charles C Thomas, 1998. Collection of essays includes contributions about the history, scope, and specialized methodologies of forensic anthropology.

Steadman, Dawnie Wolfe. *Hard Evidence: Case Studies in Forensic Anthropology*. Upper Saddle River, N.J.: Prentice Hall, 2003. Presents constructive case studies that demonstrate the scientific foundations of forensic anthropology as well the broad scope of its modern applications.

Ubelaker, Douglas, and Henry Scammell. *Bones: A Forensic Detective's Casebook*. New York: M. Evans, 2000. Intriguing, highly readable compilation of dozens of "true crime" anthropological cases, from ancient history through the end of the twentieth century.

White, Tim D., and Pieter A. Folkens. *The Human Bone Manual*. Burlington, Mass.: Elsevier Academic Press, 2005. Compact volume offers critical information about skeletal identifications as well as hundreds of illustrations and photographs. Intended for use by professional anthropologists, forensic scientists, and researchers.

See also: Anthropometry; Autopsies; Body farms; Decomposition of bodies; Forensic archaeology; Forensic odontology; Forensic pathology; Forensic sculpture; Fracture matching; Osteology and skeletal radiology; Skeletal analysis; Taphonomy.

Forensic archaeology

Definition: Profession in which standard archaeological field methods are applied to the recovery of evidence from forensic scenes and archaeological theory and experimental research findings are applied in the interpretation of such scenes.

Significance: Forensic scenes containing human remains and artifacts (representing homicides, suicides, or accidental deaths) are often initially investigated by law-enforcement personnel with limited experience in detailed data recording. When this occurs, much critical on-site evidence may be lost. The application of archaeological techniques of mapping and recovery allows for complete documentation of forensic scenes, which, in turn, permits more thorough interpretation of the events that created the scenes and strengthens the courtroom testimony of the law-enforcement officers involved.

Forensic archaeology is a specialized area in the broader field of forensic anthropology, focusing on field investigation as an initial stage in the analysis of crime scenes or other forensic settings. The goal of the application of archaeological methods is to obtain the maximum amount of information at a forensic scene before human remains and artifacts are removed to the laboratory for chemical or other analyses. Precise archaeological field techniques began to be developed in the late nineteenth century in England, but such techniques have regularly been applied to forensic investigations only since the 1990's. Areas of archaeology most directly applicable to forensic science include search-and-recovery methodology and interpretation.

Search and Recovery

Archaeological survey and excavation methods can readily be applied to forensic settings. The walkover survey, wherein individuals spaced at regular intervals along a line walk across an area and flag any remains or items visible on the surface, is one such method. If significant items are located during such a survey, then surveying equipment, such as a transit or compass, is used to establish a grid over the area for precise mapping of flagged items. Photographic documentation and production of detailed maps showing the locations of items before removal are vital in recording their spatial associations. The location of a datum, or a principal measuring point for a map, is triangulated to permanent landscape features or recorded by a Global Positioning System (GPS) device. In addition to human personnel, cadaver dogs may be used to detect decayed remains.

Such a survey can also identify disturbed soil or vegetation indicating a possible covert burial. Geophysical remote-sensing equipment, such as ground-penetrating radar, metal detectors, or proton magnetometers, can be used to detect remains buried at various depths. More intrusive methods, such as probing the ground with a metal rod or taking samples with a soil core or auger, may also be used.

For hidden or covert burials, excavation follows the standard archaeological procedures for excavating features, as is done for storage pits or cellars on archaeological sites. The identified burial area is first photographed, and then overlying leaf litter or other loose vegetation is cleared and a small grid (with a datum for a measuring reference point) is established over the identified area. A plan (horizontal) drawing of the area is made, and then one-half of the burial feature is initially excavated. Care is taken to leave objects or remains in place or, if they have to be removed, to photograph and record their horizontal and vertical (depth) measurements in relation to the grid. After complete excavation of the first half, a section (vertical) drawing is made of the wall of the remaining half of the feature, and the remaining portion is then excavated. All excavated soils are screened or sifted through small-mesh (usually one-quarter inch) hardware cloth to recover small items.

Through this process, the entire body, along with associated artifacts, is exposed. All remains and artifacts are photographed, inventoried, and placed separately in evidence bags. Samples for specialized laboratory analysis are also collected during the course of excavation. Soil, plant material, and insect remains are sampled, as analysis of these can aid in the determination of the environment of the burial, whether the remains have been moved from another location, and time since death. Photography and mapping occur at every stage of the excavation. The end products are not only the recovered evidence but also descriptive notes, spatial measurements, and photographs of all items and their places in the forensic setting.

Internationally, forensic archaeology methods are used in the investigation of mass graves resulting from genocide or other war crimes so that the persons responsible can be successfully prosecuted based on recovered evidence. Forensic archaeology methods have been used to collect evidence in such human rights cases in Argentina, Guatemala, Peru, Central Europe, and Iraq, as well as other regions.

Interpretation

Experimentation to reconstruct past events and artifacts has a long history in archaeology. Such experimentation is based on the hypothetico-deductive method, wherein researchers first examine observations from a variety of specific cases to develop broad hypotheses explaining the observations. Then, using new data from new experiments, the researchers test these hypotheses for their validity. In archaeology, these tests are referred to as actualistic studies; in these studies, researchers make experimental observations in the present

How Not to Excavate a Crime Scene

In an episode of the popular television crime drama *Bones*, one of the lead characters, Dr. Temperance Brennan, a forensic anthropologist, is seen working an excavation of multiple covert burials placed by a serial killer. No obvious grid appears over the burials, and no clear use of any measuring equipment is portrayed. At one point, Brennan picks up a skull and tosses it to her partner, FBI agent Seeley Booth. Brennan has just broken several rules of proper crime scene investigation and has compromised evidence.

Under the supervision of the Smithsonian Institution in 2004, a team of archaeologists working in Maryland's Talbot County uncover the skeletal remains of people believed to have been early seventeenth century African and European settlers. With the help of ground-penetrating radar equipment, the team found the graves of one dozen people. *(AP/Wide World Photos)*

and then use those observations to interpret past events or processes.

Experimental archaeological studies of taphonomy, or the decay process that transforms living organisms after death, and theoretical explanations of this process can be used to interpret forensic scenes. For example, archaeologists might give a fresh nonhuman bone to a carnivore, such as a dog, and observe the animal's chewing behavior. Which parts of the bone are chewed first? How does a carnivore degrade the bone over specified time periods? What are the special markings left on the bone signifying carnivore activity? How far have bones been moved from their original locations? Answering these questions through direct observation can help forensic scientists interpret crime scenes by comparing recovered bones to known experimental examples.

Many studies of this kind have been done to document the effects of carnivores, rodents, and even vultures on remains from forensic scenes. Application of the findings from experimental studies of movement or alteration of remains by scavenging animals, weathering effects, and extent of decay can thus help forensic archaeologists to distinguish natural from human-induced damage and can aid in the determination of time since death. Investigators may also reconstruct the chain of events leading to a given forensic scene through careful attention to these taphonomic effects and the recorded field data. Law-enforcement efforts thus benefit not only from the precise recording methods provided by forensic archaeology but also from enhanced interpretive data based on scientific experimentation in the field.

Cliff Boyd

Further Reading

Byers, Steven N. *Introduction to Forensic Anthropology*. 3d ed. Boston: Pearson/Allyn &

Bacon, 2008. Comprehensive textbook provides a broad survey of forensic anthropology, emphasizing analysis of the human skeleton and identification of trauma and other postmortem alterations of bone.

Dupras, Tosha L., John J. Schultz, Sandra M. Wheeler, and Lana J. Williams. *Forensic Recovery of Human Remains: Archaeological Approaches*. Boca Raton, Fla.: CRC Press, 2006. Provides detailed descriptions of search and recovery methods and the equipment used for such purposes in forensic scene investigations. Includes standardized recording forms and conversion tables in appendixes.

Haglund, William D., and Marcella H. Sorg, eds. *Advances in Forensic Taphonomy: Method, Theory, and Archaeological Perspectives*. Boca Raton, Fla.: CRC Press, 2002. Extensive edited volume presents several case studies of the recovery of human remains in a variety of settings, including remains found in water, in burned structures, and in mass graves. Emphasizes the taphonomic effects on bone in these different settings.

Killam, Edward W. *The Detection of Human Remains*. 2d ed. Springfield, Ill.: Charles C Thomas, 2004. Presents thorough descriptions of intrusive and nonintrusive forensic search methods, including various forms of remote sensing.

Komar, Debra A., and Jane E. Buikstra. *Forensic Anthropology: Contemporary Theory and Practice*. New York: Oxford University Press, 2008. Advanced text highlights the medicolegal and judicial systems and the influence of legal and ethical issues on forensic investigation.

See also: Ancient criminal cases and mysteries; Buried body locating; Cadaver dogs; Crime scene documentation; Crime scene investigation; Crime scene measurement; Crime scene search patterns; Decomposition of bodies; Exhumation; Forensic anthropology; Forensic palynology; Kennewick man; Metal detectors; Peruvian Ice Maiden.

Forensic botany

Definition: Specialized field of study concerned with the examination of plant material in relation to crimes.

Significance: The ubiquity of plants and plant-derived products and the potential for identifying the sources of plant material from small fragments make plants and plant parts very useful tools for tracing the movements of people and objects. Forensic botany can also determine the identities and sources of vegetable matter material to crimes, including drugs, rare plants, and stolen timber.

Because the use of botanical evidence to link a suspect to a crime scene depends on comparison of fragments, investigators need to collect reference samples at the scene, dry them to prevent deterioration, and store them in sealed containers. Bits of vegetable matter found adhering to suspects' clothing or in suspects' vehicles or dwellings should be similarly preserved. On-site identification of species likely to have left evidence, such as bur-producing herbs along an escape route, is helpful.

Most botanical analyses require microscopic examination. By examining the size, arrangement, and ornamentation of cell walls in a small wood fragment, an expert can often tell the genus of tree from which the fragment came. Hairs, venation, and epidermal cell arrangement are clues to the identity of leaf fragments. Pollen is extremely diagnostic. Mosses, identifiable to species based on cellular patterns, are potentially powerful diagnostic tools because many species are quite habitat-specific. Fungal spores recovered from stomach contents during autopsy can determine whether a suspicious death is attributable to mushroom poisoning.

A field survey of vegetation can pinpoint the timing of an event. Knowing the usual plant succession following disturbance in an area, a botanist can help locate a buried body or estimate the amount of time elapsed since burial. If vegetation is damaged during commission of a crime, the developmental stages of uprooted plants and broken limbs will indicate the season when the damage occurred. Annual growth rings in roots help date long-buried skeletal remains.

Dendrochronology is a useful forensic tool. The sequence of annual rings in a large piece of wood can indicate the year of harvest, geographic source, and sometimes the individual identity of the parent tree.

DNA (deoxyribonucleic acid) comparison can detect not only species but also populations and individuals, establishing, for example, that a murder suspect's truck collided with a particular tree. In one California case, comparison of the DNA of live oak leaves from a burial site with DNA of leaves on a suspect's truck showed the leaves originated elsewhere. As DNA analysis becomes more routine, more widely available, and less costly, its use to identify plant material in forensic cases is likely to increase.

Diatoms, a type of microscopic aquatic alga producing an ornamented silica shell, provide valuable clues in crimes involving bodies of water. The presence or absence of certain species of diatoms in the lungs of a body recovered from water will indicate whether the person drowned there or the body was dumped after death occurred elsewhere. A forensic botanist can determine how long a submerged body has been in the water by examining the colonization of the body by algae and aquatic fungi.

Types of Investigations

The uses of forensic botany in murder investigations include demonstrating that a suspect was present at the crime scene through identification of plant fragments on clothing or in vehicles, locating the crime scene if the body is dumped at a remote location, tracing the victim's movements prior to the murder through plant material on clothing or in stomach contents, tracing wooden items used in perpetrating the crime, locating buried bodies, and recon-

Cases Involving Forensic Botany

The case of the notorious 1932 kidnapping and murder of the son of pioneering aviator Charles A. Lindbergh marked the earliest successful use of expert botanical testimony to prosecute a murderer. Arthur Koehler, a wood expert with the U.S. Forest Service, identified part of the ladder used in the kidnapping as low-grade pine used in interior construction. When suspicion fell on Bruno Hauptmann, detectives searched Hauptmann's apartment and found a sawn-off board in his attic, the end of which exactly matched the ladder from the crime scene. This evidence was crucial in securing Hauptmann's conviction.

Dr. Jane Bock of the University of Colorado, a pioneer in forensic botany in the United States, got her start in 1982 when detectives investigating the murder of a young woman asked Bock to analyze the victim's stomach contents. Lacking a reference collection, Bock chewed, spat out, and examined samples of common plant food items and, by making comparisons, concluded that the victim must have eaten her last meal at a salad bar. This information led to inquiries at restaurants and eventually led investigators to the murderer. Bock and her colleague David Norris subsequently published a catalog of diagnostic structures found in plant-derived foodstuffs.

In 2002, Bock was asked to investigate the death of a toddler found drowned in Bear Creek in Merced, California. The child's mother reported that the little boy had been abducted at a fountain in another location. Bock found that water in the child's stomach contained diatoms from both locations. Confronted with this evidence, the mother confessed to having drowned the child herself in the fountain.

Botanical evidence and DNA provided the only evidence as to identity and cause of death when the torso of a black boy was recovered from the Thames River in 2001. Plant material in stomach contents revealed that the victim had been in England during the week immediately prior to his death; lower intestinal contents showed that he was a recent arrival from West Africa. The stomach also contained quantities of a toxic African legume seed. Authorities suspected but could not prove that a ritual killing was involved. They were able to use the botanical evidence to trace the human traffickers who had smuggled the boy into the United Kingdom.

structing the timing and sequence of events through vegetational disturbance at the crime scene. In cases of rapes, robberies, and assaults, plant evidence can help demolish alibis by demonstrating high probability of a suspect's having been at a particular place at a particular time. When a perpetrator flees a crime scene through a weedy field, burs and pollen from the species growing in the field will adhere to that person's clothing. A man who committed a rape in a patch of poison ivy was convicted based on the evidence presented in court concerning a rash he had on body parts not normally exposed to nature.

Drug-producing plants are usually identified through chemical testing for the active principle, but identification of the plant itself is sometimes important. Under laws that prohibited the growing and selling of *Cannabis sativa* (marijuana) but not other species of the *Cannabis* genus, a few suspects successfully defended themselves by presenting expert testimony to the effect that they had been in possession of a different species. Most states now ban the entire genus. When the chemical test is nonspecific or will detect levels of the drug found in legal materials, botanical examination of the seized material's morphology will confirm or refute its identity as contraband—for example, by determining that a supposed shipment of marijuana has been so cut with oregano that there is insufficient drug present to support prosecution.

Wildlife biologists sometimes examine animal stomach contents for forensic purposes, such as to determine whether an animal was killed on private land or within a nature reserve, or whether an animal has been feeding on toxic plants. Cases of deliberate human poisoning by toxic plants, including mushrooms, are extremely rare; consequently, the determination that a suspicious death can be attributed to a vegetable toxin creates a strong presumption of accidental death.

Botanical evidence is important in cases of fraud and theft involving plants and plant parts. Determining the species and ages of particular pieces of wood through anatomy and dendrochronology can help to expose art forgery and sale of reproductions as antiques or indigenous folk art. In cases involving large-scale theft of agricultural crops, determining the variety or seed source may be important. DNA analysis is used to prosecute cases of patent infringement involving deliberate propagation of genetically engineered crops and to trace the inadvertent, sometimes deleterious, migration of introduced genes into weedy species.

Forensic botany can reconstruct the timing and progression of an illegal logging event for years after it occurred and can identify logs or even sawn timber by matching tree rings to those on cut stumps. By determining the identity of individual plants or restricted populations through DNA analysis, experts can distinguish between an illegal wild source and a legitimate cultivated source for rare and endangered plants such as orchids and cycads.

Many forensic applications of botany depend on the availability of investigators trained in plant morphology and taxonomy, disciplines increasingly neglected in American universities. In the future, DNA analysis, the application of which does not depend on field experience or specific training in any particular group of organisms, will probably become the preferred tool for identification of plant material at crime scenes.

Martha Sherwood

Further Reading

Coyle, Heather Miller, ed. *Forensic Botany: Principles and Applications to Criminal Casework*. Boca Raton, Fla.: CRC Press, 2005. Comprehensive volume includes chapters on general botany, descriptions of specific forensic techniques, and accounts of individual cases.

Lane, Meredith A., et al. "Forensic Botany: Plants, Perpetrators, Pests, Poisons, and Pot." *Bioscience* 40, no. 1 (1990): 34-39. Presents a brief overview of the topic. Aimed toward encouraging the study of botany.

Nijhuis, Michelle. "Profile: Of Murder and Microscopes—How Botanist Jane Bock Became a Crime Fighter." *Sierra Magazine*, May/June, 2007. Biographical profile of Bock details how she developed her methodology.

Yoon, C. K. "Botanical Witness for the Prosecution." *Science* 260 (1993): 894-895. Provides a

general overview of forensic botany along with specific case examples.

See also: Buried body locating; DNA analysis; Forensic palynology; Lindbergh baby kidnapping; Microscopes; Pollen and pollen rain; Soil.

Forensic dentistry. *See* Forensic odontology

Forensic entomology

Definition: Application to legal issues of knowledge gained from the study of insects, their life cycles, and by-products.

Significance: Sometimes called upon to assist in legal investigations in both civil and criminal proceedings, forensic entomologists collect insect evidence that may be used to support the cases of either the prosecution or the defense.

Entomologists study insects, which constitute the largest and most diverse class of animals in the world. Accounting for nearly two-thirds of all known animal species, insects are found in all terrestrial environments on Earth. Some species even live in the oceans. Insects play vital roles in the health and well-being of many other species of both animal and plant life and thereby help to maintain the balance of life on the planet.

Forensic applications of entomology have long had an important role in both civil and criminal legal cases. Indeed, forensic entomology may be said to go back at least as far as the thirteenth century, when the Chinese scholar Song Ci (Sung Tz'u) commented on the value of evidence from flies in a murder investigation. *Xi Yuan Ji Lu* (1248; various English translations of the title include *The Washing Away of Wrongs* and *Collected Cases of Injustice Rectified*), Song Ci's treatise on forensic medicine, addressed a case in which a murderer was caught when flies were attracted to the sickle he had used as his murder weapon. However, although the first documented case in which entomology assisted in a death investigation dates back to the thirteenth century, the field of forensic entomology did not become established as a profession until many centuries later and became recognized for its value to forensic science only during the late twentieth century.

Applications in Civil Law

Litigants in civil cases might employ forensic entomologists to inspect shipments of food they suspect are contaminated by insects. In cases in which insect parts are found among food products, one of the first questions that forensic entomologists attempt to answer is when the foreign material was introduced. Whether insect parts were introduced at the time of manufacture, while the food was being stored, or at some moment following delivery can have important legal ramifications. In such cases, forensic entomologists identify the suspected contaminants and try to determine how and when they were introduced into the food.

Forensic entomologists are also sometimes involved in civil cases relating to sales of real property, such as houses that are found to be infested with insects. Again, a primary legal question that is likely to arise in such cases is when the infestations occurred. Cases of that nature require the forensic entomologists not only to identify the species infesting the structures but also to determine all the stages of the insects' growth and development. To define "infestation" legally, an understanding of the insects' life cycles is required. Consequently, forensic entomologists must identify and address examples of each state of insect development—from eggs to larvae and adults—to determine how long the properties have been infested.

Postmortem Investigations

Because of the increased popularity of mass-media depictions of death investigations, such as television's *CSI* programs, many people associate forensic entomology primarily with murder investigations. Trained forensic entomologists do many other kinds of work; however, they certainly do play important roles in estimating the lengths of decedents' postmortem intervals (PMIs), that is, how long people have been dead. By understanding how insects have been distributed in both time and space, forensic entomologists can often determine where and when crimes have taken place. Their work can reveal when dead bodies have been moved and the seasons of the year within which crimes have occurred.

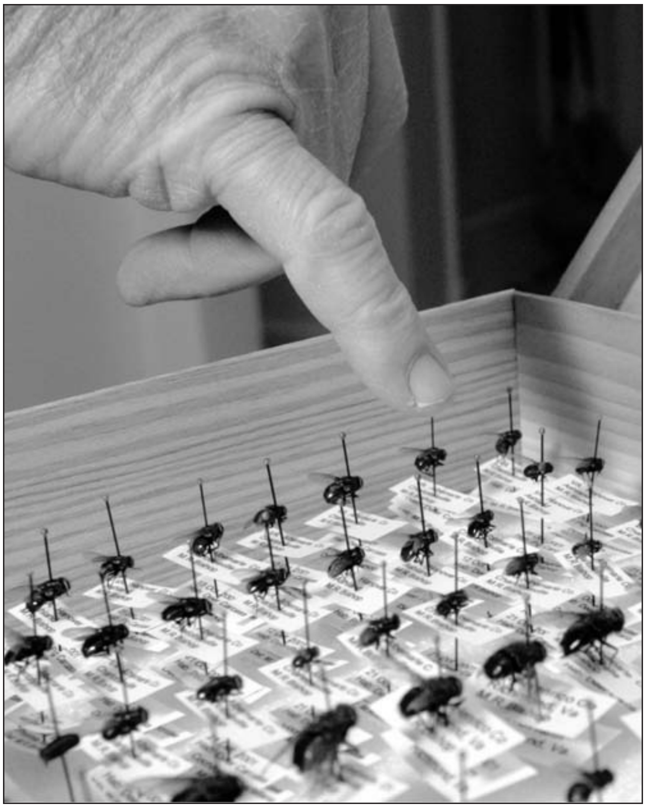
Forensic pathologists apply a variety of techniques to estimate how long decedents have been dead. For example, they study the stages of algor, livor, or rigor mortis in dead bodies. In cases in which pathologists cannot accurately determine PMI, forensic entomologists can often help. This is because insects frequently invade dead bodies and assist in the decomposition process.

Among the hundreds of insect species attracted to human corpses, the most important include flies and beetles and their larvae, as well as ants, bees, mites, wasps, and other species. Blowflies, houseflies, and flesh flies are particularly well documented as prolific and efficient contributors to decomposition. Indeed, flies are typically among the first insects to arrive on dead bodies. Blowflies often arrive within minutes after death, unless barriers impede their access to the bodies, in which case they may not arrive until several days later. Among the things that impede the arrival of insects are speedy burials; the enclosing of bodies in containers or airtight wrappers; the chemical treatment of remains with insecticides, fertilizers, or bleaches; and even such natural environmental conditions as precipitation and low air temperatures. Flies are typically inactive in rain and fog, at night, and when air temperatures drop below 65 degrees Fahrenheit (18.3 degrees Celsius).

Flies and Decomposition of Human Bodies

Most techniques employed to estimate PMI are temperature-dependent, as warmer temperatures accelerate decomposition and cooler temperatures slow it. Temperature has the same effects on insect activity. Some time after death occurs, adult flies arrive on the body and begin laying eggs. The eggs later hatch into maggots that assist the decomposition process by devouring the dead flesh. Other insects that arrive later may compete with the first arrivals. Knowing the sequences in which the insects arrive and their life cycles can enable scientists to estimate how long the individual has been dead. Because of their predictable behaviors, insect species can provide valuable forensic evidence not only about PMI but also about the causes, manner, and circumstances surrounding human deaths. Such information is deduced from such evidence as the distribution of different insect species on corpses and their chemical makeups.

Because common houseflies feed mostly on



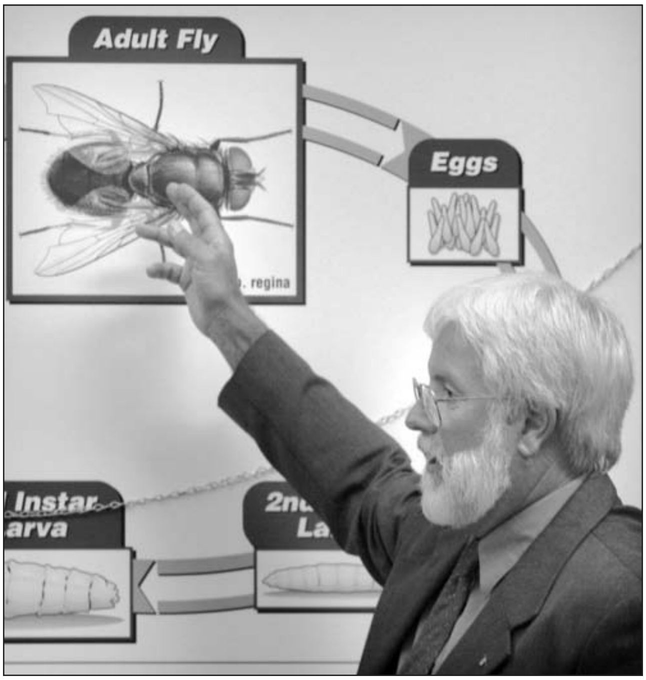
Insect samples used to identify the bugs found on dead human bodies. By identifying the insects present on bodies when they are discovered, along with the stages of the insects' lives, forensic entomologists can determine how long the decedents have been dead. *(AP/Wide World Photos)* vegetation and fecal matter, they are not primary decomposers. They do, however, lay eggs in used human diapers, making it possible for entomological information to be found that may apply to cases involving the abuse of babies and elderly persons. Maggots recovered from used diapers or bedsores can be useful in estimating how long babies and elderly persons have been neglected by those responsible for their care.

In contrast to blowflies and houseflies, which lay hundreds of eggs at a time, flesh flies do not lay eggs. Instead, they squirt out live maggots on the host bodies. Within a few hours, a single flesh fly can deliver hundreds of maggots.

Regardless of whether they emerge from eggs or are born alive, the maggots of all fly species develop through three successive and readily identifiable larval stages, or instars, until they are ready to pupate. During their pupa phases maggots undergo a metamorphosis and later emerge as adult flies. The entire life cycles of flies—from eggs to pupae—are temperature-dependent. Forensic entomologists must therefore not only identify the species of flies recovered at crime scenes but also determine the temperatures and environmental conditions in order to reconstruct accurately the chronology of the insects' life cycles. Their first objective is to estimate the minimum length of time required for a body to reach its current level of decomposition. That figure is a function of the maximum length of time it may have taken for an insect population to achieve the stage of development found on the body at the time of its discovery.

To determine the lengths of the life cycles of insects found on bodies, entomologists collect live specimens and breed them under carefully managed conditions. By matching the temperatures and humidity levels prevailing at the crime scenes, they can obtain fairly accurate estimates of how long the bodies have been dead by comparing the stages of development of the insects found on the bodies with the stages through which the control samples are developing.

Turhon A. Murad



A forensic entomologist explains the life cycle of flies to the jury during a California murder trial in 2002. *(AP/Wide World Photos)*

Further Reading

Byrd, Jason H., and James L. Castner, eds. *Forensic Entomology*. Boca Raton, Fla.: CRC Press, 2000. Rich collection of essays examines vital issues in the field. Some of the essays may assume more knowledge about insects than novice readers are likely to have.

Erzclioglu, Zakaria. *Maggots, Murder, and Men*. New York: Thomas Dunne Books, 2002. Useful collection of case studies offers basic entomological information and discussions of how forensic entomology is used, and misused, in court.

Goff, M. Lee. *A Fly for the Prosecution: How Insect Evidence Helps Solve Crimes*. Cambridge, Mass.: Harvard University Press, 2001. Lively, easy to read, and at times almost journalistic account of the field of forensic entomology by one of the leading authorities in the field. Lavishly illustrated.

Greenberg, Bernard, and John Charles Kunich. *Entomology and the Law*. New York: Cambridge University Press, 2002. Comprehensive textbook presents discussion that is both accessible to novices and essential to professionals.

Sung Tz'u. *The Washing Away of Wrongs: Forensic Medicine in Thirteenth-Century China*. Translated by Brian E. McKnight. Ann Arbor: Center for Chinese Studies, University of Michigan, 1981. The only English edition of Song Ci's thirteenth century treatise on forensics.

See also: Adipocere; Animal evidence; Autopsies; Body farms; Crime scene cleaning; Decomposition of bodies; Exhumation; Forensic pathology; Hemorrhagic fevers; Physiology; Taphonomy.

Forensic Files

Date: First aired in 2000

Identification: Half-hour documentary-style television series that outlines the background and forensic procedures used to solve real crimes and other mysteries.

Significance: *Forensic Files* was among the first major television series to examine forensic procedures employed in specific criminal investigations, and its success contributed to increased attention to forensic science among the general public.

In the late 1990's, the use of forensic sciences in criminal investigations captured the imagination of television viewers in the United States. Both reality-based, documentary-style and fictionalized programs helped to change the public perception of forensics from dry science to glamorous endeavor.

History

Originally airing under the title *Medical Detectives* on cable television's TLC (The Learning Channel) on the heels of the O. J. Simpson murder trial in 1995, the show that became *Forensic Files* was picked up by cable network Court TV (now truTV) in 2000. Airing five nights each week, it rapidly gained popularity. The National Broadcasting Company (NBC) used episodes of *Forensic Files* as a summer replacement series in 2002—the first time an original cable show had been aired on a broadcast network during its cable run. By 2007, the series was attracting more than a million viewers each week to Court TV and had become the cable network's top-rated show. It also was airing—under various titles, including *Forensic Files* and *Medical Detectives*—in more than 140 countries worldwide.

Although at least one previous television crime series, *Quincy, M.E.* (1976-1983), had developed some interest in the forensic sciences among the public, that show was fictional and focused primarily on the main character, a medical examiner, rather than on scientific principles. In contrast, *Forensic Files* was among the first to examine forensic procedures in a documentary television format, and it became a catalyst for the development of popular fictional drama series featuring forensics, such as *CSI: Crime Scene Investigation* and its spin-offs.

Forensic Files is produced by Medstar Television in association with Court TV Original Productions. Medstar produces health-related materials for a variety of private and public forums, including the Discovery Channel, the Public Broadcasting Service (PBS), and TLC. Paul Dowling, the show's executive producer and cofounder of Medstar Television, has been quoted as noting that the premise of *Forensic Files* is to demonstrate that science can "beat the bad guys." A spin-off program called *Forensic Files Advanced* was launched in 2006 that provides additional information on previously aired cases in the form of pop-ups.

Format

In each episode, *Forensic Files* focuses on a single criminal case—often a murder—and demonstrates how forensic procedures were used to solve the crime. The material is presented typically in the form of a chronology of events, from initial investigation through court or other legal resolution. Cases are culled from a variety of sources, including magazine and newspaper stories and suggestions from scientists and investigators, and are usually selected based on their intrigue value.

The show primarily follows an interview format, with commentaries from various parties on the case at hand, including family members of victims, detectives, anthropologists, journalists, medical examiners, and criminologists. Although the show is billed as a documentary and the episodes generally depict relatively little action, the producers use music, reenactments of actual events, computer animation, and other dramatic devices to give the series the ambiance of a crime mystery. The crime reenactments are typically shot in a different videographic style and frequently depict alternate explanations of the crime that are eventually disproved. Most of the cases presented do not involve high-profile crimes, but they often contain bizarre elements that enhance the show's "whodunit" aspects.

Although *Forensic Files* often highlights cases currently in the news, many of the crimes examined on the show were initially considered "cold cases"—cases that had long gone unsolved—until newer forensic technologies were used to crack them. In fact, forensic advances are often a key plot element in the program, and occasional hour-long *Forensic Files* specials are aired that focus on high-profile investigations such as the 1932 abduction and murder of the son of famed aviator Charles A. Lindbergh and the 1963 assassination of President John F. Kennedy. In addition, the show often focuses on cases in which persons who had been convicted of crimes were eventually exonerated thanks to cutting-edge forensic techniques. Criminal investigations are the primary fare of *Forensic Files*, but the program occasionally explores other realms of forensic investigation, including accidents, civil cases, suicides, and mysterious health issues, such as Legionnaires' disease and outbreaks of disease caused by hantaviruses.

Contrast with Fictional Programs

Unlike fictional crime dramas, which frequently exaggerate the capabilities of forensic science, *Forensic Files* examines real-life forensic techniques in the context of common usages. For example, the show rarely focuses on DNA (deoxyribonucleic acid) analysis and other techniques that have become part of the mainstream lexicon but are sparingly employed in real life. Such procedures are often extremely costly, and results may not be available for months, as many forensics laboratories are seriously overburdened. Well-known forensic procedures such as ballistics and fingerprinting are frequently featured on *Forensic Files*, but the program also highlights more unusual evidence and exotic techniques such as forensic zoology, botany, and psychology.

Although *Forensic Files* depicts more of the gritty reality of forensic investigation than do fictional dramas such as *CSI*, some critics have argued that, like other crime shows, it creates an overly glamorous picture of forensic work. Critics have also asserted that *Forensic Files* serves to bolster the false assumption that forensic science is infallible, as it fails to acknowledge the true limitations of the science.

Cheryl Pawlowski

Further Reading

Dowling, Paul, with Vince Sherry. *The Official "Forensic Files" Casebook*. New York: iBooks, 2004. Takes readers behind the scenes of the television show and discusses major breakthroughs in the forensic sciences. Includes a glossary.

Evans, Colin. *The Casebook of Forensic Detection: How Science Solved One Hundred of the World's Most Baffling Crimes*. Updated ed. New York: Berkley Books, 2007. Covers crimes dating from the eighteenth century forward, organized according to the forensic techniques used during the investigations.

Noguchi, Thomas T., with Joseph DiMona. *Coroner*. New York: Simon & Schuster, 1983. Los Angeles coroner Noguchi explores some of the more famous cases in which he was involved, including the deaths of Robert Kennedy, Sharon Tate, and Marilyn Monroe.

Ragle, Larry. *Crime Scene*. Rev. ed. New York: Avon Books, 2002. A forensic scientist provides a behind-the-scenes look at how forensic techniques were used to solve his most sensational cases.

Ramsland, Katherine. *The Forensic Science of "C.S.I."* New York: Berkley Books, 2001. Goes behind the crime-solving techniques dramatized on the television show to examine the reality of the cutting-edge procedures often depicted on *CSI*.

See also: Celebrity cases; *Cold Case*; *CSI: Crime Scene Investigation*; DNA extraction from hair, bodily fluids, and tissues; Homicide; Journalism; Misconceptions fostered by media; Prints; Pseudoscience in forensic practice.

Forensic geoscience

Definition: Scientific field that applies geological information and earth science techniques to investigations related to criminal or other legal proceedings.

Significance: An almost unlimited variety of earth materials, minerals, rocks, and fossils can be identified, characterized, and recognized for comparative analysis. Given the diversity of composition and unique distribution of earth materials, forensic geoscience is a useful tool for linking suspects to crime scenes.

Forensic geoscience first appeared in Sir Arthur Conan Doyle's tales of the fictional detective Sherlock Holmes, who used scientific evidence to solve crimes. The first real use of forensic geoscience occurred during a 1908 homicide case in Germany, where Georg Popp, a chemist, examined soil and rock samples from a murder scene and compared them with samples from a suspect's shoes. Popp's analysis of the samples was able to disprove the suspect's alibi. Forensic geoscience techniques are usually used in lawsuit litigation between plaintiff and defendant or in crime scene processing to provide evidence leading to the conviction or exoneration of criminal suspects.

Basis of Forensic Geoscience

Forensic geoscience is concerned with all aspects of earth materials and natural processes and phenomena associated with them, including investigations of rocks, sediments, water, air, soil, gems, fossils, dust, pollutants, and petroleum. Because of the breadth of its investigative concerns, forensic geoscience relies on many subdisciplines to accomplish its investigative goals. A forensic geoscience investigation may require the expertise of hydrologists, geophysicists, mineralogists, geoarchaeologists, gemologists, pedologists, petroleum geologists, stratigraphers, geochemists, paleontologists, geoengineers, or petrologists.

The fundamental principle in all forensic geoscience investigations is transference. Whenever any object comes into contact with another, trace evidence is transferred between the two objects. Geological materials and markers, whether natural or combined with other products, provide an abundance of transferable signatures. In the case of geological trace evidence, the transferred evidence often has unique characteristics that can be recognized and categorized. Identifying the signature of the trace evidence preserved from the transfer is crucial to identifying the source of the evidence. Because the value of earth materials as evidence is in their diversity and, often, their unique compositions, identifying the differences between samples is crucial.

Investigative Techniques

Some of the most important aspects of any criminal investigation are the questions of whether a suspect was present during the commission of a crime and whether evidence can be directly linked to a suspect or specific crime scene. Investigators often provide forensic geoscientists with samples associated with crime scenes or suspects, and the two things investigators most commonly want to know about such samples are where the materials came from and whether the materials can be linked to the crime.

The first step the forensic geoscientist takes in establishing the unique composition of earth materials from a crime scene is usually visual inspection; this is followed by geochemical tests. After studying the samples, identifying, and classifying them, the geoscientist can usually narrow down possible sources of the material. The accuracy of the conclusions drawn depends on the uniqueness of the sample materials and the knowledge and experience of the geoscientist. It is often during the initial stage of sample testing by geoscientists that additional forensic evidence is found, including fibers, hairs, insects, and botanical trace evidence such as pollens, seeds, and cellulose. These additional pieces of evidence not only aid in the overall investigation but can also help the forensic geoscientist to narrow the sample's source parameters.

Forensic geoscientists use specialized techniques and are aided by equipment designed to detect small variations in the structure and chemical composition of earth materials. The purpose of detecting these small variations is to establish with the highest possible degree of probability whether a sample is similar to other samples from a specific geographic location. In the initial stages of examining a sample, a geoscientist measures the material's particle density distribution, notes its color and size, determines its mineral composition, and looks for biological, botanical, and fossil additions.

Specialties Within Forensic Geoscience

Geoscientists with specific areas of expertise can be invaluable in certain kinds of investigations:

- Hydrologists are indispensable in investigations involving pollutants in water sources.
- Gemologists are crucial in the identification of recovered or disputed gemstones.
- Petroleum geologists and geochemists can be key figures in the tracking of petroleum linked to oil spills.
- Pedologists are expert in comparing and contrasting soil and dust samples.
- Paleontologists can aid investigations by correlating microfossils to specific geographic and environmental locations.
- Geophysicists can conduct seismic, magnetic, gravity, or resistivity surveys that may be crucial to the location of buried materials or bodies.

Forensic geoscientists also play important roles in many archaeological studies. Archaeological investigations involving geological disasters such as the volcanic eruption that destroyed Pompeii are dated through stratigraphic and petrologic methods. The migratory routes of ancient peoples are traced by the geochemistry of their stone tools, as are locations for the source materials of historic constructions such as England's Stonehenge and the great pyramids of Egypt. Many of the conclusions drawn concerning recovered ancient human remains—such as those of Europe's Ötzi the Iceman and Kennewick man of North America—rely heavily on forensic geoscience.

The most fundamental technique used by forensic geoscientists is chemical analysis for characteristic trace elements. These trace elements are derived from, and usually particular to, their original bedrock source, or they can be associated to a specific contaminated locality. Geoscientists use many techniques to confine sample variations and narrow the degree of probability in samples under investigation, including examination using specialized optical and electron microscopes, X-ray and laser diffraction, spectroscopy, gas chromatography, and chemical, fluorescence, and isotopic analyses.

Randall L. Milstein

Further Reading

Murray, Raymond C. *Evidence from the Earth: Forensic Geology and Criminal Investigation*. Missoula, Mont.: Mountain Press, 2005. One of the most easily understood and directly useful books available on the subject of forensic geology. Discusses numerous criminal cases involving forensic geology.

Murray, Raymond C., and John C. F. Tedrow. *Forensic Geology: Earth Science and Criminal Investigation*. Upper Saddle River, N.J.: Prentice Hall, 1998. Comprehensive work is an update of the classic text on forensic geology.

Pye, Kenneth. *Geological and Soil Evidence: Forensic Applications*. Boca Raton, Fla.: CRC Press, 2007. Helpful reference resource provides guidance regarding the potential value and limitations of geological and soil evidence in forensic investigations.

Pye, Kenneth, and D. J. Croft, eds. *Forensic Geoscience: Principles, Techniques, and Applications*. London: Geological Society, 2004. Collection of papers illustrates the principles of forensic geoscience and provides in-depth

discussion of the techniques used in the field.
Selinus, Olle, et al., eds. *Essentials of Medical Geology: Impacts of the Natural Environment on Public Health*. Burlington, Mass.: Elsevier, 2005. Addresses the intersection of environmental geosciences and human health, with special emphasis on toxic mineral contamination of land and water.
Wang, Zhendi, and Scott A. Stout. *Oil Spill Environmental Forensics: Fingerprinting and Source Identification*. Burlington, Mass.: Elsevier, 2007. Describes the forensic techniques used by geoscientists to identify the sources of oil spills. Case studies include the *Exxon Valdez* incident of 1989.

See also: Chromatography; Control samples; Gas chromatography; Geographic profiling; Geological materials; Isotopic analysis; Sherlock Holmes stories; Soil; Trace and transfer evidence.

Forensic linguistics and stylistics

Definition: Study of the interaction of language and the law, including using language as evidence.

Significance: Forensic linguistics and stylistics often play crucial roles in police investigations, evidence gathering, and courtroom testimony. Many forensic linguists provide expert testimony relating to such issues as the likelihood that a particular individual produced certain documents or was the person speaking on a questioned recording. Such experts are also called upon to determine the likelihood that persons might be lying on the basis of their voices and linguistic qualities.

Forensic linguistics and stylistics are tools used to gain information about individuals on the basis of the language they have used. Many different types of crimes can result in written or spoken evidence that may be used to help determine the identities of the criminals. Some written or spoken evidence may be left by criminals on purpose, such as ransom notes or threatening voice mail messages. Other linguistic evidence may be provided inadvertently, such as in recorded conversations or in notes between accomplices. No matter how the investigators acquire such evidence, forensic linguistic specialists can analyze it to provide information about the individuals in question.

Analysis of Written Language

Written language is extremely complex. Letters are arranged into words, and words are arranged into sentences that convey meaning to other people when the authors are not around to explain their intentions. Written documents, even very short ones, often contain clues that can help investigators determine the identities of the authors. Forensic stylistics is the study of documents in an attempt to determine authorship. (The term “forensic stylistics” is sometimes used interchangeably with the term “forensic linguistics,” but in most cases “forensic stylistics” is the specific term applied to the use of linguistic methods to determine authorship of particular documents.) Such analysis may be undertaken if there is a suspected author or, if no specific individual is suspected, as an attempt to determine as much information as possible about the author.

When investigators have concluded that a given individual is the suspected author of the document in question, the first step in the forensic linguist’s work is often to acquire a writing sample from the suspected individual. If the document of interest was handwritten, the investigator generally instructs the suspected individual to copy the document by hand and may request a copy written from dictation. The forensic linguist also then generally collects samples of other writings done by the individual on various topics and in various circumstances.

After the samples have been collected, the forensic linguist begins a careful comparison of the samples with the questioned document. During this analysis, other experts in related fields, such as handwriting specialists, are often also at work attempting to determine whether the suspected individual is likely to have been the author of the document. The linguist compares various aspects of the samples to those aspects of the original document. Spelling and grammar are compared as well as syntax, word choice, vocabulary, punctuation, and other elements of written language. Spelling and grammatical mistakes are often consistent in specific individuals over time. For instance, an individual who misspells the word "believe" as "beleive" is likely to do so in many different circumstances. The forensic stylistic expert thus compares the dictated sample and other samples from the suspected author to the questioned document to check spelling and punctuation choices.

If investigators have located no one who is believed to have been the author of the original document, a forensic stylistic expert is often called upon to examine the document in an effort to gain information about the author. Instead of obtaining samples for comparison, the expert must use the document itself to derive as much information as possible. Information about the level of education, nationality, and even age of the author may be revealed by the grammar and spelling in the document as well as by the level of the vocabulary used and the complexity of the sentence structure. The presence of certain word choices and sentence structures that are more common to some regions than to others may enable the forensic linguist to define the likely identity of the author further.

Forensic stylistics is also important in the investigation of documents that are being presented as the works of specific individuals but the authenticity of which is being questioned. Documents such as wills that have been drawn up by individuals without the involvement of attorneys may come under such questioning. In such cases, experts in forensic stylistics can analyze the writing styles and contents of the documents to help determine their authenticity. Documents purported to have been written by famous historical individuals, such as letters by George Washington or the diaries presented as being written by Adolf Hitler, often are submitted for stylistic analysis in addition to handwriting and document analysis in efforts to prove or disprove their authenticity.

Analysis of Spoken Language

Spoken language can also provide valuable information during the investigation of crimes. Whether criminals leave samples of spoken language on purpose (as in threatening phone calls) or inadvertently (as when a security camera records the voice of a robber during a bank robbery), forensic linguists can use such samples to help determine important information about the criminals' identities.

When a suspect has been identified in a case, the forensic linguist can request that samples of the individual's voice be recorded for comparison with the original voice recording. The forensic linguist might want to work with several kinds of samples; for example, the suspect might be recorded repeating specific words and phrases, making a general statement on a certain topic, or simply speaking freely. The linguist might also seek out samples of recordings of the suspect speaking in other circumstances. The linguist then compares the samples with the original recording across a number of different variables.

When no specific individual has been identified as a suspect, the forensic linguist uses the available evidence sample to try to gain as much information as possible about the individual, including likely gender, race, and education as well as information about the country or region in which the individual grew up. Many differences in speech and pronunciation, as well as word choice and usage, can give details about where a person grew up or has spent many years living. A regional accent can be an important clue to a criminal's identity.

Details of an individual's spoken language can provide information about race, ethnicity, nationality, and educational level that can help investigators narrow their search. Many individuals who have learned English as a second language have lingering traces of their first languages that can help linguists make educated guesses about what countries or areas of the world they are from. Native English speakers also have accents specific to the areas in which they learned the language. Some American accents—such as those associated with Brooklyn, New York, and upper Minnesota—are widely recognized and well documented in the popular media. Linguists have documented many other, less widely recognized, accents as well, and their knowledge of such accents can help them identify the likely areas in which suspects live or grew up. Although many individuals gain or lose accents to an extent over time, many retain traces of the pronunciation common in the areas in which they first learned to speak.

In addition to accents, certain words and phrases are used more commonly in some regions than in others. Word and phrase choices also tend to differ among population subgroups—such as age and ethnic groupings—within specific areas.

Helen Davidson

Further Reading

Coulthard, Malcolm, and Alison Johnson. *An Introduction to Forensic Linguistics: Language in Evidence*. New York: Routledge, 2007. Provides information about the use and place of forensic linguistics, from the initial investigation through testimony in the courtroom, with many examples drawn from famous legal cases.

Gibbons, John. *Forensic Linguistics: An Introduction to Language in the Justice System*. Malden, Mass.: Blackwell, 2003. Presents an overview of forensic linguistics with sections on the challenges and disadvantages that certain groups face when in legal settings because of linguistic differences.

McMenamin, Gerald R., ed. *Forensic Linguistics: Advances in Forensic Stylistics*. Boca Raton, Fla.: CRC Press, 2002. Comprehensive discussion of forensic stylistics includes information about data analysis and the place of stylistics in the legal process.

Olsson, John. *Forensic Linguistics: An Introduction to Language, Crime, and the Law*. New York: Continuum, 2004. Focuses on questions of authorship and provides information on evidence presentation. Includes practice exercises with answers and explanations.

Tanner, Dennis C., and Matthew E. Tanner. *Forensic Aspects of Speech Patterns: Voice Prints, Speaker Profiling, Lie and Intoxication Detection*. Tucson, Ariz.: Lawyers & Judges Publishing, 2004. Provides a close look at the speech process, with emphasis on the linguistic behaviors of different groups. Also discusses the information that criminal investigators can gain from language.

See also: Competency evaluation and assessment instruments; Document examination; Electronic voice alteration; Forgery; Handwriting analysis; Hitler diaries hoax; Hughes will hoax; Questioned document analysis; Typewriter analysis; Voiceprints; Writing instrument analysis.

Forensic nursing

Definition: Application of forensic science techniques and nursing practice in proceedings that interface with the law.

Significance: Forensic nurses help protect the legal rights of the patients for whom they care. They apply nursing science and forensic aspects of health care in public or legal proceedings related to the trauma and deaths of crime victims and to the prosecution of perpetrators of interpersonal violence.

Forensic nursing is an interdisciplinary model of care that integrates nursing science, forensic science, and criminal justice to protect the rights of crime victims as well as the rights of the victims of traumatic accidents. Forensic nursing's scientific knowledge base is grounded in theories of nursing, forensic science, and criminal justice. Professionals in this field apply nursing-related sciences to public or legal proceedings, to scientific investigation in the area of health care, and to the treatment of victims of trauma. Forensic nurses provide care, consultation services, and testimony related to the collection, preservation, and analysis of evidence in legal cases involving interpersonal violence and other health care issues. Forensic nurses sometimes testify in legal proceedings regarding questioned death investigation processes, the adequacy of delivered health care services, and diagnoses of conditions related to forensic nursing practice.

The professional title "forensic nurse" was established in 1992 at a meeting of a group of sexual assault nurse examiners (SANEs) in Minneapolis, Minnesota. From that meeting, the International Association of Forensic Nurses (IAFN) was formed to promote and support forensic nursing, to educate forensic nurses, and to educate members of the nursing profession and the general public concerning this subspecialty. In 1995, the American Nurses Association (ANA) officially recognized forensic nursing as a nursing subspecialty.

Forensic nurses have education and clinical practice experience beyond their nursing education that enable them to obtain objective medical histories from the victims of traumatic incidents and from victims' caregivers; they gather information from victims about the sequences of events that took place and identify and meticulously document victims' wounds and their stages of healing as well as patterns of injury. Forensic nurses have advanced skills in the use of specialized equipment and photography for the documentation of injuries to be presented in criminal and civil court proceedings.

Roles and Activities of Forensic Nurses

The roles that forensic nurses fill vary according to practice settings. Clinical forensic nurses, for example, provide care to survivors of crimes within health care facilities and in community settings. Sexual assault nurse examiners, who work primarily in hospital emergency rooms, examine and evaluate victims of sexual trauma. SANEs may be on call to specific facilities or to multiple sites. These nurses are trained to function as members of sexual assault response teams (SARTs), which perform crisis intervention for victims of sexual assault.

Psychiatric forensic nurses specialize in psychiatric evaluation and care of individuals in mental facilities and in legal custody; in the United States, most of these nurses work for state departments of corrections (state prison systems). Psychiatric forensic nurses are often involved in counseling both victims and perpetrators of crime.

Correctional nurses specialize in the care, treatment, and rehabilitation of the incarcerated. They identify complex health issues in correctional facilities and conduct health screenings and assessments of inmates for communicable diseases, acute and chronic mental health problems, substance abuse, and risk for self-harm and suicide. They dispense medications, manage acute illnesses and injuries, and educate inmates on health topics.

Legal nurse consultants provide education and consultation regarding legal issues, injury, and liability or malpractice to criminal justice and health care professionals. Nurse attorneys specialize in health care-related legal proceedings. Nurses in both these areas of forensic nursing must have knowledge of the medical issues related to litigation so that they can interpret medical records and other documents.

Forensic nurses can also serve as death investigators, assisting medical examiners in performing autopsies and taking part in related activities, such as examining scenes of accidents and suspicious deaths, collaborating with police investigators, examining bodies for injuries, taking tissue and blood samples, photographing bodies and crime scenes, and documenting findings related to injuries. In some U.S. states, nurse coroners initiate the investigation and certification of suspicious deaths.

Some forensic nurses serve as organ transplantation coordinators. In this capacity, they are members of teams that work with families of

Settings for Forensic Nursing

Forensic nurses may work in many different kinds of practice settings, including the following:

- Acute care facilities
- Long-term care facilities
- Psychiatric facilities
- Correctional institutions
- Emergency rooms
- Medical and nurse-run clinics
- Insurance companies
- Prosecutors' and defense attorneys' offices
- Medical examiners' or coroners' offices
- Schools
- Child and family service agencies
- Senior service agencies
- Home-care settings

potential organ donors. These nurses must have excellent communication and counseling skills as well as extensive knowledge of the legal and medical issues related to organ donation, including the criteria for brain death.

School-based forensic nurses identify, evaluate, treat, and refer abused or neglected children for appropriate follow-up. These nurses are instrumental in assessing and identifying young victims of violence and in educating teachers, children, and families about the issues surrounding interpersonal violence and how it can be prevented.

Forensic Nursing Education

A variety of education opportunities are available to those who want to specialize as forensic nurses. Programs in forensic nursing are offered by technical schools and on college campuses, and Internet-based programs are also available. The only educational prerequisite for admission to some forensic nursing certificate programs is that an individual be a registered nurse, whereas other programs require the previous completion of a bachelor's degree in nursing. Some graduate schools offer master's degrees in nursing with a specialization in forensic nursing; a bachelor's degree in nursing is required for admission to such programs. A post-master's degree certificate with a specialization in forensic nursing is another avenue to a specialization in forensic nursing; a master's degree is required for admission to such certification programs.

The American College of Forensic Examiners Institute (ACFEI) is the only organization that offers an international certification program and certification in general forensic nursing practice. To receive the designation of certified forensic nurse (CFN), an individual must qualify for membership in the ACFEI and pass the ACFEI forensic nursing examination. Nondegree programs are also available that provide certification examinations for sexual assault nurse examiners, medicolegal death investigators, and legal nurse consultants. Certification in these areas—which requires specific education, skill performance, and successful completion of a certification examination—demonstrates an understanding of a specialized body of knowledge that is acknowledged by professionals in forensic science and nursing.

Sharon W. Stark

Further Reading

Barsky, Allan E., and Jonathan W. Gould. *Clinicians in Court: A Guide to Subpoenas, Depositions, Testifying, and Everything Else You Need to Know*. New York: Guilford Press, 2002. Comprehensive handbook for nonprofessionals on forensic issues in clinical practice. Includes sample legal documents and case recommendations.

Campbell, Rebecca, Debra Patterson, and Lauren F. Lichty. "The Effectiveness of Sexual Assault Nurse Examiner (SANE) Programs: A Review of Psychological, Medical, Legal, and Community Outcomes." *Trauma, Violence, and Abuse* 6, no. 4 (2005): 313-329. Scholarly article describes the rape kit collection process in detail.

Hammer, Rita M., Barbara Moynihan, and Elaine M. Pagliaro, eds. *Forensic Nursing: A Handbook for Practice*. Sudbury, Mass.: Jones & Bartlett, 2006. Comprehensive and interdisciplinary practical manual is intended for professionals in the field. Based on the Standards of Forensic Nursing Practice developed by the International Association of Forensic Nursing.

Lynch, Virginia A. *Forensic Nursing*. St. Louis: C. V. Mosby, 2006. Covers such topics as crime scene investigation, how to collect evidence, toxicology, DNA testing, various kinds of injuries and gunshot wounds, domestic violence, and death investigation. Also discusses legal standards and practices. Recognized as a principal founder of the field of forensic nursing, Lynch created the International Association of Forensic Nursing and served as its first president.

Pyrek, Kelly M. *Forensic Nursing*. Boca Raton, Fla.: CRC Press, 2006. A veteran investigative journalist offers a comprehensive and fascinating look at the field of forensic nursing, with compelling stories about the personal experiences of many people in the profession. Useful as an introduction to the field for people who are considering joining the profession.

Stevens, Serita. *Forensic Nurse: The New Role of the Nurse in Law Enforcement*. New York: Thomas Dunne Books, 2004. Survey of the forensic nursing profession written by a registered nurse and mystery novelist with the assistance of members of the International Association of Forensic Nurses. Richly detailed work provides many case studies.

See also: Autopsies; Forensic pathology; Forensic toxicology; International Association of Forensic Nurses; Living forensics; Rape; Rape kit; Thanatology.

Forensic odontology

Definition: Scientific use of dentition patterns to identify individuals, living or dead, and to evaluate malpractice claims involving dental care and repair.

Significance: Examination of dental patterns can be useful in the identification of crime and accident victims as well as skeletal remains, and in assault cases the analysis of bite marks can help investigators to identify suspects. In civil cases, forensic odontologists provide testimony when claims are made concerning malpractice involving dental care.

The science of forensic odontology, also known as forensic dentistry, is based on the premise that dentition patterns differ across individuals in size, shape, pattern, wear, and repair. Differences are found even in identical twins, who have identical dentition patterns but have different histories of dental repair work. Forensic odontology is especially useful for identification if the dental records of the person of interest are available for comparison or a dentition sample can be obtained.

Practitioners of forensic odontology are highly trained and board-certified dental specialists who are tasked primarily with judicial cases in which dentition provides supporting or, in some cases, primary evidence and also with identification of remains. Forensic odontologists typically have advanced education in dental anatomy, dental abnormalities, pathology, and the history and current uses of types and applications of dental materials, including crowns, bridges, and fillings. These specialists are also familiar with the dental treatment shorthand used in written dental records.

Identification of Remains

Dentition has been used for centuries to establish identities from human remains. Perhaps one of the most famous uses of forensic odontology was in the positive identification of the remains of Adolf Hitler and Eva Braun, but the science has gained worldwide attention in more recent years as a means of identifying remains following mass natural or human-made disasters, such as the 2004 tsunami in Thailand or the 2001 terrorist attack on the World Trade Center in New York City. Forensic odontology is also used in cases involving searches for missing persons. Because tooth enamel is one of the hardest and most enduring substances in nature, teeth often survive under conditions that destroy all other body tissues. For example, fire, motor vehicle accidents, and other tragedies may disfigure bodies so badly that nothing remains but teeth or portions of dental crowns.

Forensic odontology is particularly important for the identification of remains in cases where neither the victims' fingerprints nor their DNA (deoxyribonucleic acid) profiles are available in existing databases. Identification is facilitated when the deceased have had restorative dental treatments—such as fillings, crowns, root canal therapy, and bridges—and information about these treatments is preserved in dental records.

In identifying an individual based on remains, the first task of the forensic odontologist is to compile a postmortem dental record by taking X rays (radiographs) and detailing the dental structures of the remains. The completed record of dental remains is then compared with the antemortem (before death) dental records of the person suspected to be the deceased to confirm or preclude identification. A positive or nearly positive identification can be established on the basis of a strong correlation between dental records and remains. Conversely, inconsis-

Forensic odontologists compared this postmortem X-ray image of molars to the dental X-ray records of Odai Hussein in making a positive identification of the body of the son of deposed Iraqi leader Saddam Hussein in July, 2005. *(AP/Wide World Photos)*

tent comparisons may preclude or exclude identification for judicial use.

Generally, no recognized minimum number of concordant features is required to establish a positive identification. In some cases overall dental patterns may be sufficient to establish identity, whereas in other cases teeth that exhibit highly specific repairs can be used to identify remains positively with confidence. This variability in what constitutes confirmation of identity is one reason the evidentiary value of forensic odontology is treated cautiously. This means that forensic odontologists must be prepared to defend their conclusions in court proceedings.

In cases that lack antemortem dental records, forensic odontologists are confronted with a much more difficult task in determining identity. In such a case, the forensic odontologist prepares a hypothetical profile of the unknown person based on the dental remains; this profile may include approximate age, ancestry, sex, socioeconomic status, dietary habits, smoking habits, history of substance abuse, and health at the time of death. Age determination is based on the Gustafson method, which measures six signs of wear, or the Lamendin method, which evaluates degree of root transparency. Dental remains of older individuals can yield clues on the basis of types of fillings, materials in fillings, crown replacement techniques, and other repairs, all of which have changed over time as newer dental techniques have been developed. If sufficient material is available, DNA analysis can show the presence or absence of the male Y chromosome. The hypothetical profile and observed characteristics are then compared with the characteristics of known missing persons or entered into a database for future comparisons.

Analysis of Bite Marks

Forensic odontologists are also tasked with the assessment of bite-mark injuries, which are frequently present in violent crimes. Bite marks include those inflicted on the victim, those that the victim inflicted on the attacker, and bite marks found on any food or other objects at the crime scene. Bite marks often occur in cases of sexual assault as well as child abuse cases.

In assessing bite-mark evidence, the first tasks of the forensic odontologist are to photograph the bite mark, record an impression of the bite mark, and take dental impressions of the suspected source of the bite mark (a practice permitted by law in most states). In establishing bite-mark evidence, the forensic odontologist considers the depth and shape of indentations and resulting pitting, tearing, and other abrasions. Measurements taken include distance between cuspids and other teeth impressions, shape of the mouth arch, width and thickness of the teeth, spacing between teeth, gaps where teeth are missing, curves of biting edges, and unique dentition and wear patterns.

A powerful bite leaves a deep impression, and this information may reveal something about the state of mind of the assailant. In assessing a bite mark, the forensic odontologist looks for hemorrhage, abrasion, contusion, laceration, puncturing, avulsion (removal of part of the skin), and artifact (removal of part of the body). Each of these factors, when present, is next classified into one of four degrees of impression: clearly defined, showing significant pressure; obviously defined, showing first-degree pressure; noticeable, showing violent pressure; or lacerated, in which the skin is violently torn from the body. Amount or degree of bite impression is considered a measure of violence and is typically used in court to identify the assailant's state of mind, aggravating circumstances, or simply heinous behavior on the part of the assailant.

The use of forensic odontology in assault cases is not without controversy. Critics assert that the use of bite marks as evidence is inevitably subjective because little agreement exists among scientists about the uniqueness of dentition or the behavior of the human skin when bitten. Some individuals bruise easily, others almost not at all. Critics also point out that the rates of healing of bite marks may vary as a function of the health of the victim. Forensic examination of bite marks on dead bodies is further complicated by the rapid skin decay that follows death. Finally, error rates associated with identification of assailants based on bite-mark analysis have not yet been established through rigorous scientific experimentation and analysis. Thus, some argue that bite-mark analysis may be given too much credit as an evidentiary source, especially when it is used in trials to establish the identities of assailants.

The results of bite-mark analysis can provide supportive evidence when considered together with DNA or fingerprint analysis, however. Among the high-profile criminal cases that have included bite-mark evidence are the case against serial murderer Ted Bundy, brought by the state of Florida in 1979, and the New Jersey case against Jesse Timmendequas for the abduction and murder of seven-year-old Megan Kanka (the crime that precipitated the passage of Megan's Law in 1994). The 1975 California court case *People v. Marx* helped to establish evidentiary standards for the use of forensic odontology in trials.

Medical Malpractice Claims

To evaluate claims of malpractice involving dental care or repair, forensic odontologists examine dentition and oral tissues to establish degree of trauma, its possible cause, and its potential impact on ability to chew food properly. Some dental malpractice suits claim that careless or improper dental work has resulted in alterations of the face, jaw, or chin, whereas others focus on unnecessary dental work. In all such cases, forensic odontologists must examine the claimants and present testimony regarding their findings.

Dwight G. Smith

Further Reading

Bowers, C. Michael. *Forensic Dental Evidence: An Investigator's Handbook*. San Diego, Calif.: Elsevier Academic Press, 2004. Discusses the management of dental evidence, including the use of dental records for identification of deceased persons and the collection and documentation of bite-mark evidence.

Dinkel, E. H., Jr. "The Use of Bite Mark Evidence as an Investigative Aid." *Journal of Forensic Sciences* 19 (July, 1974): 535-542. Provides a review of the scientific literature on the forensic use of bite marks up to the mid-1970's.

Dorion, Robert B. J., ed. *Bitemark Evidence*. New York: Marcel Dekker, 2005.Comprehensive collection of essays addresses all aspects of the anatomy and physiology of bite marks and the process of bite-mark analysis. Includes information on landmark cases involving bite-mark evidence.

Keiser-Nielsen, Søren. "Dental Identification: Certainty v. Probability." *Forensic Science* 9, no. 2 (1977): 87-97. Somewhat dated article nevertheless provides a very good overview of the field of forensic odontology and the procedures used.

See also: Anastasia remains identification; Ancient science and forensics; Asian tsunami victim identification; Autopsies; Bite-mark analysis; Croatian and Bosnian war victim identification; Forensic anthropology; Holocaust investigation; Mass graves; Oral autopsy; September 11, 2001, victim identification.

Forensic palynology

Definition: Investigative technique using microscopic examination of the morphology of pollen grains associated with crime scenes and civil cases.

Significance: Species-specific pollen morphology provides a valuable tool for determining the geographic origins, movements, and seasons of deposition of soil samples, dust, textiles, and products of plant origin, including illegal drugs. By examining pollen in stomach contents, forensic palynologists can help trace the movements and dietary habits of humans and animals.

As all those who suffer with hay fever know, some flowering plants produce pollen in enormous quantities. Pollen and spores are major components of dust and become incorporated into soil. Two characteristics of pollen make it a valuable tool for the forensic scientist as well as for archaeologists and paleontologists, who first developed techniques of pollen analysis. First, the coating, or exine, of pollen grains resists environmental degradation, and second, pollen's ornamentation enables many genera and even species to be identified from a single grain. Palynologists have produced catalogs and manuals for identification of pollens and have conducted studies that have linked pollen profiles from soils or air-filtration systems to surrounding vegetation. Large quantities of a pollen type can pinpoint the timing of an event during the flowering season of the parent plant.

Sampling and Processing

The pollen present on crime victims, at crime scenes, or on suspects or their possessions can provide important evidence. The pollen of anemophilous, or wind-pollinated, plants is most useful to forensic scientists in determining seasonality and general location. When present, the pollen of entomophilous, or insect-pollinated, plants can be used to place a suspect at a specific locality because such pollen requires direct contact for transmission.

Pollen samples need to be rigorously protected from airborne contamination. Because palynological techniques destroy the samples examined, any prior investigations using the same material need to be done in a dust-free environment. As palynology requires specialized equipment and a high degree of expertise, forensic palynological analyses are usually conducted on a consulting basis rather than in crime labs.

Uses of Forensic Palynology

Most applications of forensic palynology involve tracing the origins and movements of people and objects associated with crimes. Pollen in the hair or clothing of a homicide victim, for example, can help pinpoint where the crime occurred. The same spectrum of pollen types found in the clothing of a suspect provides good

Cases Involving Forensic Palynology

The earliest use of palynology in a forensic case occurred in Austria in 1956. After a woman disappeared, analysis of mud from the prime suspect's boots revealed a very distinctive fossil pollen type found only in a narrow area along the Danube River near the point of the woman's disappearance. When confronted with this evidence, the suspect confessed and led police to the body.

In a New Zealand case, a rape victim identified her assailant, who admitted having been in the area but denied being the perpetrator. His clothing, however, contained large quantities of pollen of *Artemisia*, which grew abundantly at the site and had been flattened during the assault. In another case in New Zealand, a suspect was convicted of growing marijuana when the pollen (including that of weed species) in his soil-testing kit matched that of the marijuana patch found by the authorities.

Forensic and anthropological palynology converged in the examination of the frozen body of a five-hundred-year-old Native Canadian recovered from a glacier in northern British Columbia. The legal issue in this case involved tribal jurisdiction over the remains. Large quantities of *Salicornia* pollen in the body's stomach contents suggested a coastal origin but also raised the possibility of the use of *Salicornia* as a trail food. The issue remains unresolved.

Pollen evidence proved crucial in resolving a civil liability lawsuit in New Mexico in 1989. Remains of an aircraft that crashed, killing two people, were stored for several months in an open shed. Subsequently, a fuel line proved to be blocked with pollen and plant trichomes, and heirs of the crash victims claimed that this blockage was the cause of the crash. The defense for the airplane manufacturer argued successfully that the pollen of insect-pollinated species could not have entered the fuel line while the plane was flying; rather, the pollen was deposited by a solitary bee during the time the wreckage was in storage.

circumstantial evidence of a connection between the two persons. Rapes, robberies, and other assaults committed around vegetation leave matching pollen traces on the victims and perpetrators. Pollen trapped in a car's air filter provides a history of where the car has been driven, which can be useful in corroborating or refuting the car's owner's presence near a crime scene.

Palynology can be very useful in tracing contraband, including illicit drugs, stolen goods, and illegal imports. Items pick up pollen at the point of origin and at any point where they are stored or repacked. In one case, by analyzing the pollen in several batches of cocaine seized in New York City, investigators determined the batches all came from the same shipment, which had been repackaged in northern New England and further processed in New York City. Pollen lodged in a shipment of oriental rugs indicated that the rugs originated in Iran—not in Egypt, as claimed by the importer.

Marijuana is a prolific pollen producer. Small amounts of *Cannabis* pollen are not diagnostic, but large amounts in an aerial sample can help law-enforcement authorities locate growing operations. Buildings that have been used for marijuana cultivation, even if thoroughly cleaned, usually harbor quantities of pollen. In addition, investigators can determine the countries and regions where marijuana shipments originated by examining the shipments for the pollen of other plant species.

Although palynology can be a powerful tool in forensic investigations, it is not a tool that is used routinely. One reason for this is that many law-enforcement authorities are unaware of the potential uses of palynology. In addition, highly skilled analysts are needed to perform palynological testing, and the findings of their work are often not conclusive. These drawbacks, coupled with the growing availability of DNA (deoxyribonucleic acid) testing for evidence samples, combine to make palynology a tool of last resort in forensic science.

Martha Sherwood

Further Reading

Bryant, Vaughan M., John G. Jones, and Dallas C. Mildenhall. "Forensic Palynology in the

United States of America." *Palynology* 14, no. 1 (1990): 193-208. Presents an overview of palynology coupled with a call for greater utilization of the technique.

_______. "Forensic Studies in Palynology." In *Palynology: Principles and Applications*, edited by Jan Jansonius and D. C. McGregor. Salt Lake City: American Association of Stratigraphic Palynologists Foundation, 1996. Chapter devoted to forensic studies is part of a comprehensive two-volume set on all aspects of palynology.

Coyle, Heather Miller, ed. *Forensic Botany: Principles and Applications to Criminal Casework*. Boca Raton, Fla.: CRC Press, 2005. Text aimed at college students in the biological sciences includes a chapter on palynology.

Holt, Cynthia. *Guide to Information Sources in the Forensic Sciences*. Westport, Conn.: Libraries Unlimited, 2006. Reference guide is useful for tracking down recent articles on specialized topics; includes a list of Web resources.

Murray, Raymond C. *Evidence from the Earth: Forensic Geology and Criminal Investigation*. Missoula, Mont.: Mountain Press, 2004. Uses actual cases to explain forensic geology. Includes discussion of methods for extracting and analyzing pollen in soil samples.

See also: Forensic archaeology; Forensic botany; Microscopes; Physical evidence; Physiology; Pollen and pollen rain; Soil.

Forensic pathology

Definition: Field of medical science in which specially trained physicians use a variety of techniques to examine bodies with the aim of establishing the causes of unnatural deaths.

Significance: In the United States, the cause and the manner of each death must be certified as a matter of public record. This certification is especially important when an individual dies under suspicious circumstances. The proper determination of the cause of death has important legal, social, and economic consequences for surviving family members of the deceased and for the larger community. Through their work, forensic pathologists can help bring to justice people who have been responsible for the deaths of others through acts of malice, negligence, or recklessness.

Coroners are public officials, elected or appointed in particular jurisdictions (such as counties or states), who are accorded the statutory authority and responsibility to perform death investigations. The first coroners' offices appeared in medieval Europe: A "crowner" would investigate deaths in order to ensure that the king was paid his death duties or taxes and that the crown received the proceeds from the sale of items used in murders (such as swords) or involved in accidents (such as horses). Coroners' offices were later established in Great Britain and the United States for the sole purpose of investigating deaths, not as a means of generating tax revenue. By the late nineteenth century, physicians were brought into death investigation, enhancing the scientific vigor and credibility of the process.

Death Investigation

In the United States, most people die from chronic diseases in medical settings and under the care of attending physicians. In most of these cases, no postmortem examination is necessary to ascertain the cause of death. When a death occurs suddenly, unexpectedly, and from unnatural or unknown causes, however, a forensic pathologist has the duty to gather evidence to determine whether the decedent died from a previously undiagnosed disease or infection or from a homicide, suicide, or accident.

A coroner performs a death investigation to identify an unknown decedent; to ascertain the proximate cause (for example, heart attack, cancer, injuries from an accident), manner (natural or unnatural), and time of death; to prepare a death certificate for the public record; and to provide the civil and criminal courts with pathologic findings and conclusions as evidence. Natural deaths are those resulting from disease, infection, or organ failure; unnatural deaths are those resulting from accident, homicide, suicide, or exposure to lethal poisons or toxins.

In addition, coroners often investigate the deaths of prominent people, such as public officials, celebrities, religious leaders, and sports figures, and the deaths of vulnerable people, such as children, senior citizens, and residents of government-operated facilities (such as prisons or nursing homes). Finally, coroners investigate deaths from communicable infections or diseases that might pose a public health threat as well as deaths resulting from multiple-fatality accidents (such as car accidents and plane crashes) or disasters (such as tornados, heat waves, and hurricanes).

Coroner or Medical Examiner

The requisite credentials, educational background, and powers of the coroner's office are defined by local or state statutes. Some jurisdictions require the coroner to be a medical doctor or trained in the medical sciences; others do not. In most jurisdictions, coroners are elected to office and considered finders of fact. As such, they are empowered to issue subpoenas (orders to appear before a legal body) and to impanel inquest juries to gather and evaluate evidence that could be used by law-enforcement authorities to investigate violent or suspicious deaths or by the prosecutor's office to indict persons suspected of causing deaths through criminal, reckless, or negligent actions.

Coroners with no medical background employ physicians and other medical professionals to perform the tests and procedures necessary to uncover the cause and manner of death. Coroners who have medical degrees and training as pathologists are called medical examiners. Unlike coroners, medical examiners are generally appointed, not elected, to office.

Pathologists are licensed medical doctors who specialize in diagnosing diseases and infections and in determining cause of death. They use a variety of techniques and procedures, including the microscopic examination of samples of bodily fluids (clinical pathology), cells (cytology), and tissues (pathologic anatomy). In establishing cause of death, they also examine dead bodies (cadavers) by performing the thorough and systematic procedure known as autopsy.

Forensic pathology is a subspecialty of pathology that focuses on cases of unnatural, sudden, or violent death. Forensic pathologists or medical examiners possess a broader range of skills and competencies than do basic pathologists. Following the completion of medical school, physicians prepare for the subspecialty of forensic pathology with four years of training in anatomic and clinical pathology and one year of training in a fellowship or residency in forensic pathology, during which they gain practical experience in all aspects of death investigation. Forensic pathologists seeking board certification must pass an examination administered by the American Board of Pathology.

In ten U.S. states, the coroner is the official death investigator; in twenty-three states, that position is held by a forensic pathologist (medical examiner). The remaining seventeen states have "mixed" offices of death investigation that include both coroner and medical examiner. Death investigations in large jurisdictions are led by a chief medical examiner or coroner and staffed by deputies and other medical and nonmedical personnel.

Forensic pathologists are "medical detectives" who gather data from a wide range of sources both inside and outside the laboratory and morgue. In working to specify cause of death, forensic pathologists use the same procedures (such as autopsies) and assess the same types of medical data (such as tissues and bodily fluids) as do basic pathologists who work mostly in hospitals and investigate the causes of natural deaths. Forensic pathologists often extend their investigatory techniques beyond those of basic pathology, however, as they attempt to place medical evidence in the larger context and circumstances in which a death occurs.

To perform their duties effectively, forensic pathologists must be trained in a variety of exploratory strategies and technologies, including firearms examination (wound ballistics) and DNA (deoxyribonucleic acid) analysis. Forensic pathologists collect or supervise the collection of evidence from crime scenes. In performing this task, their goal is to assist law-enforcement officials in preserving the scene integrity and to gain firsthand knowledge of the physical surroundings in which a body was discovered. Furthermore, they gather facts from witnesses in order to learn more about the activities of the deceased in the days immediately preceding the individual's death.

Autopsy

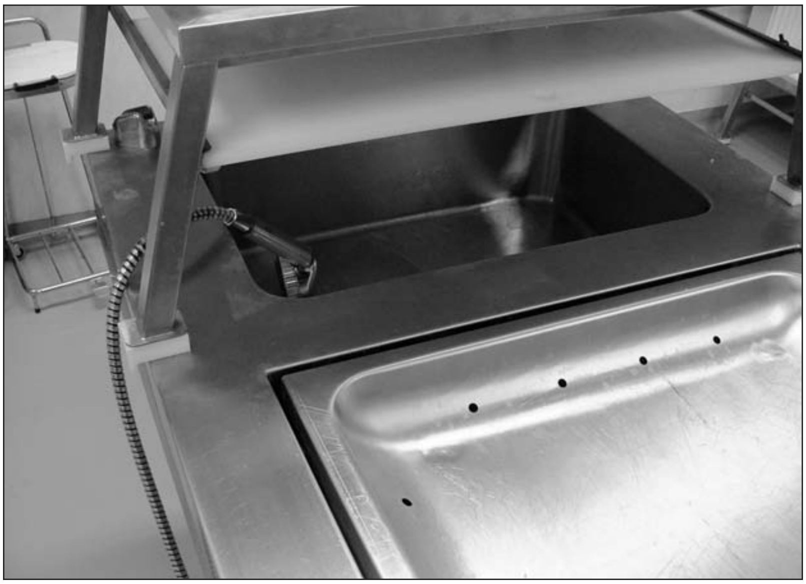
The procedure known as autopsy (from the Greek word *autopsia*, meaning "to see for oneself") has been used for centuries as an investigatory, clinical, pedagogical, and public health tool. More than twenty-five hundred years ago, Greek physicians were the first to perform autopsies as part of death investigations. In 1761, Italian anatomist Giovanni Battista Morgagni published the first medical text on autopsies, *De Sedibus et Causis Morborum per Anatomen Indagatis* (*The Seats and Causes of Diseases Investigated by Anatomy*, 1769).

Modern-day forensic pathologists conduct medicolegal autopsies or postmortem examinations to obtain valuable information about the cause and manner of unnatural death. Basic pathologists perform clinical autopsies to illuminate the nature and extent of fatal diseases or infections in patients who were being treated by attending or primary care physicians or the causes of death in persons with no medical histories or records of previous treatment.

An autopsy consists of an external and internal examination of the cadaver. The former is conducted to discover signs of injury, such as broken bones, burns, bruises, contusions, lacerations, gunshot wounds, stab wounds, punctures, scratches, abrasions, or dislocated joints. The latter is conducted to discover signs of disease or injury in the major body organs (brain, heart, lungs, liver, spleen, stomach, pancreas, and kidneys) and any signs of internal bleeding. An autopsy also involves laboratory and toxicological analyses of stomach contents and samples of bodily tissue and fluids.

The external examination begins immediately after the body is received for autopsy, enclosed in a sterile body bag or evidence sheet. A morgue attendant, or diener, is responsible for moving and preparing the body for the procedure. The decedent is first photographed and X-rayed; the type of clothing worn and its positioning on the decedent's body are then noted. Trace evidence and samples of hair and nails are collected, and then the body is undressed and inspected for wounds and other types of injuries. Next, the body is washed, weighed, measured, and described in terms of approximate age, race, gender, hair (color, length, and texture), eye color, and distinguishing features, such as missing teeth, moles, tattoos, scars, birthmarks, or prostheses—all of which are also carefully documented in autopsy photographs.

When a body is discovered without identification, an external examination can produce valuable clues regarding the decedent's identity. The forensic pathologist and police officers can sometimes find useful clues to the person's identity from his or her clothing or jewelry. Any ex-



An autopsy table's washing basin. Autopsy tables are constructed of stainless steel and have raised edges to prevent spillage. Slanted surfaces and drainage slots enable the safe disposal of bodily fluids. *(© Ragne Kabanova/Dreamstime.com)*

A morgue technician weighs a brain during an autopsy. *(Custom Medical Stock Photo)*

ternal markings on the body, such as scars or tattoos, can also help identify the person. The participation of the forensic pathologist in the identification process is especially critical when the body has decomposed or is so seriously damaged that the facial features are unrecognizable. In such cases, forensic pathologists work with experts in facial reconstruction, who start with the underlying structure of the decedents' skulls and use clay modeling, drawings, and computer graphics to simulate the appearance of their faces. These renderings can be disseminated to the public or compared with pictures of missing persons in efforts to identify unknown decedents.

X-rays and dental records are also used for identification purposes, as are fingerprints. When these methods are unsuccessful, DNA samples extracted from hair, tissues, or fluids may be analyzed and the results compared against the DNA found on items belonging to missing persons or the DNA of possible surviving relatives.

For the internal examination, the body is laid on a specially designed table, on top of a body block that raises the chest wall for dissection. The autopsy table is constructed of stainless steel and has several faucets. It is slanted and has drainage slots to permit the safe disposal of bodily fluids as well as raised edges to prevent spillage. In one common dissection technique, a deep Y-shaped incision is made from the shoulders, meeting at the breastbone, and proceeding in a straight line to the pubic bone (circumventing the navel).

The chest cavity is opened and the chest plate is removed, exposing the heart and lungs for extraction and direct examination. Although techniques vary, the heart, lungs, kidney, spleen, stomach, and liver are severed from their connections and removed en bloc (in one group) in a procedure known as the Rokitansky method. The organs are inspected and weighed individually. Tissue samples are prepared for microscopic analysis, and the contents of the stomach and intestines are removed, weighed, and studied. In addition, all major blood vessels are sliced open lengthwise and checked for evidence of plaque (arteriosclerosis) or blood clots.

The final steps in the internal examination are the removal of the brain and the reconstitution of the body. To remove the brain, the pathologist makes an incision across the crown of the skull, from one ear to the other, and the scalp is pulled forward and backward. An electric saw is used to cut into the exposed cranium to create a circular "cap" that is dislodged to expose the brain; the brain is then severed from the spinal cord and removed from the cranium for inspection. If the brain must be preserved, or "fixed," before inspection, it is placed in a container of formalin, which renders it easier to slice for laboratory samples and to manipulate for visual assessment. When the autopsy is complete, the body cavity is lined with cotton or other absorbent materials and the body organs are placed in plastic bags and returned to the cavity; this prevents the leakage of bodily fluids. The skull cap is replaced, and the scalp flaps and Y incision are closed and sewn back in their original position.

Time of Death

The establishment of time of death is one of the medical examiner's most important tasks, especially in homicide cases. Unless the death was witnessed, time of death can only be approximated; the accuracy of the estimate depends on the quality and amount of evidence culled from the death scene investigation and autopsy. The length of time between the occurrence of death and the discovery of the body is known as the postmortem interval. Estimates of time of death are more accurate and reliable when the postmortem interval is short; the specification of time of death thus becomes increasingly difficult when significant time has elapsed between the occurrence of death and the discovery of the body.

Estimates of time of death are based on several types of evidence. For example, witnesses can attest to when a person was last seen alive and when that person's body was discovered, allowing an approximation of the postmortem interval. The extent to which stomach contents have been digested can suggest time of death, as different foods are digested at different rates. Liquid foods (such as soup), for example, empty more quickly than heavy foods (such as steak). The higher the fatty content of a food, the longer it takes to empty from the stomach. In addition, alcohol consumption slows the stomach-emptying process.

Postmortem changes in body composition also hint at the length of time from death to discovery. Hence, an external examination of the body at the scene or shortly thereafter—taking into consideration the ambient temperature (or weather conditions if the deceased was found outdoors)—is also used to calculate time of death through three indicia: rigor mortis, livor mortis, and algor mortis.

Rigor mortis is the increasing rigidity of the muscles and joints that occurs one to three hours after death. The body remains in a state of rigor mortis until the dissipation of the chemical changes that cause it or until the joints are forcibly moved or broken. The body is in full rigor mortis when the jaw, knee, and elbow joints are immovable; this process takes ten to twelve hours and lasts twenty-four to thirty-six hours, at which point the muscles start to decompose and the joints loosen again. Rigor mortis develops more rapidly with higher temperatures, whether external (hot weather) or internal (fever). It also develops more rapidly if the decedent was physically active immediately preceding death.

Livor mortis, also called lividity or hypostases, is the settling of blood inside the body; it is caused by gravity after the heart has stopped pumping. Livor mortis appears within one hour postmortem and becomes fixed in eight to ten hours. Before it is fixed, lividity travels to different dependent areas of the body each time the body is repositioned. Discoloration of the skin can also appear in nondependent (nongravitational) areas of the body in cases of natural death caused by conditions such as congestive heart failure, which can produce lividity in the head, neck, shoulders, and upper chest. Livor mortis can be difficult to detect in individuals with dark skin pigmentation or who suffered from anemia. It can also be difficult to detect in cases of exsanguination (massive blood loss). Livor mortis is no longer visible after the body has started to decompose.

After death, the body equilibrates with the external temperature in a process called algor mortis. Unless the decedent is outdoors in direct sunlight on a hot day, the body progressively loses temperature at a rate of approximately 1.5 degrees Fahrenheit each hour postmortem until it matches the ambient temperature. If the individual experienced a rise or decline in internal body temperature preceding death, this can interfere with the use of algor mortis to arrive at an accurate estimation of time of death. In addition, cadavers with more clothing or fat (that is, insulation) lose temperature more slowly than do those with less clothing or fat.

Forensic pathologists can also estimate the time of death and length of the postmortem interval by evaluating the innate changes that occur in a dead body during the decomposition process, as tissues are broken down or destroyed. Four mechanisms are responsible for decomposition. The first of these, autolysis, begins in the early stages of decomposition and results from the uncontrolled action of the body's enzymes, which destroy protein and tissues. The second, putrefaction, follows autolysis and is caused by the tissue-destroying activity of bacteria that were in the body before death or entered the body after death. The third mechanism, consumption, is carried out by carnivorous insects or animals that eat bodily tissues. The fourth, fragmentation, occurs when body parts are torn away by animals or dislodged by forces such as running water. In general, buried bodies decompose at a slower rate than do bodies on dry land or in water, where putrefaction occurs at its slowest rate.

Death Certification and Expert Testimony

When a death investigation is completed, the medical examiner records the findings in a death certificate, which is a legal document in the public domain. The death certificate is the authentication of a death; it contains details about the decedent's identity and address, date and place of birth, and demographic characteristics (gender, occupation, educational level, race, age, marital status, military service). It also contains information about the physician who pronounced the person dead, the time and place of the death pronouncement, and how the body will be disposed of (burial, cremation, donation for medical research). The most crucial material in the death certificate, from the standpoint of forensic pathology, is that concerning the manner and cause of death. Death certificates in the United States are sent to state vital records offices and forwarded to the National Center for Health Statistics of the Centers for Disease Control and Prevention.

The evidence collected by forensic pathologists is often instrumental in the apprehension and conviction of suspects in homicide cases. Forensic pathologists also gather evidence that can establish liability in civil suits, such as evidence regarding workplace deaths or deaths resulting from automobile, train, or airplane accidents caused by negligence or recklessness. In both criminal and civil trials, forensic pathologists testify as expert witnesses on the cause and manner of death.

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Further Reading

Dix, Jay, and Michael Graham. *Time of Death, Decomposition, and Identification: An Atlas*. Boca Raton, Fla.: CRC Press, 2000. Covers in depth the methods used to identify decedents and estimate time of death. Engaging text, accompanied by extensive photographs, explains the various changes the body undergoes after death, all of which can be valuable evidence in death investigations.

Graham, Michael, and Randy Hanzlick. *Forensic Pathology in Criminal Cases*. Carlsbad, Calif.: Lexis Law, 1997. Technical work written primarily for criminal law attorneys and medical doctors in the early stages of training in forensic pathology is also useful to students in criminal justice, public health, and forensic science. Covers the background and credentialing of professionals in the field, details the process of dying and postmortem changes in body composition, and describes the procedures of death investigation and autopsy.

Helpern, Milton, with Bernard Knight. *Autopsy: The Memoirs of Milton Helpern, the World's Greatest Medical Detective*. New York: St. Martin's Press, 1977. Classic work written for a general audience describes the postmortem investigative process as it recounts the most baffling and famous cases encountered by the chief medical examiner of New York.

Noguchi, Thomas T., with Joseph DiMona. *Coroner at Large*. New York: Simon & Schuster, 1985. Focuses on the cases encountered by Noguchi in his role as Los Angeles County medical examiner. Examines the forensic evidence involved in some of the most famous cases of unnatural death during the 1970's, including those of Elvis Presley, Sal Mineo, and Freddie Prinze, in addition to several of the most notorious murder trials of that time, including those of Jean Harris and Jeffrey MacDonald. Entertaining and informative.

Randall, Brad. *Death Investigation: The Basics*. Tucson, Ariz.: Galen Press, 1997. Describes, step by step, the operations and procedures of a medical examiner's office. Features real case studies that illustrate the death investigation process. Written in a straightforward and practical style.

See also: Algor mortis; Antemortem injuries; Autopsies; Biohazard bags; Coroners; *Forensic Files*; Forensic odontology; Forensic sculpture; Forensic toxicology; Livor mortis; Medicine; Microscopes; Rigor mortis; Toxicological analysis.

Forensic photography

Definition: Photography used to document crime and accident scenes and to provide visual exhibits for legal proceedings.

Significance: Photographs taken at crime scenes serve to preserve forensic evidence so that investigators can later examine scenes that have been processed and no longer exist. Forensic photographs can help in the legal resolution of both recent and cold cases by revealing details that prove who committed crimes and how.

Soon after cameras were invented, photographs began to be used to capture evidence of crimes and for other legal purposes. In 1839, Jacques Daguerre, a pioneer in the technology of photography, took a photograph that proved a spouse's infidelity in a French divorce case. Several years later, police in Paris, France, began photographing apprehended criminals. Since that time, forensic photographs have documented many kinds of crime, including theft, assault, and document fraud. The 1959 quadruple murders that are the subject of Truman Capote's book *In Cold Blood* (1966) provide a notable example of an investigation aided by forensic photography: Kansas investigator Harold Nye's photographs of the crime scene exposed a shoe print that detectives used to identify a suspect who was later convicted.

Procedures and Strategies

Immediately after law-enforcement officials respond to crime or accident scenes, specially trained photographers use their skills and camera equipment to record crucial information at the scenes on digital storage devices or black-and-white or color film, depending on how quickly the investigators need images. In addition to forensic photography specialists, various law-enforcement professionals carry cameras and incorporate forensic photography among their assignments. Photography enables investigators to capture images of large pieces of evidence that cannot be removed from crime or accident scenes; it also allows the quick documentation of temporary or fragile evidence, such as prints or tracks, that weather might obliterate. Adjusting to all kinds of situations, forensic photographers take shots of many types of evidence, including wounds, skid marks, license plates, and razed building sites.

Prior to shooting photographs at crime scenes, forensic photographers consult with the law-enforcement personnel present regarding photography needs and assess the scenes to evaluate lighting conditions and whether specific lenses, filters, or flashbulbs will be needed to improve the clarity of the photos. Wearing protective clothing so that they do not contaminate any evidence, photographers document crime scenes during three stages of shooting, emphasizing accuracy, not aesthetics. First, they take overview photos from various directions and wide angles to capture comprehensive pictures of the sites, with each piece of evidence identified with a numbered marker for legal reference. They then move closer to specific pieces of evidence to take midrange shots that show the locations of those items and provide site context for them. Finally, they take close-up photos of individual pieces of evidence, first placing a ruler next to each item to indicate size. In addition to taking photos, forensic photographers keep notes, compiling information about each photograph, such as time taken.

Awareness of lighting and framing techniques enables forensic photographers to capture images of tire treads, shattered glass around bullet holes, and other damage that might otherwise be obscured. Forensic photographers use luminol or infrared and ultraviolet light sources to reveal otherwise invisible evidence, including dried blood and latent fingerprints, so that this evidence can be preserved in photographs. Photomicrography, a laboratory technique that couples the camera and the mi-

Forensic photographers take pictures of the remains of an unidentified woman in the Clark County coroner's autopsy lab in Las Vegas, Nevada, in 2004. *(AP/Wide World Photos)*

croscope, expands forensic photography options, producing images of evidence that are highly magnified.

Law-enforcement personnel also value aerial and underwater photography for forensic uses when crime scenes involve vast areas or when evidence is submerged. In addition, the field of forensic photography encompasses the use of photography during police surveillance, when investigators watch and photograph people or places suspected of being involved in criminal activity.

Video photography has a number of uses in law enforcement. Investigators frequently use forensic videography to scan crime scenes, and police sometimes videotape suspects while they interrogate them or to document confessions. Still photographs from videos and security cameras are considered evidence; measurements in such forensic images are determined through photogrammetry.

Legal Applications

Photographs often help investigators comprehend what occurred during a crime. Police detectives scrutinize crime scene photographs, and occasionally in reviewing such photos they notice details of which they were unaware at the scene or only later realized were significant in context with other information. In addition, detectives frequently use forensic images to verify details they describe in their reports.

Photographs also help both investigators and witnesses to identify suspects, particularly when the photos depict crimes in progress or culprits at scenes. When suspects are arrested, law-enforcement agencies take photographs of them (so-called mug shots) and add these photographs to computerized databases of known and suspected criminals.

Legal personnel prepare forensic photographs, often enlarging them, for use in courtrooms; frequently the purpose of presenting such photos is to stress the links between the suspects or evidence pictured and crimes. Police often use photographs to prove that particular vehicles and drivers were involved in traffic and parking infractions. In addition to being useful in court, photographs of injuries and of damages to structures and vehicles suffered during crimes can support insurance claims and help victims gain compensation.

Many misconceptions about forensic photography have been fostered by inaccurate portrayals in the mass media, and some observers have asserted that jurors sometimes have unrealistic expectations regarding the photographs used in courtrooms. Forensic photography experts aim to provide images that accurately portray crime scenes and evidence, have not been altered, and do not represent biases. International, U.S., and state courts have ruled on many legal cases in which the issue was whether specific photographs were admissible evidence. The Federal Bureau of Investigation's Scientific Working Group on Imaging Technologies has created guidelines concerning the presentation of legally acceptable forensic photographs and videos.

The Evidence Photographers International Council (EPIC) sponsors training programs for forensic photographers and publishes the *Journal of Evidence Photography*. Collegiate criminal justice programs and law-enforcement and photography associations offer classes to educate forensic photographers.

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Further Reading

Bevel, Tom, and Ross M. Gardner. *Bloodstain Pattern Analysis: With an Introduction to Crime Scene Reconstruction*. 2d ed. Boca Raton, Fla.: CRC Press, 2002. Describes strategies for photographing blood evidence, including the road-mapping technique, which documents stains and spatter patterns.

Blitzer, Herbert L., and Jack Jacobia. *Forensic Digital Imaging and Photography*. San Diego, Calif.: Academic Press, 2002. Volume coauthored by the executive director of the Institute for Forensic Imaging emphasizes the uses of computer technology in the processing of effective, legally admissible forensic photographs. Includes CD-ROM.

Buckley, Cara. "In Domestic Abuse, Digital Photos Can Say More Than Victims." *The New York Times*, May 7, 2007, p. B1. Discusses how forensic photographs can expedite legal decisions and remain convincing proof even when victims do not testify.

Redsicker, David R. *The Practical Methodology of Forensic Photography*. 2d ed. Boca Raton, Fla.: CRC Press. 2001. Reference guide details approaches to documenting various kinds of crimes using both traditional photography and innovative technologies. Includes glossary.

Robinson, Edward M. *Crime Scene Photography*. San Diego, Calif.: Academic Press, 2007. Comprehensive text explores basic and advanced photographic techniques, examines legal aspects of forensic photography, and discusses the reasons photographic evidence was questioned in some particular cases.

See also: Biometric identification systems; Buried body locating; Celebrity cases; Closed-circuit television surveillance; Courts and forensic evidence; Crime scene documentation; Imaging; Night vision devices; Oblique lighting analysis; Photograph alteration detection; Tire tracks.

Forensic psychiatry

Definition: Branch of medical practice at the interface of psychiatry and law that involves the application of medical expertise and research findings in legal contexts.

Significance: Physicians who work in forensic psychiatry assume a wide range of responsibilities that are essential to decision making in the criminal and civil justice systems.

Forensic psychiatrists focus on legal principles and evidentiary rules when assisting the courts on matters that require specialized knowledge and experience regarding mental disorders and cognitive capacities. In the field of forensic psychiatry, physicians typically serve as consultants and expert witnesses in criminal or civil litigation. As consultants, forensic psychiatrists educate attorneys and defendants about science-validated techniques for diagnosing and treating mental illness and the relevance of these techniques to the cases at hand. As expert witnesses, forensic psychiatrists testify on a variety of probative issues that advance court cases and are beyond the understanding of laypersons (such as jurors) and legal professionals (such as attorneys and judges). Expert witnesses generally do not proffer direct evidence about a defendant's guilt in a criminal trial or liability in a civil trial, nor do they testify as fact witnesses regarding the alleged criminal or negligent act. Instead, their testimony answers complicated legal questions through the expression of informed medical opinions that help the fact finders (judges and jurors) arrive at those ultimate decisions. Therefore, the participation of forensic psychiatrists in the court system can be instrumental in the determination of legal cases and clearly promotes the pursuit of justice.

Treatment Techniques and Settings

Psychiatrists treat mental illness largely through the prescription of medications that target the brain chemicals believed to be responsible for the causes and symptoms of mental disorders. They also treat patients with psychotherapeutic techniques (talk therapy) as well as other medical interventions, such as electroconvulsive therapy, which is an effective treatment for severe depression.

Forensic psychiatrists use the same treatment regimens as other psychiatrists. They differ from other psychiatrists mostly with respect to the settings in which they administer treatment and the types of patients they treat. Forensic psychiatrists engage in clinical practices in correctional settings, such as jails, prisons, departments of forensic services, and other venues that are under legal jurisdiction and control. All of the patients evaluated or treated by forensic psychiatrists are involved in different stages of the legal process.

Competency to Stand Trial

Forensic psychiatrists are probably best known for their work in the criminal justice system. In criminal courts, they perform assessments and deliver testimony on two major issues: competency to stand trial and the insanity defense. In the case of *Dusky v. United States* (1960), the U.S. Supreme Court declared that the prohibition against trying a mentally incompetent defendant is a fundamental principle of the American justice system. Competency to stand trial is a legal question that demands the expertise of a forensic psychiatrist because it hinges on a defendant's mental or cognitive capacity to comprehend and process information and to communicate rational choices. An evaluation of competency to stand trial can be requested by a judge or by an attorney.

Competency is a defendant's ability to participate meaningfully in his or her own defense in consultation with legal counsel. It also presumes that a defendant has a factual understanding of the charges and legal proceedings. The right to due process guaranteed under the Sixth Amendment to the U.S. Constitution stipulates that both of these conditions must be met before a person can be tried for an alleged criminal offense. In assessing competency or fitness to stand trial, the forensic psychiatrist examines, among other areas of functioning, the "McGarry criteria," which are concerned with the defendant's appreciation of the possible penalties in the case, capability to testify, and willingness and ability to communicate effectively with defense counsel in order to develop a basic defense plan. When conducting competency evaluations, forensic psychiatrists use psychological tests, structured interviews, and observations. They also perform mental status examinations during which they evaluate the individuals' insight, judgment, mood, thinking, alertness, and speech.

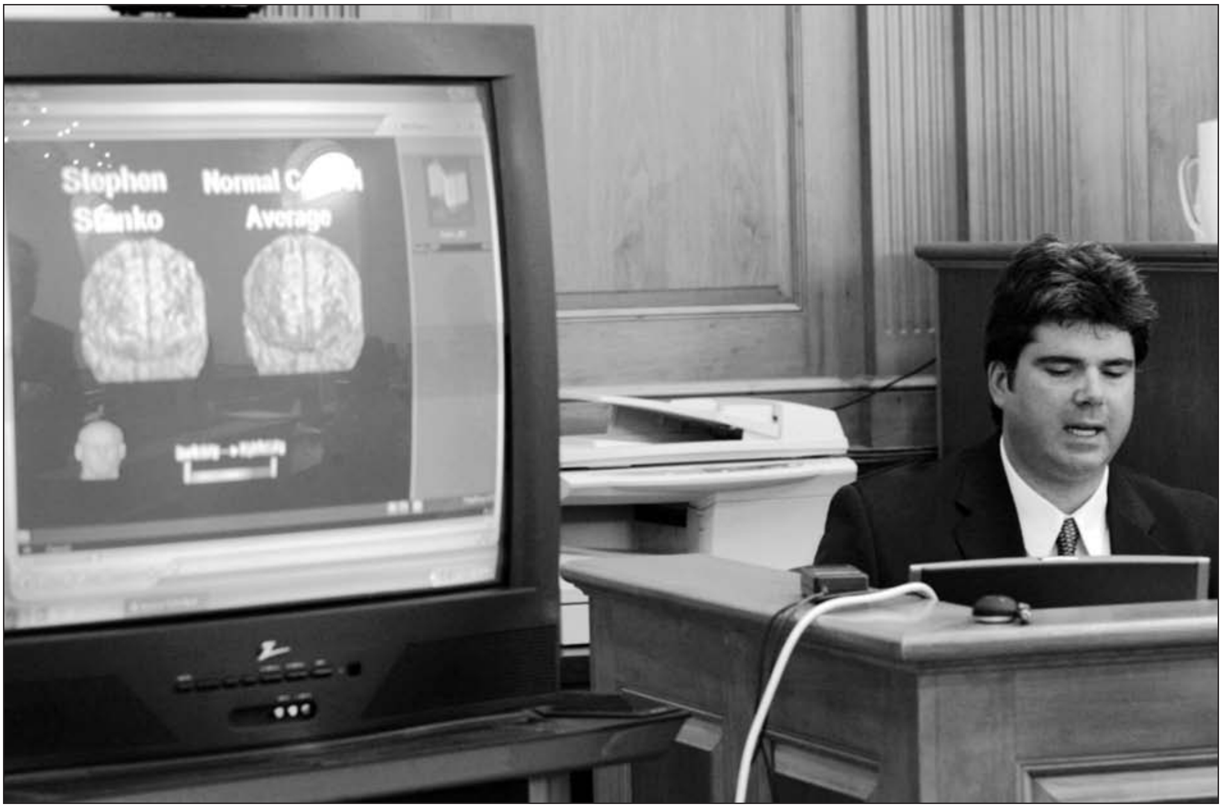
If a forensic psychiatrist deems a defendant incompetent to stand trial and the judge declares the defendant to be such, trial is delayed until the defendant can be restored to competency. (The judge's ruling on competency elevates the forensic psychiatrist's opinion to a court finding.) The competency restoration process consists of standard psychiatric care in a correctional psychiatric facility. Other types of criminal court decisions involving forensic psychiatrists include evaluations to determine competency to testify, to refuse medical treatment, to be executed, and to be a juror.

Insanity Defense

The insanity defense is a widely misunderstood, rarely invoked, and controversial criminal defense. Insanity is a legal concept that dates back to the twelfth century. In order for a behavior to constitute a crime, two elements must be present to establish criminal responsibility: voluntary conduct (*actus reus*) and willful and malicious intent (*mens rea*). The insanity defense raises questions about the defendant's intentionality, which is evaluated by a forensic psychiatrist who then testifies to the court about whether the defendant could control his or her behavior and understood the wrongfulness of his or her actions at the time of the crime.

Several tests or rules have evolved to determine criminal responsibility and have served as legal touchstones for forensic psychiatrists when they must gather and interpret clinical information to render opinions to the courts. These include the M'Naghten rule of 1843, which states that defendants are not criminally responsible (not guilty by reason of insanity) if, at the time of their crimes, they suffered from diseases of the mind that rendered them unable to discern the difference between right and wrong or caused them to harbor delusions that, if true, would have justified their criminal behavior as legitimate self-defense.

The two-prong test of criminal responsibility of the American Law Institute's Model Penal Code is somewhat similar to the M'Naghten rule. It states that persons are not criminally responsible (are insane) if, at the time of their alleged criminal conduct, a mental disease or defect (a legal term) prevented them from having the substantial capacity to appreciate the wrongfulness of their behavior (cognitive prong)



Dr. Thomas Sachy, a forensic psychiatrist, testifies at a pretrial hearing for Stephen Stanko in Georgetown, South Carolina, in July, 2006. Sachy stated that Stanko was insane at the time he killed his live-in girlfriend and assaulted a young girl. *(AP/Wide World Photos)* and to conform their conduct to the law (volitional prong). A forensic psychiatrist's opinion about insanity is formulated, in part, on the basis of the psychiatrist's assessment of the nexus of the defendant's mental illness and the crime; the defendant's thinking and behavior before, during, and after the offense; the defendant's criminal record; and the defendant's motive or justification for the crime. In most criminal cases that invoke the insanity defense, two or more psychiatrists are asked to testify for the defense and for the prosecution in an adversarial proceeding, sparking a debate about the defendant's state of mind during the commission of the crime.

Forensic Psychiatrists' Training

Psychiatrists are medical doctors who use their clinical and research expertise to assess, diagnose, and treat mental illnesses. Psychiatrists base their diagnoses of mental illnesses on the definitions laid out in the American Psychiatric Association's *Diagnostic and Statistical Manual of Mental Disorders*, fourth edition, text revision (*DSM-IV-TR*), which describes the major signs and symptoms of a large number of brain diseases of childhood and adulthood, including schizophrenia, bipolar disorder, major depression, and anxiety disorders. Psychiatrists use *DSM-IV-TR* as a diagnostic nomenclature and guidebook that enumerates the criteria necessary to render diagnoses for the primary purposes of research and treatment. These diagnoses are often core factors in the legal cases that fall within the purview of forensic psychiatry.

To become psychiatrists, doctors must complete three or more years of postgraduate residency training in psychiatry in addition to their four years of medical school training. To become forensic psychiatrists, they must also complete at least two years of fellowship training in forensic psychiatry. In the United States, the professional organization of forensic psychiatry is the American Academy of Psychiatry and the Law.

Civil Courts

Forensic psychiatrists testify in a wide range of civil court proceedings. For example, in medical malpractice litigation, they are called to present evidence in cases where patients or others (such as patients' family members) sue psychiatrists for negligence (these may involve prescription errors, failure to warn victims of patients' stated intention to harm them, failure to take precautions with suicidal patients, or inflicting harm on patients through irresponsible or unethical conduct). In such cases, forensic psychiatrists must show that the physician defendants deviated from standards of care and that these actions directly resulted in patient harm or damages.

In child-custody cases, forensic psychiatrists advise the court on parental rights based on the standard of the best interests of the child. In personal injury cases, forensic psychiatrists must ascertain the nature and extent of the psychological trauma sustained by plaintiffs following accidents and rule out the possibility of plaintiff malingering.

Arthur J. Lurigio

Further Reading

Barsky, Allan E., and Jonathan W. Gould. *Clinicians in Court: A Guide to Subpoenas, Depositions, Testifying, and Everything Else You Need to Know*. New York: Guilford Press, 2002. Excellent reference source on forensic issues in clinical practice, written for a broad, nonmedical audience. Includes sample legal documents and case recommendations.

Heilbrun, Kirk, Geoffrey Marczyk, and David DeMatteo. *Forensic Mental Health Assessment: A Casebook*. New York: Oxford University Press, 2002. Presents an extensive review of forensic principles and case materials as well as illustrative case studies that will appeal to both students and seasoned practitioners of forensic psychiatry.

Rogers, Richard, and Daniel W. Shuman. *Fundamentals of Forensic Practice: Mental Health and Criminal Law*. New York: Springer, 2005. Provides comprehensive and practical coverage of legal and clinical issues in all phases of criminal proceedings, from pretrial to posttrial evaluations. Includes discussion of expert testimony.

Rosner, Richard, ed. *Principles and Practice of Forensic Psychiatry*. New York: Oxford University Press, 2003. Definitive text in forensic psychiatry covers the full range of topics in the field. Includes material applicable to practices outside the United States.
Simon, Robert and Liza Gold, eds. *Textbook of Forensic Psychiatry*. Washington, D.C.: American Psychiatric Publishing, 2004. Offers a comprehensive array of practice guidelines and case examples in all areas of criminal and civil litigation of interest and relevance to forensic psychiatrists.

See also: Attention-deficit/hyperactivity disorder medications; Brain-wave scanners; Competency evaluation and assessment instruments; Criminal personality profiling; *Diagnostic and Statistical Manual of Mental Disorders*; False memories; Forensic psychology; Guilty but mentally ill plea; Insanity defense; Irresistible impulse rule; *Mens rea*; Minnesota Multiphasic Personality Inventory; Parental alienation syndrome.

Forensic psychology

Definition: Field of psychological practice concerned with assessment, consultation, psychotherapy, and the study of human behavior and thinking within judicial systems.

Significance: Forensic psychologists play an important role in the American criminal and civil justice system, lending their understanding of human behavior and thinking to the description, explanation, prediction, and change of the behaviors of persons working for and involved with the system.

Forensic psychology is an international effort that can be traced to the 1890's and the memory experiments conducted by James McKeen Cattell, Alfred Binet, William Stern, and others. Their research suggested that eyewitness testimony is often unreliable and incomplete. Subsequently, comments by Sigmund Freud in 1906 suggesting that his therapeutic approach could assist Austrian judges, along with Hugo Münsterberg's book *On the Witness Stand: Essays on Psychology and Crime*, first published in 1908, popularized the notion that psychology had something to offer the legal system. Münsterberg was an outspoken advocate for the application of psychology to legal settings. He became involved in a number of criminal cases in the United States and ridiculed attorneys and judges for their reluctance to see the value of applying psychological principles and methods to the judicial process. His drive to apply psychology to the legal setting resulted in a backlash from the influential legal scholar John Henry Wigmore, who satirized Münsterberg in an article that appeared in the *Illinois Law Review* in 1909. As a result, psychologists' influence within the legal system diminished.

The Practice of Psychology in Legal Settings

Psychologists continued to work within the legal system in varying capacities. In 1913, psychological services were provided to inmates at a U.S. correctional facility for the first time, and in 1917, Lewis Terman became the first American psychologist to use psychological testing in the selection process for police officers. During the 1920's, Karl Marbe became the first psychologist to testify in a German civil trial, and William Moulton Marston became the first professor of legal psychology at American University. In 1931, Harold E. Burtt published the first textbook on legal psychology.

The partnership between psychology and law began to strengthen during the 1960's and 1970's, encouraged by the publication of *Legal and Criminal Psychology* (1961), edited by Hans Toch, and H. J. Eysenck's proposed theoretical account of criminal behavior in *Crime and Personality* (1964). During this period Martin Reiser became the first full-time police psychologist in Los Angeles, California, and correctional psychology became recognized as a profession as the result of the efforts of Stanley Brodsky, Robert Lewinson, and Asher Pacht. Training and certification began to change as well. The University of Nebraska established the first interdisciplinary program in psychology and law, and the American Board of Forensic Psychology provided professional certification for qualified applicants.

Psychological Research and the Law

Psychologists had been recognized by the legal system for their contributions regarding the practice of psychology, but psychological research concerning the issue of eyewitness reliability continued to be largely ignored. Psychologists such as Robert Buckout, Elizabeth F. Loftus, Gary L. Wells, and Saul M. Kassin met the challenge of persuading judges, attorneys, and law-enforcement personnel that psychology as a science could benefit the legal system in regard to eyewitness testimony as it pertained to eyewitness identifications and memory.

The 1970's and 1980's were productive decades for mounting psychological evidence identifying the factors that influence eyewitness reliability. Wells distinguished between controllable factors in the criminal justice system that can lead to mistakes in eyewitness reports, such as lineup identification instructions, and uncontrollable factors, such as witnesses with poor eyesight, that lend themselves to mistaken eyewitness testimony. Loftus's book *Eyewitness Testimony* (1979) summarized scientific support for the idea that misinformation introduced during a witness interview can change a witness's memory of an event. Roy Malpass and his colleagues provided evidence that cross-race identifications can interfere with witness accuracy and that biased police lineup instructions can increase identifications of innocent suspects. R. Edward Geiselman, Ronald P. Fisher, and others began to test an interview technique, the cognitive interview, that uses memory strategies to increase the amount of accurate information a witness provides without increasing errors.

Despite the growing psychological evidence questioning the reliability of eyewitness testimony, courts continued to be reluctant to provide a legal remedy. During the 1990's, forensic science began to utilize DNA (deoxyribonucleic acid) evidence derived from skin tissue, semen, and hair samples recovered from crime scenes. DNA, when available, was strong evidence against a defendant, but it was also useful in excluding innocent persons from investigation.

In 1996, the U.S. National Institute of Justice published a report titled *Convicted by Juries, Exonerated by Science: Case Studies in the Use of DNA Evidence to Establish Innocence After Trial*. The report noted that eyewitness testimony was often key evidence against innocent defendants. At that time, the attorney general of the United States, Janet Reno, responded to the report by gathering law-enforcement personnel, attorneys, and psychologists to form the Technical Working Group on Eyewitness Evidence. The group was charged with compiling scientifically based guidelines for the handling of eyewitness evidence. The resulting work, *Eyewitness Evidence: A Guide for Law Enforcement*, published in 1999, provides recommendations for procedures to be followed in the collection of eyewitness statements and the conduct of suspect identifications that minimize eyewitness error.

The successful application of psychological science to eyewitness evidence is only one example of the contributions of psychology to forensic work. Psychologists actively study many areas of human behavior related to criminal justice and forensic issues, including jury decision making, police interrogations and suspect confessions, and the testimony of child witnesses.

Becoming a Forensic Psychologist

The practice of psychology, and the conduct of psychological research, by persons working in or involved with the justice system has gained credibility and influence in modern criminal and civil justice systems worldwide, making the field of forensic psychology a dynamic career option. A common misconception is that forensic psychologists are primarily criminal personality profilers or behavior analysts, but in reality forensic psychologists work within the criminal and civil justice system in a number of ways that may never involve profiling criminal behavior. Although there are exceptions, profiling is actually a very small, specialized area conducted predominantly by law-enforcement personnel and not by forensic psychologists.

Forensic psychologists are typically individuals with graduate degrees in clinical or nonclinical psychology and some form of training in forensics. Requirements for admission to graduate programs vary, but all programs require that students have bachelor's degrees from accredited institutions along with acceptable grade-point averages. Having majored in psychology as an undergraduate may be helpful, but it is not a prerequisite of admission to most graduate programs.

Programs vary in emphasis from clinical to nonclinical forensic issues. Graduate degrees in clinical or experimental psychology are likely to take the form of a master of arts (M.A.) or master of science (M.S.) degree or a doctor of philosophy (Ph.D.) or psychology degree (Psy.D.). Forensic training may involve a subspecialty within a chosen graduate program or a separate degree in conjunction with a psychology degree, such as a law degree (J.D.), a master of legal studies (M.L.S.), or master of science and criminal justice (M.S.C.J.). Generally, programs offering master's degrees are of shorter duration (usually two to three years) than those offering doctorates (four to six years), and dual-degree programs, such as J.D.-Ph.D., may be longer. In addition, students—clinical students primarily, but some nonclinical students also—may be required to participate in some form of internship or mentoring program within a legal setting before completing degree requirements.

Content Areas in Forensic Psychology

In 2001, the American Psychological Association (APA) stipulated that education for a forensic specialty should be in applied psychology and recommended areas of specialization in clinical psychology, counseling psychology, neuropsychology, and school psychology, with advanced instruction in law and justice administration. These areas require some form of professional practice, such as psychological assessment (for example, competency to stand trial), consultation (for example, child custody determination), or psychotherapy (for example, treatment for sexual offenders).

Although not included in the APA recommendations for the forensic psychology specialty, many nonclinical programs with specialization in cognitive psychology, developmental psychology, and social psychology emphasize the study of law or legal issues that emerge as the result of judicial processes. A psychologist who focuses primarily on forensic research will acquire expertise in the use of scientific methodology, statistics, and scholarly writing to advance the study of forensic issues. Forensic issues can include phenomena related to cognitive processes (such as a police officer's decision to use deadly force), techniques (such as the use of anatomically detailed dolls in interviews with children), or legal legislation, laws, and policy (such as racial profiling that results in searches of airline passengers of Middle Eastern heritage).

Clinical psychologists may conduct research on forensic issues and have many of the skills of nonclinical psychologists, but they are also skilled in the practice of psychology within the legal setting. Therefore clinical psychologists, for example, may provide psychotherapy to juvenile offenders and conduct research assessing juveniles who are at risk for exhibiting violent behavior. Clinical psychologists may work in private practice, in academic settings such as universities, or for state mental health or corrections facilities. In contrast, nonclinical psychologists typically work in academic or government settings as researchers. Clinical and nonclinical psychologists may consult (for example, acting as trial consultants) or provide expert testimony relevant to their areas of expertise (such as the reliability of eyewitness memory).

Kimberley A. McClure

Further Reading

Bartol, Curt R., and Anne M. Bartol. *Introduction to Forensic Psychology: Research and Application*. 2d ed. Thousand Oaks, Calif.: Sage, 2008. Compares forensic psychology with other forensic sciences and elaborates on the applications of psychology within the legal system. Discusses police and investigative psychology, criminal psychology, victims and victim services, psychological science in the courts, and correctional psychology.

Connors, Edward, Thomas Lundregan, Neal Miller, and Tom McEwan. *Convicted by Juries, Exonerated by Science: Case Studies in the Use of DNA Evidence to Establish Innocence After Trial*. Washington, D.C.: National Institute of Justice, 1996. Government research report discusses a study initiated to identify and review cases in which convicted persons were released from prison as a result of posttrial DNA testing of evidence.

Costanzo, Mark. *Psychology Applied to Law*. Belmont, Calif.: Thomson/Wadsworth, 2004. Describes the relationship between psychology and the law by focusing on specific areas such as interrogations, confessions, and lie detection; profiles and syndromes; competence and insanity; juries' and judges' decision making; memory evidence; risk assessment; workplace law; and sentencing, imprisonment, and the death penalty.

Doyle, James M. *True Witness: Cops, Courts, Science, and the Battle Against Misidentification*. New York: Palgrave Macmillan, 2005. Provides historical and modern-day details concerning how psychologists have worked to apply science to the issue of eyewitness testimony and its reliability.

Fulero, Solomon M., and Lawrence S. Wrightsman. *Forensic Psychology*. 3d ed. Belmont, Calif.: Thomson/Wadsworth, 2008. Explores all aspects of the relationship between the practice of psychology and the legal system. Discusses the roles and responsibilities of psychologists in relation to law enforcement, techniques of criminal investigation, and issues related to eyewitness memory as well as psychologists' involvement in assessing insanity and competency to stand trial in legal cases and their roles in cases concerning child custody, discrimination, and sexual harassment.

Münsterberg, Hugo. *On the Witness Stand: Essays on Psychology and Crime*. 1908. Reprint. Whitefish, Mont.: Kessinger, 2007. Facsimile reprint of a classic work that argues for the application of the discipline of psychology to legal settings.

Technical Working Group on Eyewitness Evidence. *Eyewitness Evidence: A Guide for Law Enforcement*. Washington, D.C.: National Institute of Justice, 1999. A panel of police officers, prosecutors, psychologists, and defense attorneys provides suggestions regarding the conduct of reliable, effective identification procedures.

Weiner, Irving B., and Allen K. Hess, eds. *The Handbook of Forensic Psychology*. 3d ed. Hoboken, N.J.: John Wiley & Sons, 2006. Collection geared primarily for professional psychologists presents issues in the field of forensic psychology from the perspectives of a number of experts. Topics covered include civil proceedings such as divorce and competency, criminal responsibility and the insanity defense, and the communication of expert opinion to the courts.

See also: Actuarial risk assessment; Brainwave scanners; Cognitive interview techniques; Competency evaluation and assessment instruments; Criminal personality profiling; Expert witnesses; Eyewitness testimony; False memories; Forensic psychiatry; Hostage negotiations; Insanity defense; Police psychology; Psychological autopsy; Sexual predation characteristics.

Forensic Science Service

Date: Formed in April, 1991

Identification: Organization established to coordinate forensic science services in England and Wales.

Significance: The Forensic Science Service is one of the world's leading providers of forensic science analyses. The organization has also earned an international reputation as an innovator in forensic technology.

During the late 1920's, detectives of London's Metropolitan Police had two avenues for assistance with the scientific analysis of evidence: They could rely on help from consulting experts or seek out Sergeant Cyril Cuthbert, a forensic science enthusiast. Using a secondhand microscope and primitive equipment, Cuthbert offered basic analyses of bloodstains and other evidence.

The first Metropolitan Police Laboratory opened at Hendon Police College in the spring of 1935. The small facility's staff consisted of a pathologist, a chemist, Cuthbert as police liaison officer, a technician, a clerk, and a cleaner.

Within a few years, the lab's duties included analyses of blood and semen stains, identification of poisons, tool-mark examination, forensic firearm identification, and investigation of explosives.

During the late 1930's, local police forces in Birmingham, Bristol, Cardiff, Nottingham, and other locations established their own forensic laboratories. The Home Office, the government department in the United Kingdom that leads efforts to protect the public from crime, gradually brought the regional labs under its control, and the Home Office Forensic Science Service was born.

In 1991, the Forensic Science Service (FSS) became an executive agency of the Home Office. As an agency, the FSS could charge for services provided to any British customer and overseas clients. The FSS pioneered forensic technology, especially in the area of DNA (deoxyribonucleic acid) analysis. In April, 1995, the agency launched the world's first national criminal intelligence DNA database. The National DNA Database enables investigators to run searches for matches to DNA samples from crime scenes.

Beginning in 1999, the FSS began another change when it transformed from a government agency to a business organization legally separate from the government. Today, the Forensic Science Service is the trading name of Forensic Science Service Ltd., a British government-owned company. The Home Office anticipated that an independently run FSS could compete more effectively against commercial forensic service companies.

With eleven facilities in England and Wales and a staff of more than twenty-five hundred, the FSS serves a variety of clients in both criminal and civil matters. The wide-ranging services of the FSS include analyses of evidence from crimes of bodily injury, property crimes, vehicular accidents, computer crimes and fraud, crimes involving illegal drugs, and terrorism. The FSS has also helped overseas governments to establish or enhance their own forensic laboratories. The organization's research and development unit is devoted to the advancement of forensic technologies, which the FSS makes available to law-enforcement entities.

Phill Jones

Further Reading

Fido, Martin, and Keith Skinner. *The Official Encyclopedia of Scotland Yard*. London: Virgin Books, 1999.

Walls, H. J. "The Forensic Science Service in Great Britain: A Short History." *Journal of the Forensic Science Society* 16 (October, 1976): 273-278.

White, Peter, ed. *Crime Scene to Court: The Essentials of Forensic Science*. 2d ed. Cambridge, England: Royal Society of Chemistry, 2004.

See also: Biological terrorism; Bombings; Computer crimes; Crime laboratories; European Network of Forensic Science Institutes; Federal Bureau of Investigation Forensic Science Research and Training Center; Forgery; Identity theft; Meth labs.

Forensic sculpture

Definition: Process in which sciences such as anthropology, osteology, and anatomy are combined with artistry to approximate, from human remains, parts of individuals in three-dimensional form.

Significance: Forensic anthropologists are sometimes called upon to reconstruct facial features or other parts of human beings from decayed remains to aid in the identification of those individuals. This work can enable law-enforcement authorities to close cases and to return the remains to the families of the deceased.

When a forensic anthropologist examines unknown and decayed remains, the first questions that arise concern the age, sex, and race of the decedent. When remains are sufficient, age at time of death is easily approximated based on when bone growth stops and on joint and dental wear. For gender, the anthropologist looks for differences that tend to appear between the sexes. Because a woman is built to bear children, the bones of the female pelvis tend to flare out more widely from the spine than do those of the male pelvis; in addition, the foramen, the

Sculptor Eileen Barrow (left) and forensic anthropologist Mary Manhein pose with the bust of a woman's head that they made at Louisiana State University in 2004. They created the bust from the skull of an unknown murder victim whose drowned body had been discovered seventeen years earlier and then buried. Law-enforcement officials hoped to use the bust to identify the woman and catch her killer. *(AP/Wide World Photos)*

opening between the hip joints, tends to be larger in circumference in a woman than it is in a man. On the skull, the bony ridge of the forehead along the brow line (the supraorbital ridge) tends to be more pronounced in men than it is in women. These features vary widely among individuals, however; the anthropologist may need to rely at times on other clues, such as the clothing recovered with the remains.

Determining race is less clear-cut than determining age or sex. *Homo sapiens* is a single species with a single, shared gene pool across all populations, and this makes it exceedingly difficult for forensic anthropologists to assess race from skeletal characteristics. Remains can be compared with reference populations—skeletal collections containing reliable antemortem information such as age, sex, and ancestry. Databases are available on collections of unknown casualties—the vast majority young men—from World War II and the Korean War. The Smithsonian Institution maintains a skeletal reference collection, and certain fetal samples have been collected, but reference collections on racially diverse populations are distinctly lacking. Unidentified decedents' ancestries often remain unknown.

Kinds of Identification

The two types of identification established in forensic anthropology are known as circumstantial identification and positive (or direct) identification. Circumstantial identification occurs when skeletal remains fit a particular biological profile. As many individuals may fit the same profile, this does not prove identity. Positive identification occurs when unique characteristics of an individual, such as medical or dental records, bite marks, or DNA (deoxyribonucleic acid), among other traits, are positively matched with known samples. When other identification techniques have failed, forensic sculpture, also known as forensic facial reconstruction, offers the possibility of identification to law-enforcement investigators and to family members of the deceased.

The two main methods used for forensic facial reconstruction both require possession of the decedent's skull. (Although X-ray images are sometimes used when the skull is unavailable, this method is far from ideal, as certain cranial structures may be invisible or distorted in the images.) Two-dimensional methods employ handmade drawings or computer images; three-dimensional methods can also use computer-generated images, or they may involve sculpture.

Three-Dimensional Reconstruction

In general, the tissue that covers the human skull lies at predictable depths at various points; for example, more tissue is found in the cheek area than over the forehead. In the absence of tissue fragments, forensic anthropologists conducting facial reconstruction base both computer-generated images and sculptures on predicted tissue depths. These predicted depths are derived from information on people of average weight.

In the creation of a computer-generated facial reconstruction, photographs of the cranial remains are scanned, and facial planes are approximated at predicted depths on the bones. Facial features are added based on the resulting planes and the anthropologist's informed guesswork; stock photographs of features may be used, particularly when the decedent's race is known. If necessary, computer software can also age the image. When completed, the high-resolution image can be rotated, so that the computer-generated face can be viewed from different perspectives.

For forensic sculpture, a plaster cast is usually made from the decedent's skull, and the facial reconstruction is built on the cast. Tissue-depth markers—each about the diameter and consistency of the eraser on the end of a pencil—of appropriate lengths are first glued to the cast. Then, using a special oiled clay that does not harden, the forensic anthropologist applies underlying musculature and a facial surface to the depths of the markers. Noses are difficult to recreate, because shapes vary and the cartilage that creates the shape of the nose is absent from decayed remains; the anthropologist must apply educated guesswork. Final touches are cosmetic; these include prosthetic eyes. If hair was recovered with the remains, a wig of appropriate color is added. Forensic sculpture can create a rather masklike but recognizable likeness of the decedent.

Jackie Dial

Further Reading

Clement, John G., and Murray K. Marks. *Computer-Graphic Facial Reconstruction*. New York: Academic Press, 2005. Discusses a variety of approaches to techniques of computer-aided victim identification.

Gill, George W., and Stanley Rhine. *Skeletal Attribution of Race: Methods for Forensic Anthropology*. Albuquerque: Maxwell Museum of Anthropology, University of New Mexico, 2004. Contains images of skull and face-form variations useful for determining ancestry.

Taylor, Karen T. *Forensic Art and Illustration*. Boca Raton, Fla.: CRC Press, 2001. Illustrated text by a renowned forensic artist is considered a classic research tool for experienced analysts as well as a fascinating and easy-to-follow primer for novices to the field of forensic art.

Walton, Richard H. *Cold Case Homicides: Practical Investigative Techniques*. Boca Raton, Fla.: CRC Press, 2006. Comprehensive volume on cold-case investigation includes a chapter on forensic art by Karen T. Taylor, with contributions by medical illustrator Betty Pat Gatlin, that presents a scrupulously thorough discourse on postmortem imagery in cold cases.

Wilkinson, Caroline. *Forensic Facial Reconstruction*. New York: Cambridge University Press, 2004. Includes all available published data on tissue depths and variations with age, sex, and race, and evaluates techniques and problems of reconstructing the faces of children.

See also: Ancient criminal cases and mysteries; Anthropometry; Composite drawing; Direct versus circumstantial evidence; Forensic anthropology; Forensic pathology; Kennewick man; Lasers; Osteology and skeletal radiology; Skeletal analysis; University of Tennessee Anthropological Research Facility.

Forensic toxicology

Definition: Application of the knowledge of poisons to the identification of cases of homicide, suicide, accidents, and drug abuse for legal purposes.

Significance: Forensic toxicologists provide information for law-enforcement investigators by determining the substances involved in deaths caused by poisoning, whether accidental, homicidal, or suicidal. Toxicologists also determine the amounts of toxic substances present in poisoning cases, thus helping investigators to distinguish cases of accidental poisoning from cases of intentional homicidal poisoning.

Forensic toxicology plays the important role of linking specific chemicals with homicides, suicides, and alcohol- and drug-related deaths. Most homicidal and suicidal poisonings involve single, large doses of toxic substances (accidental and suicidal poisoning deaths include accidental and intentional deaths caused by drug abuse). Many job-related poisonings, in contrast, result from chronic exposure to low concentrations of poisons; in such cases, those exposed may have no apparent symptoms for a long time after exposure begins. In cases of suspected poisoning, forensic toxicologists use chemical and biological techniques to analyze samples of the bodily fluids and tissues of victims for the presence of poisons.

Poisons

Poisons are substances that, when introduced into the body, cause disturbances of normal body functions, injury, disease, or death. Chemical poisons are grouped as supertoxic (this group includes botulinum toxin), extremely toxic (this group includes the most toxic dioxin, known as TCDD), highly toxic (this group includes nicotine), and moderately toxic (this group includes alcohol). Poisons can enter the body through ingestion of contaminated foods or liquids, through inhalation, or through contact with skin and eyes. Knowledge of the route of entry of a poison into the body can help forensic scientists to determine when an individual was poisoned. The dosage (dose multiplied by the duration of intake) of the poison determines the poisoning.

Certain poisons can be more toxic to particular persons because of specific genetic and physiological traits, including weight, health, gender, and developmental maturity. Conditions surrounding the victim, such as activity, crowding, and environment (temperature, humidity, barometric pressure), can also affect the manifestation of poisoning. After entering the body, any poison is diluted by water in the blood and body tissues.

Signs and Symptoms of Poisoning

The analytical chemistry techniques used in forensic laboratories can detect minute amounts of chemical poisons and their alteration products in postmortem materials when there is a suspicion that chemicals have played a role in murders, suicides, or accidents (traffic and workplace). Forensic toxicologists must have extensive knowledge of deadly and slow-acting poisons—their chemistry and their biological actions—and expertise in identifying the signs and symptoms of poisoning caused by specific substances. Such practitioners have broad educational backgrounds in biology, chemistry, and psychology. The responsibility for establishing cause of death in a given case rests with the medical examiner, coroner, or pathologist, but success in arriving at the correct conclusion depends on the combined expertise of the pathologist and the toxicologist. The cause of death cannot be proved without a toxicological analysis, which establishes and confirms the presence or absence of specific poisons in the biological specimens of the deceased.

Common Signs of Poisoning and Possible Causes

Signs of Poisoning	*Possible Causative Agents*
Coma	Alcohol, atropine, barbiturates, carbon dioxide, carbon monoxide, chloral, opium and derivatives, phenols
Contraction of pupils	Muscarine, opium and derivatives, organophosphate and carbamate esters, pilocarpine
Convulsions	Aspidium, camphor, cyanides, organophosphate and carbamate esters, strychnine
Cyanosis	Acetanilide, aniline, nitrobenzene, opium and derivatives
Dilation of pupils	Belladonna, cocaine, nicotine, organophosphate and carbamate esters, stramonium
Dyspnea	Carbon monoxide, cyanides, organophosphate and carbamate esters, strychnine
Hyperventilation	Atropine, carbon dioxide, cocaine
Hypoventilation	Carbon monoxide, opium and derivatives
Paralysis	Botulinum toxin, carbon dioxide, carbon monoxide, cyanides
Vomiting	Acids, aconite, alkalis, antimony, arsenic, cantharides, colchicine, food-borne toxins, hellebore, iodine, mercury, phosphorus

The suspicion of poisoning or intoxication of the victim is based on the signs and symptoms observed and recorded. Knowledge of the common symptoms of particular kinds of poisoning enables forensic toxicologists to test for specific poisons; in some cases, this knowledge can be helpful in protecting the lives of victims by pointing to correct treatment.

The signs and symptoms of poisoning are identical whether the exposure to the poison is accidental, suicidal, or homicidal. Investigating police officers at death scenes where poisoning is suspected ascertain whether the victims vomited and whether the victims suffered convulsions, diarrhea, or paralysis before they died. Along with this information, they also record any information available from witnesses regarding the victims' breathing, pupil size, skin color, and difficulty in swallowing before death. The investigating officers then attempt to compile detailed histories of the victims' activities during the three days preceding their deaths. These histories include information on any medications taken by the victims and the sources of those medications and on any meals eaten by the victims and when and where they were eaten. Medical histories of the victims are also investigated.

Chronic or even acute nonfatal exposures to poisons can cause some observable symptoms. Early warning signs of poisoning include headache, nausea, dizziness, discomfort in the epigastric region, gastrointestinal upset, and excessive fatigue. These symptoms occur without fever after the entry of the poison into the body and usually disappear with the cessation of exposure to the poison.

Homicides, Suicides, and Accidental Poisonings

In cases of poisoning in which homicide is suspected, crime scene investigators collect physical evidence in the same manner they would if the cases were clearly homicides. Sometimes, deaths involving poisonings can be confusing because of the synergistic interaction of several poisons; for example, the ingestion of alcohol with amphetamines can be fatal. Identifying the signs of poisoning enables forensic toxicologists to decide what specimens to collect from bodies (tissues, fluids, organs) and what laboratory tests to run on those specimens.

In the United States, poisons are involved in 26 percent of suicidal deaths, and law-enforcement investigators must be aware of the signs of the use of poisons in such deaths. About 75 percent of those who commit suicide using poisons take some form of barbiturates, 17 percent poison themselves with carbon monoxide from automobile exhaust, and the rest use various other kinds of poisons, such as arsenic or strychnine. Alcoholics and drug abusers are more susceptible to suicide than are persons who do not abuse such substances. In cases of suicide, investigators examine the scenes for suicide notes and interview any witnesses as well as all persons who were close to the deceased.

Poisons are involved in only 3 percent of accidental deaths in the United States. Of these deaths, 20 percent are connected with barbiturates and 20 percent with opiates. The victims of some 65 percent of accidental poisonings in the United States are children under the age of six; another 21 percent are children between the ages of seven and fifteen; the remainder are adults. Oral medications, especially painkillers, account for 90 percent of accidental poisoning deaths. The rest are caused by cleaning and polishing agents, turpentine, petroleum products, pesticides, and plants.

Specimen Collection and Initial Testing

In cases of suspicious deaths, pathologists collect at autopsy the specimens that will be subjected to toxicological analysis. In general, the specimens collected from a body for this purpose include urine, blood, stomach and intestinal contents, bile, bone, fat, tissues of the brain and liver, and one whole kidney. When such specimens cannot be collected—for example, when a body has been badly burned or only skeletal remains are available—bone marrow, hair, muscle, or vitreous humor may provide specimens for toxicologists to analyze for the presence of poisons. In cases of severely decomposed bodies, maggots (which feed on dead flesh) found on the corpses may be collected for analysis. In every case, the collection, handling, and storage of the specimens and their transportation to the forensic toxicology lab are thoroughly documented for court presentation, as are the toxicologist's analysis and the resultant reports.

At the forensic toxicology lab, the analytical toxicologist carefully chooses the test methods to apply to the specimens and conducts repeated procedures to ensure maximum accuracy. The analysis of specimens takes into account the chemical changes that take place during the decomposition of the cadaver. The tests selected to determine the presence of causative chemicals in specimens depend on the suspected agent. For example, when substance abuse is suspected, urine samples are analyzed. The initial screening tests include common tests (such as tests of urine color and pH) and immunoassays conducted using high-speed, large-throughput analyzers for drugs and their metabolites in urine.

Chemical Analysis of Specimens

Forensic toxicologists use sophisticated techniques and equipment to detect the presence of minute amounts of chemicals and their metabolites in the specimens they examine. These techniques and equipment are capable of analyzing specimens for the presence of such diverse poisons as prescription drugs (including analgesics, antidepressants, hypnotics, and tranquilizers), drugs of abuse (such as hallucinogens, antidepressants, narcotics, and stimulants), and many different commercial products (including antifreeze, pesticides, and radioactive substances).

The qualitative and quantitative techniques that forensic toxicologists use include various chromatographic methods—such as column, thin-layer, gas, and liquid chromatography—as well as spectrophotometry and spectrometry. Final identification of the chemical structure of a substance is made using gas chromatography coupled with mass spectrometry (GC-MS) and liquid chromatography with mass spectrometry (LC-MS). The interpretation of the results of an analysis takes into consideration the case history, the site of the specimen collection, and postmortem changes.

Forensic Testing for Drugs of Abuse

In the United States, many categories of employers subject employees to mandatory urine testing to screen for the presence of illicit substances; these include federal and state agencies, the military, public utilities, employers related to the criminal justice system, and employers in the transportation and nuclear industries. Two national agencies regulate the laboratories that are involved in drug urine testing: the Substance Abuse and Mental Health Services Administration (part of the U.S. Department of Health and Human Services), which has established mandatory guidelines for workplace drug testing; and the College of American Pathologists, which has established the Forensic Urine Drug Testing Accreditation Program. Specific regulations are in place for every step of the process, from specimen collection through the reporting of the analysis results.

Urine testing is performed for a limited number of drugs (marijuana metabolites, cocaine metabolites, morphine and codeine opiates, phencyclidine, and amphetamines and methamphetamine). Initial screening analysis uses immunoassays on high-speed, large-throughput analyzers. Positive samples are then processed through GC-MS for confirmation of the drug structure.

In cases of fatal accidents—motor vehicle accidents, workplace accidents, and others—high concentrations of alcohol, drugs, or both are often found in the bodies of the persons involved. Toxicological analyses for alcohol and other drugs are performed on breath, blood, and other specimens taken from persons suspected of driving under the influence. Cocaine, benzodiazepines, marijuana, and phencycladine (PCP) are the drugs most commonly related to traffic accidents. The analytical methods used by forensic toxicologists can detect minute concentrations of these drugs.

M. A. Q. Khan and S. F. Khan

Further Reading

Gerber, Samuel M., and Richard Saferstein, eds. *More Chemistry and Crime: From Marsh Arsenic Test to DNA Profile*. Washington, D.C.: American Chemical Society, 1997. Comprehensive collection of essays covers a variety of topics relating to forensic toxicology, including depictions of forensic science in detective fiction.

Hayes, A. Wallace, ed. *Principles and Methods of Toxicology*. 5th ed. Philadelphia: Taylor & Francis, 2007. Comprehensive textbook addresses such subjects as testing procedures, guidelines for interpreting data, and controversies in the field of toxicology.

Klaassen, Curtis D., ed. *Casarett and Doull's Toxicology: The Basic Science of Poisons*. 7th ed. New York: McGraw-Hill, 2007. Standard handbook in the field of toxicology discusses concepts, principles, and procedures.

Levine, Barry, ed. *Principles of Forensic Toxicology*. 2d ed., rev. Washington, D.C.: American Association for Clinical Chemistry, 2006. Textbook intended for beginning courses in forensic science covers the analytical, chemical, and pharmacological aspects of a variety of drugs and chemicals.

Marrs, Timothy C., Robert L. Maynard, and Frederick R. Sidell, eds. *Chemical Warfare Agents: Toxicology and Treatment*. 2d ed. Hoboken, N.J.: John Wiley & Sons, 2007. Presents a technical discussion of the factors affecting the toxicity of agents. Includes description of tests done with sarin on volunteers.

Suzuki, Osamu, and Kanako Watanabe, eds. *Drugs and Poisons in Humans: A Handbook of Practical Analysis*. New York: Springer, 2005. Collection of highly technical articles discusses analytic techniques. Includes information on procedures for analysis of poisons using gas chromatography and mass spectrometry.

Trestrail, John Harris, III. *Criminal Poisoning: Investigational Guide for Law Enforcement, Toxicologists, Forensic Scientists, and Attorneys*. 2d ed. Totowa, N.J.: Humana Press, 2007. Focuses on intentional poisonings and the techniques used to investigate poisoning crimes.

See also: Air and water purity; Alcohol-related offenses; American Academy of Forensic Sciences; Chromatography; Drug and alcohol evidence rules; Drug confirmation tests; International Association of Forensic Toxicologists; Marsh test; Mass spectrometry; Nervous system; Sherlock Holmes stories; Toxic torts; Toxicological analysis.

Forgery

Definition: Manufacture or alteration of printed or electronic documents, literary works, or works of art in order to conceal or misrepresent their authorship or terms with the intention to deceive and defraud.

Significance: Forgery is a ubiquitous crime, touching the lives of millions of individuals in ways that range from mere annoyance to financial ruin. The advent of the electronic age opened up countless new avenues for forgers to defraud the public through identity theft and Internet scams. At the same time, computers and sophisticated image analysis software provide powerful tools for detecting forgery, creating a sort of arms race in which white-collar criminals and law-enforcement investigators vie for the technological upper hand.

Forgery is most commonly perpetrated for monetary gain, but it may also serve to enhance personal or national prestige or to fuel political controversy. The crime of forgery can overlap somewhat with counterfeiting, which involves passing off replicas of genuine articles as the authentic articles, and with plagiarism, in which someone represents another person's work as his or her own. The long list of items subject to forgery includes items documenting the transfer or ownership of money and property, such as wills, contracts, deeds, checks, and invoices; written and printed materials whose rarity makes them valuable as collector's items, such as postage stamps and celebrity autographs; literary works in the style of dead authors; scientific data; artworks; and documents purporting to give a firsthand view of history. Forgery is sometimes used to perpetrate hoaxes, in which the aim is to deceive large numbers of people not for personal gain but as practical jokes or as means of exposing folly.

Forensic detection of forgery involves analysis of the materials, techniques, and tools used in the production of a fraudulent document or other item, as well as analysis of handwriting, style, and internal facts such as dates. Comparison with known authentic samples is important. Forensic evidence is used both to determine authenticity and to track down and prosecute forgers.

Forgery in History

The forging of commercial documents probably goes back to the dawn of written records, although the absence of specific laws relating to written forgeries in either the Old Testament or the Code of Hammurabi suggests it was not common. More evidence exists of the production of documents of religious or mythological significance purporting to be the work of legendary ancestral figures who could not possibly have written them. In the process of assembling what became the accepted Christian Bible in the fourth century C.E., Saint Jerome and his contemporaries relied on some of the same techniques that literary scholars still use to distinguish between texts written by accepted figures in the Hebrew and Christian traditions and a mass of apocryphal writings of dubious authenticity.

A low level of literacy and lack of opportunity to compare documents led to rampant forgery in medieval Europe. In 1198, Pope Innocent III issued a proclamation condemning the forging of papal bulls and threatening forgers with excommunication. The pope outlined six elements that judges should look for in detecting forgeries: outward appearance, style, broken thread, doubtful origin of the parchment, erasures and altered words, and broken or indistinct seals.

The Donation of Constantine, the History of Crowland Abbey, and the Shroud of Turin are three well-known medieval forgeries that have been exposed by successively more sophisticated forensic analyses. In the fifteenth century, Italian scholar Lorenzo Valla demonstrated that the Emperor Constantine could not have written a charter granting the Western Roman Empire to the papacy, as the charter was written in ecclesiastical Latin of the eighth century, when the document first surfaced. In the eighteenth century, British scholars who examined the text of the History of Crowland Abbey found many anachronisms that indicated it was a fictitious work written in 1486 to support a land dispute. In the late twentieth century, radiocarbon dating of the Shroud of Turin and X-ray spectrography of the image on this supposed burial shroud of Christ indicated that the object dates from the fourteenth century.

The eighteenth century was a golden age for literary forgery in England. Among the best-known literary forgers were James Macpherson, who published epic poems alleged to be translations from the Scots Gaelic semimythic bard Ossian; Thomas Chatterton, who published quasi-medieval poetry; and William Ireland, who claimed to have discovered a previously unknown play by William Shakespeare. Ireland earned substantial sums from forgeries of letters attributed to Shakespeare, but his attempt at forging a play was immediately recognized for what it was—a clumsy fake. Chatterton's poetry, in contrast, had real literary merit, and Macpherson relied on a genuine oral tradition in producing his works.

Banknote forgery became a hot political topic in early nineteenth century England. Forgery remained a capital crime in Britain for some time after most nonviolent property crimes ceased to be so punished. Rather than change the law, Parliament concentrated on making banknotes more difficult to forge. The geometric drawing tool that later developed into the Spirograph, a popular children's toy, was invented to create intricate banknote designs that could foil forgers.

Detecting Forgery

Much forgery detection comes under the heading of questioned document analysis, a subspecialty of forensics. Many questioned document analysts in the United States are independent contractors certified by professional organizations. A few colleges offer degree programs in document analysis, but most practitioners receive the bulk of their training on the job.

In many cases, people who work in positions where they are likely to encounter forged documents are trained to spot obvious fakes. The store clerk who compares a signature on a check with that on the person's photo identification and the bartender who scrutinizes a youthful patron's driver's license are doing rudimentary detective work. Sellers of rare books, historic documents, and memorabilia familiarize themselves with telltale signs of the forger's art. Serious collectors of books, stamps, and antique currency do the same. Forgeries in wills and contracts often surface when such documents become the subjects of civil legal actions.

Forgery is suspected if the means and materials used to produce a document, or portions of it, are inconsistent with the document's alleged age and origin. Techniques of papermaking, the chemicals used in ink manufacture, types of writing instruments, fonts used in printing presses and typewriters, and the mechanics of presses, typewriters, and copiers change rapidly and vary from country to country. A steel-nibbed pen produces a more incised line than does a quill pen. The composition of ballpoint pen ink changed significantly in 1952. One line of evidence that pointed to forgery in the case of

Arguably the most powerful pope of the Middle Ages, Innocent III (r. 1198-1216) threatened to excommunicate from the Roman Catholic Church anyone who forged a papal bull. To help church officials identify forgeries, he outlined six elements to look for. More than nine centuries later, the same elements remain central to forgery investigations. *(Library of Congress)* the diaries purportedly written by Adolf Hitler from 1932 to 1945 and "discovered" in 1979 was a paper type not manufactured before 1950. If individual pages within a document have been substituted, there will often be materials evidence indicating this.

Exposure of the Vinland map as a forgery illustrates the use of modern forensic techniques to analyze a questioned historic document. The "discoverers" of the Vinland map claimed it was a fifteenth century copy of a thirteenth century map that proved the Vikings had settled in North America, something still disputed in 1957, when the map was offered for sale. Radiocarbon dating confirmed the parchment to be fifteenth century, but the carbon ink used in drawing the map had been artificially yellowed with titanium dioxide to simulate discoloration of medieval iron gall paint. The cartographer-forger had also included the northern coastline of Greenland, which is hidden under the Arctic ice cap.

X-ray emission and X-ray fluorescence are two techniques that are used to determine the chemical composition of objects without destructive sampling. When subjected to a high-energy beam of radiation, compounds reemit radiation at a lower frequency in bands diagnostic of the elements and molecules present. The presence of certain compounds in the materials of a given work narrows the time frame in which the work could have been created and can help analysts to identify alterations and additions, including substances used to mask or bleach portions of text.

Handwriting analysis is crucial to forgery detection. It is based on the premise that each person's handwriting is unique and that certain basic characteristics of a person's handwriting remain even when the person consciously attempts to disguise his or her writing. Computers make the handwriting analyst's task much less tedious than it was in the past, measuring such elements in handwriting as slant, character width, connectors, and relative height of letters. In addition to retaining traces of the forger's normal handwriting, forged writing may exhibit other characteristics, such as uneven speed of execution. A penciled guideline may be detected if a signature was traced. A series of forged signatures will reproduce a single model exactly, whereas a series of genuine signatures will be quite variable.

Political Forgery

Political forgeries are usually perpetrated in attempts to sway public opinion. Such forgeries are particularly dangerous because they may trigger sweeping and irreversible actions before the inauthentic nature of the underlying documents is discovered.

One high-profile example of a political forgery is the 2003 "yellowcake" forgery involving Iraq's alleged attempts to buy uranium from the Republic of Niger. Documents pertaining to this "transaction" contain many features, apparent even in photocopies, that are inconsistent with their claimed origin. Questions remain as to why intelligence agencies and key U.S. government officials failed to subject the documents to routine forensic analysis before using them as a key justification for going to war with Iraq.

One of the most notorious and malevolently influential political forgeries of the twentieth century is *The Protocols of the Elders of Zion*, first published in a Russian newspaper under the headline "Programma zavoevaniya mira evreyami" in 1903 and translated into English in 1920. It was claimed that the *Protocols* originated in the World Zionist Congress and were a blueprint for Jewish world domination. In exposing the forgery in 1921, *The Times* of London demonstrated that large sections of the work were plagiarized from an earlier (1867) French pamphlet opposing Napoleon III that made no mention of Jews and that the author/translator was unfamiliar with Jewish theology and traditions. Despite this definitive debunking, many people continue to accept the *Protocols* as authentic, particularly in the Middle East.

Electronic Forgery

Endless possibilities for forgery are opened up by the tremendous power of individual computers, sophisticated yet inexpensive desktop publishing hardware and software, and the Internet. Copying technology that allows a person to scan a document or image into a computer, add or delete elements of the document or image electronically, and transmit the altered file or print it in color has led to the explosive proliferation of fakes in many areas. Originators of critical documents, such as government-issued identification papers, have responded by incorporating holograms, embedded electronic chips, and extremely faint images in their originals.

An electronically inserted signature is readily apparent on a supposed original document, but not in a photocopy. Alteration of electronic records poses a special problem when the original transaction was electronic and no definitive hard copy exists. An unscrupulous Internet-based service provider can alter dates and payment amounts or insert contract terms that were never disclosed to the customer. Detection of such alterations relies on the substance of a customer complaint coupled with inconsistencies such as an impossible sequence of dates.

Cutting and pasting in digital images produce discontinuities in color values, repeated patterns, and objects that fail to line up. Although not apparent on casual inspection, these telltale signs can be detected through computer analysis. Most applicable to doctored photographs, the technique can also be applied to photocopies of written documents, which may show, for example, the failure of substituted text blocks to line up precisely.

Some U.S. states prosecute "spoofing" as forgery. A spoofer hacks into an unsuspecting person's e-mail account and sends out messages under that person's online name; this has been interpreted as tantamount to forging another person's signature. Commonly used to propagate junk e-mail advertising (spam) and viruses, spoofing can also be used to deceive people into divulging sensitive personal information, such as account numbers or Social Security numbers, because they think they have received requests for such information from legitimate financial institutions. The problem of disinformation and defamatory material either being sent from kidnapped e-mail accounts or appearing to come from reputable Web sites is growing. Although e-mail is relatively easy to track, this is often a futile exercise in the case of cybercrime, because the sources change very rapidly and are frequently located outside the United States.

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Further Reading

Dines, Jess E. *Document Examiner Textbook*. Irvine, Calif.: Pantex International, 1998. Practical manual for forensic document examiners includes a lengthy discussion of handwriting analysis.

Innes, Brian. *Fakes and Forgeries: The True Crime Stories of History's Greatest Deceptions—The Criminals, the Scams, and the Victims*. Pleasantville, N.Y.: Reader's Digest Association, 2005. Offers a broad discussion of many types of forgeries and covers a variety of scientific techniques used to detect them. Includes numerous photographs.

Nickell, Joe. *Detecting Forgery: Forensic Investigation of Documents*. 1996. Reprint. Lexington: University Press of Kentucky, 2005. Excellent introduction to the topic approaches forgery from an investigative perspective. Presents the technical aspects of analyzing documents while discussing several famous forgery cases.

Silver Lake Editors. *Scams and Swindles: How to Recognize and Avoid Internet Era Rip-Offs*. Aberdeen, Wash.: Silver Lake, 2006. Covers spoofing and identity theft. The most comprehensive information on electronic forgery is found—not surprisingly—on the Internet itself.

See also: Art forgery; Counterfeiting; Document examination; Fax machine, copier, and printer analysis; Forensic linguistics and stylistics; Handwriting analysis; Hitler diaries hoax; Hughes will hoax; Identity theft; Paper; Secret Service, U.S.; Sports memorabilia fraud; Typewriter analysis; Writing instrument analysis; X-ray diffraction.

Fourier transform infrared spectrophotometer

Definition: Instrument used to collect the infrared spectrum of a sample to enable identification of its components.

Significance: The infrared spectrum of a molecule is unique, and the technique of Fourier transform infrared spectroscopy can be used to identify molecules within a sample definitively. The instrument used to perform such spectroscopy has a variety of applications in forensic science; for example, it may be used to identify the controlled substances present in street samples of drugs or to identify the polymers present in fiber or paint evidence found at a crime scene.

A Fourier transform infrared (FTIR) spectrophotometer includes a source of infrared (IR) radiation, a beam splitter, two mirrors (one stationary and one moving), a sample chamber, and a detector. The sample to be analyzed is placed in the sample chamber, and IR radiation is emitted from the source. Before it interacts with the sample, however, the radiation hits the beam splitter, which divides the IR beam in two.

Half of the IR beam is reflected off the beam splitter to one of the mirrors as the other half of the beam is transmitted through the beam splitter to the second mirror, which is moved back and forth with respect to the beam splitter. Each half beam impinges on the respective mirror and is reflected back to the beam splitter. The two beams recombine at the beam splitter. Because the half beam that reflects off the moving mirror travels a distance different from that traveled by the beam that reflects off the stationary mirror, when the two beams recombine, the IR beam is in a form (known as an interferogram) that is different from the original beam from the source.

The interferogram is then directed through the sample. Solid samples are often analyzed in the form of a potassium bromide (KBr) disk. The forensic scientist prepares this disk by mixing some sample with KBr and then, using a special

A forensic scientist at the Washington State Patrol Crime Laboratory in Cheney, Washington, uses a Fourier transform infrared spectrophotometer to analyze the components of a controlled substance. *(AP/Wide World Photos)*

assembly, pressing the mixture into a disk by applying pressure. Ideally, the KBr disk should be transparent, containing particles of sample distributed throughout the disk. Only the sample particles will absorb IR radiation; KBr is transparent in this IR range and, hence, does not contribute to the absorbance.

Molecules in the sample will absorb IR radiation at certain frequencies according to the groups of atoms that are in the molecule. The pattern of the interferogram changes depending on the frequencies where the IR radiation is absorbed. The sample interferogram passes to the detector, where the Fourier transform is performed. This is a mathematical procedure that is used to convert the interferogram into the IR spectrum, which is a plot of detector response versus wave number. Identification is based on the characteristic wave numbers at which the sample absorbs IR radiation. The absorbancies are observed as peaks on the IR spectrum at the corresponding wave numbers.

FTIR spectroscopy offers a very powerful technique for identification purposes, but the sample must be in a relatively pure form, or contaminants in the sample may mask the IR absorbancies of the sample. Steps may need to be taken to purify the sample before the technique can obtain a spectrum that is sufficiently detailed for identification to be possible.

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Further Reading

Bell, Suzanne. *Forensic Chemistry*. Upper Saddle River, N.J.: Pearson Prentice Hall, 2006.

Houck, Max M., and Jay A. Siegel. *Fundamentals of Forensic Science*. Burlington, Mass.: Elsevier Academic Press, 2006.

Rubinson, Kenneth A. and Judith F. Rubinson. *Contemporary Instrumental Analysis*. Upper Saddle River, N.J.: Prentice Hall, 2000.

See also: Analytical instrumentation; Electromagnetic spectrum analysis; Micro-Fourier transform infrared spectrometry; Microspectrophotometry; Paint; Quantitative and qualitative analysis of chemicals; Spectroscopy; Tape.

Fracture matching

Definition: Inspection of the torn or broken edges of pieces of evidence to match the edges to their sources.

Significance: In some cases, pieces of evidence found at crime scenes are not in their original states, having been broken, torn, or otherwise separated from other pieces. By matching the edges of two or more pieces of broken or torn materials, forensic scientists may be able to determine the origins of these pieces of evidence and thus link them to possible suspects.

Fracture matching is similar to putting together pieces of a puzzle. Anything that can be broken, torn, or otherwise separated can be subjected to fracture matching. Forensic scientists are called upon to perform fracture matching with many different kinds of materials, including glass, cloth, metal, paint, paper, plastic, tape, and wood. Matching a bullet to the gun from which it was fired is considered a special kind of fracture matching.

The combination of the composition of an object and the force used to separate it into pieces results in unique characteristics. For example, a piece of cloth, when ripped or cut, will never be ripped or cut apart in the same way twice. The cloth will have slight flaws that will span the rip or cut, and the force applied to separate it into different pieces can never be repeated identically. Because of these unique qualities, evidence of matched fractures is considered very strong scientific evidence in court.

In successful fracture matching, the broken pieces of an object can be realigned along the fracture point and the fit of the broken pieces can be verified by markings on the surface or in-

Two-dimensional fracture matching entails the realigning of broken or torn pieces of flat objects along a single plane. When the realigned pieces form a coherent whole, matches can be simple. When additional pieces are missing, investigators may have to match the surviving pieces' chemical compositions and textures and look for microscopic matches. *(R. Kent Rasmussen)* side the broken object. Fracture matching can be done two-dimensionally, such as with cloth, paper, or tape, or three-dimensionally, such as with glass, metal, plastic, or wood. Investigators try to match fractures based on the chemical composition of the object, irregularities on the surface of the object, the shape of the break, and similarities between pieces of the object in age, deformation, or texture. Often, microscopic examination of the materials is necessary to determine the tiny matches in a fractured object.

Glass is a special material in terms of fracture matching; it is usually quite easy to match broken pieces of glass back together. The ridges that are formed in glass when it is broken (Wallner lines) are nearly always aligned to curve toward the point of impact. It is relatively easy for forensic scientists to use these ridges to match pieces of broken glass.

Tools can present another special kind of fracture-matching task. When metal tools are used with force against surfaces, such as to pry open windows or locked drawers, small shavings of metal from the tools are often left behind. Forensic scientists can match the markings seen on such small shavings against particular tools to determine whether those tools were used at certain crime scenes.

Fracture matching has provided important evidence in some seemingly unsolvable cases. For example, in a Florida case, a body that had been wrapped in sheets and taped with masking tape was found, and a suspect was apprehended. A forensic scientist was able to fracture match one end of the masking tape found on the body with the corresponding end of a roll of masking tape found in the suspect's home. Based on this and other corroborating evidence, the suspect was convicted of the murder.

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Further Reading

Fisher, Barry, David Fisher, and Jason Kolowski. *Forensics Demystified: A Self-Teaching Guide*. New York: McGraw-Hill, 2007.

Gardner, Ross M. *Practical Crime Scene Processing and Investigation*. Boca Raton, Fla.: CRC Press, 2005.

Mozayani, Ashraf, and Carla Noziglia, eds. *The Forensic Laboratory Handbook: Procedures and Practice*. Totowa, N.J.: Humana Press, 2006.

See also: Ballistics; Fibers and filaments; Firearms analysis; Glass; Paint; Paper; Tape; Tool marks.

Frye v. United States

Date: Ruling issued on December 3, 1923

Court: Court of Appeals for the District of Columbia

Significance: This appellate ruling held that polygraph results are inadmissible in court. The appeals court also introduced a new standard for the admissibility of new or novel scientific evidence in court, which came to be known as the general acceptance standard.

Courts in the United States may employ various standards to determine the admissibility of novel scientific evidence. From 1923 to 1993, the dominant standard for determining admissibility of such evidence at both state and federal levels was the "general acceptance" test. This standard stems from the seminal case *Frye v. United States*, in which a federal appeals court held that expert testimony was admissible only if the scientific principle, theory, or discovery on which it was based was "sufficiently established to have gained general acceptance in the particular field in which it belongs." This standard, known as the *Frye* standard or general acceptance standard, has frequently been cited in federal and state cases as a test of admissibility of expert scientific testimony, and it became general practice in most courts for almost three-quarters of a century.

Background of the Case and *Frye* Requirements

Frye concerned the admissibility of a systolic pressure deception test, a precursor of the polygraph, in a murder case. The Court of Appeals for the District of Columbia considered an appeal based on the failure of the trial court to admit the deception test. Specifically, the trial court precluded the defendant, James Alphonzo Frye, from introducing expert testimony concerning the deception test as well as evidence about his truthfulness through the test. In a unanimous decision, the appeals court concluded that the deception test had not yet gained sufficient general acceptance among physiological and psychological authorities to justify its admission into evidence and upheld Frye's murder conviction. Hence, under the *Frye* standard, it is not sufficient that a sole expert, or even several experts, testify to the validity of a particular scientific technique or device. Rather, *Frye* imposes a unique hurdle—that is, the technique or device must be generally accepted by the relevant scientific community.

The *Frye* standard conditions the admissibility of expert testimony in court on acceptance of other scientists within the field, although unanimity is not required. In order to meet the *Frye* standard, novel scientific evidence—which includes techniques, procedures, and principles—must be interpreted by a court as generally accepted by a meaningful segment of the relevant scientific community. In practice, the relevant scientific community often includes professional organizations or a sufficient number of individual experts within a specific field.

Issues in Forensic Science

Since the ruling in *Frye v. United States* in 1923, the *Frye* standard has been applied to numerous forensic science techniques in both criminal and civil cases, including DNA (deoxyribonucleic acid) analysis, human leukocyte antigen (HLA) paternity testing, voiceprint analysis, bite-mark comparison, use of truth serum, use of hypnosis, hair analysis, fingerprint analysis, serological electrophoresis, neutron activation blood analysis, breath tests for blood alcohol, sudden infant death syndrome (SIDS) probability analysis, and analysis of pesticide toxicity and carcinogens. The *Frye* standard has also been applied to expert testimony in such areas of social science research as the sociology of racial bias, drug trafficking practices, eyewitness reliability, rape trauma syndrome, battered woman syndrome, and profile evidence.

From the Court's Decision in *Frye v. United States*

Just when a scientific principle or discovery crosses the line between the experimental and demonstrable stages is difficult to define. Somewhere in this twilight zone the evidential force of the principle must be recognized, and while courts will go a long way in admitting expert testimony deduced from a well-recognized scientific principle or discovery, the thing from which the deduction is made must be sufficiently established to have gained general acceptance in the particular field in which it belongs.

With the advent of new scientific techniques and discoveries, the *Frye* standard has generated criticism concerning whether it is flexible enough to adapt to novel scientific evidence for which general acceptance has yet to be achieved. In 1993, in the case *Daubert v. Merrell Dow Pharmaceuticals*, the U.S. Supreme court rejected *Frye* and modified the standard for the admissibility of expert testimony in federal courts. In *Daubert*, the Court held that Congress intended for the Federal Rules of Evidence, specifically Rule 702, to supersede *Frye*; Rule 702 allows the introduction of scientific, technical, or other specialized knowledge by a qualified expert if such knowledge "will assist the trier of fact to understand the evidence or to determine a fact in issue." According to the highest court, *Frye's* general acceptance test was to be only one indicator of reliability. Despite the federal court's shift in position, the *Frye* standard remains the standard for admission of scientific evidence in a number of state jurisdictions.

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Further Reading

Faigman, David K., David H. Kaye, Michael J. Saks, and Joseph Sanders. *Modern Scientific Evidence: The Law and Science of Expert Testimony*. 4 vols. St. Paul, Minn.: Thomson/West, 2005. Comprehensive set addresses the standards governing admissibility in scientific cases, scientific research methods, and the application of law and science in each specific field.

_______. *Science and the Law: Forensic Science Issues*. St. Paul, Minn.: West, 2002. Textbook focuses on various forensic techniques, including DNA testing, alcohol and drug testing, and analysis of fingerprints, handwriting, bite marks, voices.

Golan, Tal. *Laws of Men and Laws of Nature: The History of Scientific Expert Testimony in England and America*. Cambridge, Mass.: Harvard University Press, 2004. Examines the history of scientific expert testimony in the courts and discusses how law and science have affected each other, particularly in the United States and England, over the past two hundred years.

Kiely, Terrence F. *Forensic Evidence: Science and the Criminal Law*. 2d ed. Boca Raton, Fla.: CRC Press, 2006. Introductory textbook presents examples of federal and state case decisions involving forensic science.

Lee, Henry C., and Howard A. Harris. *Physical Evidence in Forensic Science*. 2d ed. Tucson, Ariz.: Lawyers & Judges Publishing, 2000. Provides a general overview of legal aspects of forensic science and the collection, storing, and analysis of physical evidence from crime scenes.

Wecht, Cyril H., and John T. Rago, eds. *Forensic Science and Law: Investigative Applications in Criminal, Civil, and Family Justice*. Boca Raton, Fla.: CRC Press, 2006. Collection of essays by renowned experts in forensics and law discusses the ways in which forensic science evidence has been used in the American civil and family justice systems as well as in the criminal courts.

See also: Courts and forensic evidence; *Daubert v. Merrell Dow Pharmaceuticals*; Ear prints; Expert witnesses; Federal Rules of Evidence; Polygraph analysis; Wrongful convictions.

G

Gang violence evidence

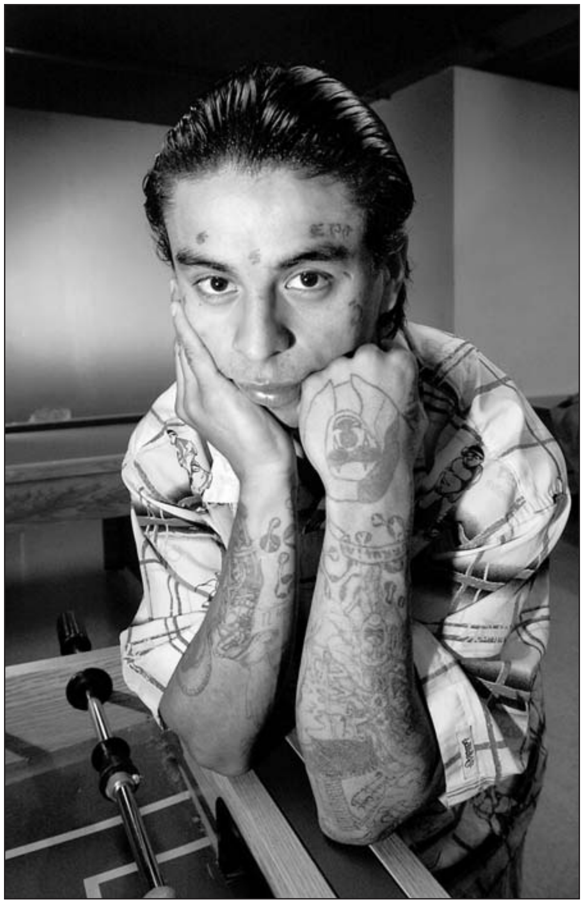
Definition: Evidence of violent crimes inflicted by known gang members on one another.

Significance: Gang-related crimes are frequently violent in nature, and perpetrators of these crimes are generally not difficult to identify because of the evidence they leave behind. Nevertheless, such crimes can be difficult to prosecute because of codes of silence and the culture of fear fostered by the gangs themselves.

Evidence that violence is gang related is not always as easy to procure as members of the public may believe. Part of the difficulty lies in the fact that different American law-enforcement jurisdictions define "gangs" differently. Moreover, defining "gang violence" itself can also be problematic. The term can be broadly defined as any violent act committed by any member of a gang. However, "gang violence" is more commonly defined as any violent act committed by one gang member on another.

Street gangs tend to be extremely territorial and demand a high degree of loyalty from their members. Any persons whom gang members perceive as encroaching on gang interests or territories may become the targets of violence. Moreover, because gang members actively work to establish their "street credentials," or "cred," they are prone to take credit openly for their violent actions. For example, gang members participating in drive-by shootings are apt to yell out their gang names so that witnesses know who is responsible for the shootings. Gang members also often publicize their collective and individual acts of violence in the graffiti they draw in public places. Trained investigators frequently use such information to identify suspects in crimes.

Members of street gangs also tend to make themselves easy to recognize by having themselves heavily tattooed. Furthermore, many of their tattoos are readily visible on their faces, necks, shaved heads, and arms. These identifying marks often make it easy for investigators to identify gang members from descriptions provided by victims of their crimes. In areas with heavy gang activity, the gang investigation units within local law-enforcement agencies typically keep copious records on gang mem-



A twenty-four-year-old Oklahoma City man shows the numerous tattoos he has collected since he was twelve years old. Many of his tattoos, including those he made on his face himself, signify gang membership. After renouncing his ties to the gang, the young man planned to have his gang insignia surgically removed. *(AP/Wide World Photos)* bers, their associates, the types of vehicles they drive, and the patterns and types of tattoos they have.

Investigators of gang-related crime are trained to mine the evidence gang members themselves readily provide in their efforts to advertise their crimes. However, the same evidence that can make it easy to identify and locate perpetrators of gang violence can also work against successful prosecutions. The reason gang members like to trumpet their crimes is to establish their violent reputations and make themselves feared. The fear they foster within communities often makes the victims of their violence unwilling to testify against them.

Prosecuting violent gang crimes is also impeded by the silent codes under which gang members live. When members believe that they or their gangs have been wronged, they try to retaliate against their transgressors themselves and do not want police or the legal system to interfere. Their code of silence and their desire to right wrongs themselves naturally helps to perpetuate cycles of gang violence. Perpetrators of violent crimes are frequently known to law-enforcement investigators, who cannot initiate prosecutions because of the unwillingness of victims and witnesses to cooperate. Even victims of gang crimes who are not themselves gang members are often so afraid of gang reprisals they remain silent and live in fear.

Lawrence C. Trostle

Further Reading

Curry, David, and Scott Decker. *Confronting Gangs: Crime and Community*. Los Angeles: Roxbury, 2002.

Goldstein, Arnold P., and C. Ronald Huff. *The Gang Intervention Handbook*. Champaign, Ill.: Research Press, 1993.

Jackson, Robert K., and Wesley D. McBride. *Understanding Street Gangs*. Costa Mesa, Calif.: Custom Publishing, 1995.

Leet, Duane, George Rush, and Anthony Smith. *Gangs, Graffiti, and Violence: A Realistic Guide to the Scope and Nature of Gangs in America*. 2d ed. Belmont, Calif.: Wadsworth, 2000.

Mays, G. Larry, ed. *Gangs and Gang Behavior*. Chicago: Nelson-Hall, 1998.

See also: Expert witnesses; Illicit substances; Interrogation; Living forensics; National Crime Information Center; Racial profiling; Tattoo identification.

Gas chromatography

Definition: Separation technique used in the qualitative and quantitative analysis of evidence samples.

Significance: Gas chromatography is widely used in forensic science for the identification of the specific makeup of a variety of different types of evidence, including drugs, body fluids, and chemical residues found in fire debris.

A basic gas chromatography (GC) instrument (gas chromatograph) consists of an injector, a column that is housed in an oven, and a detector. The inside of the column is coated with a thin layer of liquid known as the stationary phase. One end of the column is connected to the injector, and the other is connected to the detector. The mobile phase is a flow of pressurized gas, known as the carrier gas, that feeds into the injector and continually flows through the column and into the detector. A syringe is used to inject the sample (typically liquid) into the injector, which is heated to vaporize the sample. The vaporized sample then travels through the column in the flow of carrier gas.

Chemical substances in the sample are separated based on differences in attraction between the mobile phase (carrier gas) and the stationary phase (inside the column). Of these analytes, those that have greater attraction for the mobile phase will travel quickly through the column and reach the detector. Analytes with greater attraction for the stationary phase will spend more time retained on the column, and so their travel through the column to reach the detector will be retarded. Analytes thus are separated and arrive at the detector in order of increasing attraction for the stationary phase.

The time it takes for an analyte to travel from the injection port to the detector is the retention time of the analyte. A variety of different detectors are available, but the flame ionization detector (FID) is among the more common. The FID uses a flame to ionize the analyte, resulting in an increase in electric current, which is recorded as the detector response. For the FID, the response is proportional to the concentration of analyte present. Other detectors include the nitrogen-phosphorus detector, which is sensitive for molecules containing nitrogen or phosphorus, and the mass spectrometer detector (MSD), which allows conclusive identification of analytes.

A technician injects a sample into a gas chromatograph. *(© iStockphoto.com/Lorenzo Colloreta)*

A computer records the retention time and detector response for each analyte. This information is plotted in the form of a graph (known as a chromatogram) with detector response on the y-axis and retention time on the x-axis. Forensic scientists use chromatograms to identify analytes based on comparison of retention time with known standards analyzed under exactly the same conditions. Comparison of retention times only is not sufficient for conclusive identification of analytes, however; given the nearly infinite number of possibilities, it is conceivable that two or more analytes will have the same retention time.

Gas chromatography is widely used in forensic science to identify the chemical substances that make up particular drugs, whether in samples seized by police or in body fluids submitted for analysis. The technique is also used in explosives analysis and fire debris analysis to determine the presence of any ignitable liquid residues, which are indicative of deliberately set fires.

Ruth Waddell Smith

Further Reading

Houck, Max M., and Jay A. Siegel. *Fundamentals of Forensic Science*. Burlington, Mass.: Elsevier Academic Press, 2006.

Saferstein, Richard. *Criminalistics. An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007.

See also: Accelerants; Analytical instrumentation; Chromatography; Column chromatography; Fire debris; High-performance liquid chromatography; Mass spectrometry; Quantitative and qualitative analysis of chemicals; Questioned document analysis; Soman; Thin-layer chromatography.

Genocide

Definition: Deliberate and systematic attempt to destroy an ethnic, religious, racial, or national group.

Significance: The nature of genocide is such that those who perpetrate genocidal acts seek to deny their actions and cover up evidence of their guilt. Forensic science can assist in determining the objective facts when genocide is alleged.

Polish lawyer Raphael Lemkin (1900-1959) coined the word "genocide" to describe the German policy toward the Jews during World War II. His campaign for recognition of this crime resulted in the 1948 adoption by the United Nations of the Convention on the Prevention and Punishment of the Crime of Genocide, which defined genocide as acts intended to destroy, in whole or in part, a national, ethnic, racial, or religious group by killing or doing serious physical or mental harm to members of the group, by preventing births within the group, and by separating children of the group from other group members.

Conflicting Definitions

The importance of the international recognition of the crime of genocide was that the pre-World War II laws of war (the laws under which war crimes could be charged) covered only the

One of the most systematic genocidal programs in history was Germany's campaign to exterminate European Jews while Adolf Hitler was chancellor from 1933 to 1945. Hitler's Nazi regime rounded up millions of Jews and members of other groups it deemed undesirable and herded them into concentration camps. In some camps, the Germans methodically killed prisoners and burned their bodies; in others, they worked prisoners to death or let them die from malnutrition, disease, and physical abuse. By the end of World War II, approximately six million Jews had died as a direct result of Germany's genocidal policies. The full horror of what later came to be known as the Holocaust was largely unknown to the outside world, and even to most ordinary Germans, until Germany's collapse permitted Allied forces to enter German-occupied territories and open the camps. This picture, taken in a Bavarian camp one week after Germany's May 7, 1945, surrender, shows an American soldier standing amid piles of Holocaust victims while speaking to two hundred German civilians whom American troops forced to enter the camp to see the grim evidence of their government's work. *(AP/Wide World Photos)* actions that governments took against citizens of other countries. For this reason, after World War II, the charges of war crimes brought against several high-ranking German officials at the Nuremberg Trials included charges for their mass execution of Jews from Poland, France, and other nations, but not for the Nazi slaughter of German Jews. By establishing genocide as a crime against humanity, the United Nations made it possible to punish government officials after that time for comparable crimes against their own citizens.

Some legal scholars and other observers have asserted that the definition of genocide should be broadened to include acts intended to destroy political opponents or unpopular minorities (such as homosexuals) as well as the usual national, ethnic, racial, or religious targets of genocide. Some have even coined words—such as "politicide" and "democide"—to cover additional groups they feel should be protected under international law.

Given that legal scholars differ somewhat in their interpretations of the precise definition of genocide, those accused of genocidal acts sometimes attempt to defend themselves against the charge by playing varying interpretations against one another. Forensic science has an important role to play in determining the objective facts of situations involving accusations of genocide, given that defendants nearly always attempt to hide evidence of their crimes.

Applications of Forensic Science

At the Nuremberg Trials, the testimony of victims and eyewitnesses as well as substantial documentary evidence were presented to sustain the charges against the Germans. Forensic science was able to answer one important question that was raised at the trials: Although the Germans were guilty of many atrocities, they did not perpetrate the 1940 massacre of Polish military officers that was carried out in Russia's Katyn Forest. Forensic evidence proved that the massacre was carried out by the Soviets, who subsequently tried to blame it on the Germans.

Advances in forensic science techniques led to the increasing use of such techniques in determining the truth of numerous situations in which genocide had been alleged. Between 1976 and 1983, the military junta that ruled Argentina carried out "democide" against trade unionists and left-wing students who opposed the regime. The junta was accused of secretly kidnapping opponents, torturing and killing them, and burying the victims in unmarked graves. The junta acknowledged burying some bodies in unmarked graves but insisted that the graves contained only the bodies of elderly male indigents who had died of natural causes. After the regime fell, an international outcry led to exhumations and forensic investigations of the alleged burial sites. It was determined that although a few of those in the graves were elderly males who apparently died of natural causes, the vast majority were young men and women who had died of execution-style gunshot wounds, and their skeletons showed the effects of extreme torture.

In the period 1991-1995, wars in the former Yugoslavia resulted in mass genocidal killings (so-called ethnic cleansing). Bosnian Muslims (Bosniaks) charged the Serbs with genocide against Bosniaks and pointed to a large number of mass graves. The Serbs replied that the graves held only members of the Bosnian armed resistance who were killed in combat. Forensic science was able to establish that the Serbian contention could not be sustained because the remains in the mass graves included a large number of elderly women and children whose remains indicated they were executed at close range and not victims of battle wounds. Based partly on this evidence, the International Criminal Tribunal for the former Yugoslavia found various Serbian officials guilty of genocide.

In both Croatia and Bosnia and Herzegovina, a critical problem of identifying the remains of those killed in the genocidal conflict—so that the remains could be returned to their families for proper burial—was the absence of antemortem (before death) medical and dental records for comparison to the remains. Few such records had existed in the first place, and many of those were destroyed in the shelling and burning of the cities, towns, and villages from which the people had come. The groups involved in attempting to identify the victims of the conflict interviewed family members of the missing, asking them to recall whether their loved ones had any possibly identifying dental work or any injuries that might be reflected in their skeletal remains, but this system was not very helpful. The situation would have been hopeless without the application of advanced forensic science techniques. DNA (deoxyribonucleic acid) analysis, in particular, was useful for identifying many victims.

Forensic anthropologist Douglas Owsley assisted the government of Croatia in creating a system for identifying remains and determining causes of death in individual victims. The system involved coding and inventorying the remains as well as storing all information on the remains—including age, gender, and stature of each victim—in a computerized database. These data could then be used to determine whether any atrocities had occurred so that the information could be forwarded to the international war crimes tribunal.

Richard L. Wilson

Further Reading

Benedict, Jeff. *No Bone Unturned: Inside the World of a Top Forensic Scientist and His Work on America's Most Notorious Crimes and Disasters*. New York: HarperCollins, 2003. Details the diversity of the forensic science done by Douglas Owsley, who contributed to the work of identifying the victims of the Bosnian-Croatian genocide.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005. Comprehensive text provides an excellent summary of mitochondrial DNA analysis for general readers.

Scheffler, Immo E. *Mitochondria*. 2d ed. Hoboken, N.J.: John Wiley & Sons, 2008. Offers an extensive technical discussion of mitochondrial DNA analysis, which has been used to identify the remains of many genocide victims.

Totten, Samuel, William S. Parsons, and Israel W. Charny. *Century of Genocide: Critical Essays and Eyewitness Accounts*. 2d ed. New York: Routledge, 2004. Interesting collection of essays explores the issue of genocide.

Valentino, Benjamin A. *Final Solutions: Mass Killing and Genocide in the Twentieth Century*. Ithaca, N.Y.: Cornell University Press, 2004. Reviews a large number of cases of genocide in the twentieth century.

See also: Buried body locating; Croatian and Bosnian war victim identification; Forensic anthropology; Forensic archaeology; Forensic odontology; Holocaust investigation; Mass graves; Mitochondrial DNA analysis and typing; Y chromosome analysis.

Geographic information system technology

Definition: Computer-based mapping technology that can store, retrieve, and analyze relationships among geographically referenced or geospatial data.

Significance: Law-enforcement agencies employ geographic information system technology in carrying out strategic and tactical planning. The primary uses of this technology include intelligence gathering for crime analysis, crime trend analysis, and crime prevention.

The advent of geographic information system (GIS) technology transformed the scientific field of cartography (mapmaking) and allowed for the storage and manipulation of what was once thought to be an unmanageable number of data points into an interactive, visual, and efficient method of communicating information. The first use of modern-day GIS technology for criminal forensics in the United States can be traced to the 1960's, when the police department in St. Louis, Missouri, used crime-mapping technology to improve the efficiency of patrol operations. At this early stage of development, however, GIS technology and computer hardware were bulky and very expensive, so these tools of information management were used only by a small number of government entities that had sufficient resources.

Trends

It was not until the late 1980's and early 1990's, when GIS software and desktop computers became less expensive and more user-friendly, that increasing numbers of law-enforcement agencies began to adopt GIS technology. This is not to suggest that law enforcement has fully embraced the utility of GIS in crime fighting and crime prevention, however. A survey of police departments across the United States revealed that only 13 percent of them were using crime-mapping software during the late 1990's, and, on average, those departments had been using GIS technology only for about three years. By far, the largest departments (those with one hundred or more officers) were the ones that had adopted GIS to map crime trends and calls for service, to identify hot spots for crime control and crime prevention activities, and to archive data, for example. Large police departments were about ten times more likely than small departments to have adopted GIS technology.

Although GIS technology and computers are generally recognized as being less costly, faster, and more efficient than traditional methods of data collection and analysis in law enforcement, many police departments, both large and small, have not perceived an immediate need to adopt GIS technology and transform what they consider to be time-tested and relatively effective ways of responding to crime and promoting public safety. Many police administrators do not understand how GIS technology could improve law enforcement and, consequently, the roles and functions of GIS in criminal forensics have only scratched the surface of what is possible.

In the future, GIS technology will undoubtedly continue to evolve and improve in areas such as remote sensing, statistical crime forecasting, and integration of GIS with Global Positioning System (GPS) technology. As the utility of GIS technology for improving crime fighting and public safety becomes increasingly apparent, more law-enforcement agencies of all sizes will integrate this technology into their daily operations and planning.

Primary Uses

Law-enforcement agencies often use GIS technology as an aid to intelligence gathering. The evidence collected in criminal cases may come from a variety of sources, from victims to offenders, from cellular telephone signals to computer files, and from informants or witnesses to the physical locations of crimes. GIS can create interactive maps and examine relationships among relevant pieces of evidence to reconstruct the contexts in which crimes occur. This process can be extremely beneficial in criminal investigations, and prosecutors also find the maps valuable in the courtroom when they are presenting evidence to juries.

GIS technology is also useful for crime trend analysis. Police departments can employ it to plot crime data or calls for service on maps for entire cities or for specific neighborhoods. Details such as the times of day that crimes are committed and the characteristics of crimes (such as amount of property damage) can also be plotted for visual assessment or for statistical crime forecasting. Police officials may use the data derived from crime trend analyses to help with the efficient allocation of resources or to determine how best to prevent crimes in the future.

Crime prevention can be enhanced by the use of GIS technology. Law-enforcement agencies can use the information derived through crime

Beginnings of Geographic Information Systems

Geographic information systems have been applied to the tracking of crimes at least since 1916, when Ernest Burgess published the results of a study of crimes reported to the police in Chicago, Illinois. During the 1920's, Clifford Shaw and Henry McKay reported on the distribution of adjudicated juvenile delinquents living in Chicago and other cities in the United States. Paul and Patricia Brantingham later revolutionized the use of GIS for law enforcement and crime prevention. The computerization of GIS began slowly in the 1960's, and by 1975 the field was dominated by the ArcViewGIS and MapInfo software programs.

Lawrence M. Salinger

An Ohio sheriff's deputy uses a map created by his county's geographic information system to determine whether any registered sex offenders are residing near schools. The system provides detailed information on residents' names and addresses. *(AP/Wide World Photos)*

trend analyses to discover locations of hot spots for drug dealing, auto thefts, and violent activities, for example. Police administrators and patrol officers can use GIS mapping to help them monitor the residences of high-risk offenders, such as sex offenders, more effectively. Through trend analysis, GIS technology can locate the phone numbers of residences in an area where a particular crime problem has arisen and then call each number with a recorded message that warns residents of the crime problem, educates them on what precautions they can take, and requests that they report suspicious activities to the police.

Michael P. Brown and Taiping Ho

Further Reading

Chainey, Spencer, and Jerry Ratcliffe. *GIS and Crime Mapping*. Hoboken, N.J.: John Wiley & Sons, 2005. Uses three perspectives of law enforcement—operational, tactical, and strategic—to emphasize problem-solving, collaborative, and analytic methods for using GIS in crime fighting.

Gottschalk, Peter. *Knowledge Management Systems in Law Enforcement: Technologies and Techniques*. Hershey, Pa.: Idea Group, 2007. Addresses how all of the information that police collect needs to be converted into usable knowledge through the use of a variety of technologies, one of which is GIS.

Greene, R. W. *Confronting Catastrophe: A GIS Handbook*. Redlands, Calif.: ESRI Press, 2002. Provides insight into how GIS technology can provide information and analysis for law-enforcement agencies and other organizations involved in emergencies and incidents endangering homeland security.

Harries, Keith. *Mapping Crime: Principle and Practice*. Washington, D.C.: National Institute of Justice, 1999. Guide oriented toward law-enforcement practitioners provides an introduction to crime mapping and crime analysis.

Leipnik, Mark R., and Donald P. Albert, eds. *GIS in Law Enforcement: Implementation Issues and Case Studies*. New York: Taylor & Francis, 2003. Examines how law-enforcement agencies in small or large cities and in urban or rural environments can use GIS when investigating specific criminal activities.

Mamalian, Cynthia A., and Nancy G. La Vigne. *The Use of Computerized Crime Mapping by Law Enforcement: Survey Results*. Washington, D.C.: National Institute of Justice, 1999. Reports the findings of a national survey of law-enforcement agencies concerning their uses of GIS.

See also: Crime scene documentation; Crime scene investigation; Forensic geoscience; Geographic profiling; Megan's Law.

Geographic profiling

Definition: Use of information about geographic locations and their connections to draw conclusions about the probable characteristics and identity of unknown offenders.

Significance: With roots in epidemiology, environmental psychology, and criminal personality profiling, geographic profiling has helped to popularize the idea of crime mapping as a tool in the investigation of serial criminals.

Law-enforcement investigators draw conclusions about criminals from facts about crimes. Geographic profiling (also known, in various versions, as geographical offender profiling, psychogeographic profiling, geoforensic analysis, and geoprofiling) begins from the pattern of locations of a series of (apparently) connected crimes. In England in December, 1980, forensic investigator Stuart Kind made calculations relating the locations and times of thirteen murders during the preceding six years attributed to an unknown criminal dubbed the Yorkshire Ripper by the news media. Kind's projection of the probable base of action for the killer, made on the assumption that he attacked later in the day the closer he was to home, was proved to be accurate when Peter Sutcliffe was arrested for the crimes a month later (although Kind's information played no role in the arrest).

In the mid-1980's, English investigative psychologist David Canter independently discovered related techniques through his involvement in the so-called Railway Rapist case. With his associate Malcolm Huntley, Canter developed a software program (called Dragnet) to computerize the calculations. "It did not occur to me," Canter later stated, "that this might be a process that could be given a catchy name and turned into a commercial product." Both were soon done in British Columbia, Canada, by D. Kim Rossmo, who, working on his Ph.D. degree at Simon Fraser University and building on earlier work in environmental criminology by Paul and Patricia Brantingham, developed his own approach to what he labeled "geographic profiling."

By analyzing links within the spatial and temporal distribution of a criminal's activity, it is sometimes possible to determine what brought perpetrator and victim together and thereby to gain clues about the location, and possibly the motivation, of the offender. Most individuals live within relatively restricted patterns of movement (home, work, shopping, entertainment, school, vacation, and so on). The psychological principle of "least effort" suggests that human beings tend to attempt to reach their goals with the least expenditure of energy. Another psychological principle postulates that criminals prefer not to let their crimes occur too

British serial killer Peter Sutcliffe, known as the Yorkshire Ripper, in police custody in 1983. In December, 1980, when police were searching for the perpetrator of thirteen murders over the preceding six years, a forensic investigator made calculations relating the locations and times of the murders. His projection of the probable base of action for the killer, made on the assumption that he attacked later in the day the closer he was to home, was proved to be accurate when Sutcliffe was arrested for the crimes a month later. The geographic profile, however, played no role in the arrest. *(Hulton Archive/Getty Images)* close to home and predicts the existence of a "buffer zone" between an offender's base and where that person commits crimes. Under the influence of both principles, laziness and caution, the criminal would want to commit the crime close to home, but not too close.

What is "too close" has not been determined, however, and critics have questioned whether such abstract principles are reliable and when they might apply. Proponents of geographic profiling are confident that sufficient empirical study of offender patterns can provide substantive content for these principles, whereas critics attack what they see as undefended assumptions and the failure of proponents to place behavioral information in its proper context.

As geographic information system (GIS) technologies and other forms of social monitoring continue to advance, a condition of universal surveillance increasingly emerges, and the resulting pervasive information about people's locations can support more comprehensive geographic profiling. Already, technological innovations—from traffic cameras to global positioning devices to facial recognition software—seem to point in that direction.

Edward Johnson

Further Reading

Canter, David. *Mapping Murder: The Secrets of Geographical Profiling*. London: Virgin Books, 2003.

Canter, David, and Donna Youngs, eds. *Principles of Geographical Offender Profiling: A Reader*. Burlington, Vt.: Ashgate, 2007.

Petherick, Wayne. *The Science of Criminal Profiling*. New York: Barnes & Noble, 2005.

Rossmo, D. Kim. *Geographic Profiling*. Boca Raton, Fla.: CRC Press, 1999.

See also: Biometric identification systems; Criminal personality profiling; Epidemiology; Facial recognition technology; Geographic information system technology; Megan's Law; Rape.

Geological materials

Definition: Natural earth materials such as rocks, minerals, fossils, petroleum, soil particles, and humus.

Significance: Geological materials have signature characteristics that make them very useful in the investigation of many criminal and civil cases. Comparisons of earth materials can allow investigators to locate the origins of evidence and to pinpoint the locations of crime scenes.

Forensic geoscientists examine geological materials as well as some human-made products (such as glass, bricks, and concrete) to determine the origins of these materials and to compare them with samples collected from crime scenes. Because earth materials have specific characteristics and origins, these materials can provide very useful evidence in criminal as well as civil investigations.

Diversity of Geological Evidence

The many different kinds of rocks have clearly distinguishable origins, colors, sizes, crystalline structures, hardnesses, and chemical compositions. All rocks may be classified into one of three major groups: igneous, sedimentary, or metamorphic. Igneous rocks are formed by the cooling of molten magma as the magma moves from the earth's mantle to near the air at the surface; the crystal formation in such rocks varies with the cooling time. When the magma cools very slowly, very large crystals are formed. Rocks of this type are called intrusive igneous rocks (an example is granite). In contrast, the expelled magma from volcanic eruptions cools rapidly, forming what are called extrusive igneous rocks. Some of these have very fine crystals (such as basalt) and others have no crystal and an amorphous or noncrystalline appearance (such as pumice).

Sedimentary rocks, which include sandstone, shale, and limestone, are made of loose sediments deposited by wind or water that have become cemented together and hardened over time. Metamorphic rocks, which include quartzite, slate, and marble, are formed when igneous or sedimentary rocks are altered by heat, temperature, pressure, and chemical reactions as they are compressed by the earth's crust before they sink to the hot mantle.

Every rock is a mixture of minerals, which are pure substances that exhibit unique properties. Granite is composed of three minerals: quartz, feldspar, and mafic minerals. Basalt and pumice rocks contain feldspar and mafic minerals, but no quartz. Quartz—the major component in sands and glass—is light-colored pure crystalline silicon dioxide without aluminum, iron, magnesium, calcium, sodium, or potassium. In feldspar, 25 to 50 percent of the silicon is replaced by aluminum, and potassium, sodium, or calcium is present, but no magnesium or iron. Feldspar weathers slowly to form silt and clay; it is a minor component of sands. Mafic minerals (such as olivine and pyroxene) contain silicon and high amounts of magnesium, iron, or both. They weather rapidly to form silt and clay. Crystals of mafic minerals are dark in color, because of their high magnesium or iron content, compared with the light-colored crystals of feldspar. Sandstone is composed mostly of sand deposits cemented by silicon dioxide mineral (called silica), and limestone is composed of sand, silt, and clay deposits cemented by calcium carbonate mineral (called lime).

In the weathering of rocks and minerals, physical, chemical, and biological processes form particles of sand (the largest), silt, and clay (the smallest), the inorganic components of soil. When rocks are wet, mosses grow on them, and microorganisms such as bacteria and fungi feed on rocks by releasing their enzymes to dissolve the rocks' surfaces and then absorbing elements from the rocks. Rock fragments and dead tissues of organisms that accumulate on rock surfaces can serve as media for seed germination and growth of plants. As these processes con-

To the untrained eye, many rocks may look the same. However, rocks actually have many distinguishing characteristics that can make them valuable as forensic evidence. *(© iStockphoto.com/Mark Hilverda)*

A Conviction Supported by Geological Evidence

A Canadian case involving the death of an eight-year-old boy illustrates the importance of forensic comparisons of soils and related evidence. Gupta Rajesh's body was found on a roadside in Scarboro, Ontario; there was oil on the boy's shirt, and at first it was assumed that he had been the victim of a hit-and-run accident. Forensic geologist William Graves of Toronto examined the evidence and came to a different conclusion, however.

The oil on Rajesh's shirt was compared with samples of oily material collected from the floor of an indoor concrete parking garage where a suspect, Sarbjit Minhas, parked her car. Analyses of the sand, heavy minerals, broken glass, yellow particles of paint, and oil found on Rajesh's clothes showed them to be similar to the materials found in that parking garage. The same oil and other particles were also found in the suspect's car. Materials collected from ten other garages in the area were found to be similar to but different from the samples gathered from where the suspect parked and from Rajesh's clothes.

Graves concluded that the body of Gupta Rajesh had been in contact with the floor of the garage where the suspect parked her car, and his testimony helped to convict Minhas in November, 1983.

tinue over time, a layer of soil particles develops above the rocks. The dead organisms, including decomposed plant and animal residues, become humus, the organic matter component of soil.

Synthetic products made from geological materials retain the characteristics of those materials when the products break down. Bricks, for example, are made of clay minerals. Concrete is made from a mixture of Portland cement (limestone mixed with clay or shale), water, and sand.

Sample Collection and Examination

Like all types of evidence samples, forensic geological samples must be collected with care. Records must be kept regarding when, where, and how each sample was collected, and proper procedures for taking samples must be followed. The details of the case being investigated generally dictate the kinds of samples collected. For example, to enable a determination of whether a particular automobile was present at a crime scene, technicians would collect separate samples of rocks, minerals, and chunks of soils from several places under the vehicle (such as fenders, tires, and tailpipe) for comparison with similar materials found at the crime scene.

When forensic geoscientists examine evidence samples, they use a variety of techniques and instruments to determine the physical and chemical properties of the materials and to make comparisons. With soil samples, they look at particle size distribution—that is, the percentages of sand, silt, and clay that make up the samples. These scientists use stereomicroscopes to characterize the size and color of geological samples and petrographic microscopes to identify minerals and examine rock textures. Among the tools used to determine the chemistry and structure of rocks are scanning electron microscopes and mass spectrometers (instruments that measure the quantity of atoms, or groups of atoms, in a sample based on their mass). Forensic geoscientists also use X-ray diffraction to identify clay minerals and other crystalline materials based on their crystal structures.

Domingo Jariel

Further Reading

Martin, Michael. *Earth Evidence*. Mankato, Minn.: Capstone Press, 2007. Discusses the various kinds of fossils, minerals, soil, and rocks that may be found at crime scenes and how forensic geologists search for clues to catch criminals.

Murray, Raymond C. *Evidence from the Earth: Forensic Geology and Criminal Investigation*. Missoula, Mont.: Mountain Press, 2004. Covers the application of geological techniques to criminal and civil investigations involving earth materials.

Perry, Dale L., ed. *Instrumental Surface Analysis of Geologic Materials*. New York: VCH, 1990. Describes techniques for studying chemical reactions on the surfaces of rocks, soils, and minerals and devotes significant discussion to spectroscopy and scanning electron microscopy.

Pye, Kenneth. *Geological and Soil Evidence: Forensic Applications*. Boca Raton, Fla.: CRC Press, 2007. Provides an overview of the physical and chemical properties of geological evidence and explains the procedures used in analyzing such evidence. Includes numerous case studies.

Tarbuck, Edward J., Frederick K. Lutgens, and Dennis Tasa. *Earth Science*. Upper Saddle River, N.J.: Pearson Prentice Hall, 2006. Explains the many elements of the physical environment and presents clear examples. Includes maps, illustrations, and color photographs.

See also: Forensic geoscience; Geographic information system technology; Microscopes; Soil; X-ray diffraction.

Gestational age determination

Definition: Calculation of the age of a fetus or newborn based on the time of the mother's last menstrual period.

Significance: In certain legal cases involving the deaths of fetuses, the charges brought depend on whether the fetuses would have been viable—that is, able to live outside the womb—at the time of death. Viability of a fetus can usually be determined based on its gestational age.

Gestational age is measured in weeks based on the time from the mother's last menstrual period. Most women have a 28-day menstrual cycle, although both longer and slightly shorter cycles are considered normal. Conception, the fertilization of egg by sperm, normally occurs at the midpoint of the cycle, around day 14. Because gestational age is calculated from the woman's last menstrual period, at conception the embryo has a gestational age of two weeks; the gestational age is thus always two weeks greater than the conceptional or developmental age of the fetus. A normal pregnancy ends at forty weeks, or 280 days, gestational age, with babies being born between thirty-eight and forty-two weeks considered normal.

Fetal development happens in an orderly way, with certain developmental events occurring at specific gestational times. When a dead fetus is brought to a pathologist, the pathologist can use several methods to judge the gestational age of the fetus. If the fetus has decomposed, one common method is to measure the middle part of the long bones of the leg that have hardened into bone (the ends of the bones do not harden because they are still growing). Bones that can be used for this calculation include the femur (thighbone), tibia, or fibula (lower-leg bones). The measurements are then plugged into an equation that gives the gestational age. Certain measurements of facial bones also can give an accurate estimate of gestational age. If the fetus is intact, the development of various organs such as the lungs will help solidify an estimate of gestational age made through the examination of X rays of the bones.

Gestational age is important in determining whether the fetus would have been able to live outside the mother's body. With improvements in the technologies available for treating premature babies, the age of viability for fetuses has steadily decreased. In cases in which a woman is killed in late-term pregnancy, resulting in the death of her fetus, and in some cases of illegal late-term abortion, charges may be filed for murder of the fetus if it had reached an age where survival outside the mother was likely.

Martiscia Davidson

Further Reading

Harding, Richard and Alan D. Bocking. *Fetal Growth and Development*. New York: Cambridge University Press, 2001.

Huxley, Angie, Richard Froede, and Walter Birkby. "Strangulation of Pregnant Woman Leads to One First-Degree Murder Indictment for the Death of the Mother: A Medicolegal Reconsideration of Maternal/Fetal Homicide." *American Journal of Forensic Medicine and Pathology* 22 (March, 2001): 51-54.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005.

See also: Autopsies; Forensic anthropology; Osteology and skeletal radiology; Skeletal analysis.

Glass

Definition: Hard, brittle substance, typically consisting of a mixture of silicates, that is neither liquid nor solid but instead exists in an amorphous state.

Significance: When law-enforcement investigators find fragments of broken glass at crime scenes, forensic scientists can often link the fragments to their sources through comparisons of the physical and chemical characteristics of the glass.

When glass breaks, fragments of the material shower other objects and people in the vicinity, and often tiny pieces of glass become embedded in clothing, shoes, and other objects. When glass fragments are found at a crime scene, forensic scientists can collect them and compare them with the various sources of glass at the scene. Such analysis consists mainly of the comparison of density and refractive index. Although these comparisons can link the fragments to a particular kind of source, they are not sufficient to link the fragments to one source to the exclusion of all other sources.

For density determinations, two thin glass columns are filled with a liquid mixture. The glass fragment of interest is placed in one column, and a similarly sized piece of possible source glass is placed in the second. Each piece of glass will float at the level where the density of the liquid is equal to the density of the glass. Therefore, the two fragments will float at the same level if they have the same density. If the fragments cannot be distinguished by density, the refractive index can be determined.

For refractive index determinations, the glass fragment is immersed in an oil of known refractive index and viewed through a microscope. A bright halo, known as the Becke line, is observed around the fragment. As the microscope stage is lowered, the Becke line will move into the medium (oil or glass) that has the higher refractive index. This procedure is repeated with the glass immersed in different refractive index oils until the match point is determined. At that point, the Becke line disappears, indicating that the oil and the glass have the same refractive index. The procedure is repeated for a piece of the possible source glass, and then the refractive indices of the two pieces of glass are compared. Automated methods now

When glass fragments are found at a crime scene, forensic scientists can collect them and compare them with the various sources of glass at the scene. Forensic scientists also analyze glass fracture patterns to determine the direction and sequence of impacts. *(© Jovan Nikolic/Dreamstime.com)* exist for refractive index determinations in which the oil is heated using a microscope equipped with a hot stage. The refractive index of the oil changes on heating, although the refractive index of the glass is unaffected. Heating is stopped when the match point is reached and the refractive index of the glass can be determined.

In some investigations, forensic scientists also analyze glass fracture patterns to determine the direction and sequence of impacts. With low impact, a projectile bounces off a pane of glass and falls on the side of impact. With high impact, the projectile creates a hole and passes through the glass. The hole is smaller in diameter on the entrance side than it is on the exit side. Cracks also radiate from each point of impact. Because radial cracks from second and subsequent points of impact always terminate at preexisting cracks, the sequence of impacts can be determined.

Ruth Waddell Smith

Further Reading

Caddy, Brian, ed. *Forensic Examination of Glass and Paint: Analysis and Interpretation*. New York: Taylor & Francis, 2001.

Houck, Max M., and Jay A. Siegel. *Fundamentals of Forensic Science*. Burlington, Mass.: Elsevier Academic Press, 2006.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007.

See also: Class versus individual evidence; Criminalistics; Fracture matching; Geological materials; Hit-and-run vehicle offenses; Physical evidence; Spectroscopy.

Guilty but mentally ill plea

Definition: Alternative plea in which the defendant admits guilt for the crime charged but also claims to have been mentally incompetent at the time the crime was committed.

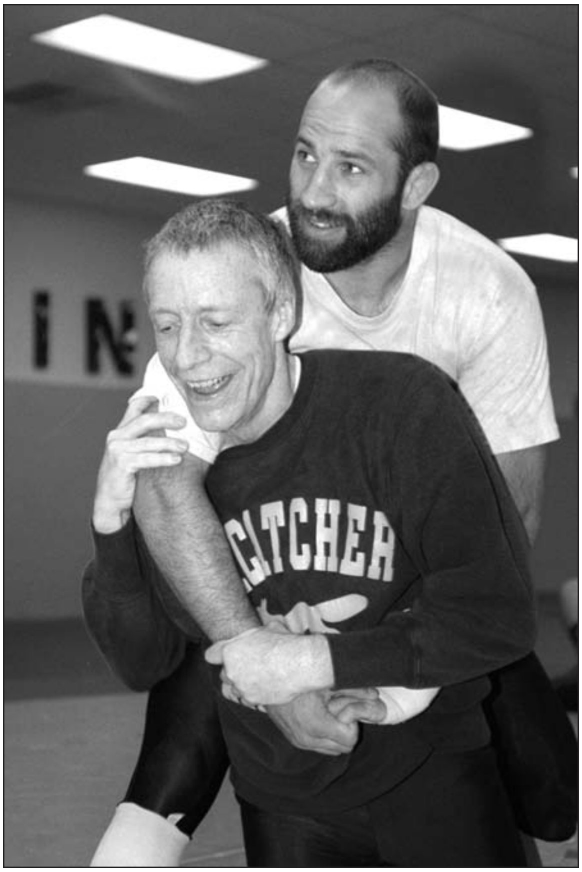
Significance: Forensic psychologists and psychiatrists provide expert testimony concerning a defendant's mental condition as defined by law. Juries and judges rely on this evidence in reaching the alternative verdict of guilty but mentally ill.

When a person commits a crime, the government has the right to punish the wrongdoer and take steps to protect society. Some offenders, however, may have mental impairments that inhibit their ability to conform to society's rules. The purpose of a plea or verdict of guilty but mentally ill (GBMI, known in some jurisdictions as guilty but mentally incompetent), therefore, is to allow both society and the criminally responsible but mentally incompetent offender to achieve specific goals. Society's objectives are to punish criminals for their crimes and to prevent further criminal acts. With a GBMI plea or verdict, these goals are accomplished as the mentally incompetent criminal receives not only a sentence but also appropriate mental health treatment.

History

Historically, fact finders in criminal cases (that is, juries in jury trials, judges in bench trials) could reach three possible verdicts: guilty, not guilty, or not guilty by reason of insanity. Many defendants who are found guilty are incarcerated in correctional facilities. Defendants found not guilty are usually released into society. The insanity defense is used very rarely in criminal prosecutions, and defendants do not have a high success rate in achieving acquittal by proving they are not guilty by reason of insanity. In those few cases in which the insanity defense is successful, the majority of the acquittees are held in mental health facilities for testing, observation, and treatment until they are released because mental health professionals have made the judgment that these persons no longer pose a serious danger to others or themselves.

American society has always been critical of the insanity defense, which relieves a defendant of criminal responsibility and, many argue, allows serious offenders to return to society with little or no punishment. Research, however, in-



Millionaire John du Pont (foreground) with Olympic wrestler David Schultz in an undated photograph taken at the Foxcatcher National Training Center in Pennsylvania. In 1997, du Pont was found guilty of third-degree murder but mentally ill in the shooting death of Schultz; he received a sentence of thirteen to thirty years, and the judge ruled that he was to receive treatment for his mental illness during his incarceration. *(AP/Wide World Photos)*

dicates that many insanity defense acquittees serve as much time in mental health facilities as they would have served in correctional facilities had they been found guilty. In 1975, Michigan became the first U.S. state to adopt the GBMI verdict to assuage the public outcry that arose after two defendants who had been found not guilty by reason of insanity committed violent crimes soon after their release from a mental health facility. In response to high-profile insanity defense cases, other states began to adopt GBMI statutes modeled after the Michigan law. By the beginning of the twenty-first century, twenty states had adopted GBMI statutes, and some of these states had also repealed their laws allowing the insanity defense.

Whereas defendants found not guilty by reason of insanity are likely to be civilly committed to mental health facilities for observation and possible treatment, GBMI defendants are criminally committed or sentenced, albeit GBMI offenders are supposed to receive appropriate treatment for their mental illness. In contrast with civil commitments to mental health facilities, under criminal commitments GBMI offenders are not entitled to periodic reviews to determine whether their mental health is improving. Moreover, when those who have received GBMI verdicts are sentenced to incarceration, they are released after they have served their sentences, even if their mental incompetence still exists.

Legal Standards

State GBMI statutes vary, but most require the fact finders to make three specific findings to arrive at a GBMI verdict. First, the state must prove beyond a reasonable doubt that the defendant is guilty of the crime charged. Then the defendant must provide expert testimony that evidences the defendant's mental incompetence or impairment, as defined by state law, when the crime was committed. Most states also require that the defendant plead insanity and that the fact finder determine there is insufficient proof for a legal insanity defense but sufficient evidence of mental incompetence to support a GBMI verdict. Forensic mental health experts conduct evaluations to assess whether the defendant meets the legal requirements to support an insanity defense and, if not, to assess whether the defendant comports with the mental illness criteria for the GBMI verdict.

Juries do not have to be informed of the consequences of a GBMI verdict or that a mentally incompetent offender will receive the same sentence for the underlying crime as would an offender who does not have a mental impairment. This fact has raised debate, particularly in the case of the death sentence, which courts have upheld as appropriate for certain crimes despite a jury's finding that a defendant was mentally incompetent when the crime was committed. Moreover, after a jury has made a mental incompetence finding, any grant of parole or sentence of probation the offender might receive is likely to be conditioned on the offender's receiving mental health treatment; thus the individual is labeled as mentally ill.

Most defendants who receive GBMI verdicts are sentenced to incarceration in correctional facilities where they are to receive appropriate mental health treatment. There is evidence, however, that these offenders may not receive adequate mental health treatment, as correctional facilities rarely have the funding or resources to provide meaningful services, and some defendants may refuse treatment.

Carol A. Rolf

Further Reading

Ellis, Van W. "Guilty but Mentally Ill and the Death Penalty: Punishment Full of Sound and Fury, Signifying Nothing." *Duke Law Journal* 43 (October, 1993): 87-112. Presents a good discussion of the state of law that allows those found GBMI to receive a sentence of death despite their diminished mental capacity when they committed their crimes.

Mickenberg, Ira. "A Pleasant Surprise: The Guilty but Mentally Ill Verdict Has Both Succeeded in Its Own Right and Successfully Preserved the Traditional Role of the Insanity Defense." *University of Cincinnati Law Review* 55 (1987): 943-996. Provides an excellent review of twelve state statutes and the wide variety of provisions associated with the GBMI verdict.

Plaut, Vicki. "Punishment Versus Treatment of the Guilty but Mentally Ill." *Journal of Criminal Law and Criminology* 74, no. 2 (1983): 428-456. Presents an informative review of various GBMI standards imposed by the first four states to adopt the alternative verdict.

Rogers, Richard, and Daniel W. Shuman. *Conducting Insanity Evaluations*. 2d ed. New York: Guilford Press, 2000. Includes a good overview of the legal standards for performing a forensic evaluation when a GBMI plea is made.

Sherman, Scott. "Guilty but Mentally Ill: A Retreat from the Insanity Defense." *American Journal of Law and Medicine* 7 (1981): 237-264. Compares the GBMI defense with the insanity defense and discusses the requirements for each verdict.

See also: ALI standard; Borderline personality disorder; Criminal personality profiling; *Diagnostic and Statistical Manual of Mental Disorders*; Forensic psychiatry; Insanity defense; Irresistible impulse rule; Legal competency; *Mens rea*; Psychopathic personality disorder.

Gunshot residue

Definition: Burned, partially burned, and unburned powder and primer that are released as a firearm is discharged.

Significance: When a firearm is discharged, gunshot residue deposits on the target and the shooter, so the presence of such residue is strong evidence that a firearm has been discharged. Forensic scientists can also estimate the distance between shooter and target at the time a firearm was discharged by the pattern and intensity of gunshot residue.

Different types of firearms use different types of ammunition, but the basic ammunition cartridge used in handguns and revolvers contains a primer, a powder, and a bullet, all enclosed in a metal casing. The primer is an explosive mixture that is commonly composed of three chemical compounds: lead styphnate, barium nitrate, and antimony sulfide. The primer is used to initiate the ignition of the powder, which is commonly a form of smokeless powder. The powder typically contains at least nitrocellulose; some powders also contain nitroglycerin, whereas others contain nitrocellulose, nitroglycerin, and nitroguanidine. As the powder burns, pressure is applied to the bullet, forcing the bullet through the barrel of the firearm and releasing the bullet at high velocity.

As the bullet is discharged from the firearm, the buildup of heat and pressure results in the release of vapors and particulates that constitute gunshot residue (GSR). GSR is composed mainly of burned and unburned particles from the primer and powder that deposit on the shooter and the target or on objects in the path between shooter and target. As the distance between the firearm and the target increases, the deposition of GSR is less concentrated; this fact allows forensic scientists to estimate firing distance based on the pattern of GSR.

The study of evidence from a shooting incident often involves the microscopic examination of samples followed by color tests. The powder particles in GSR have characteristic shapes that can be determined through microscopic examination. Color tests determine the presence of GSR based on color changes that occur when areagent is added to evidence containing GSR. The modified Griess test determines the presence of nitrite compounds from the powder—the reaction between the reagent and any nitrite compounds results in an orange color. The sodium rhodizonate test determines the presence of lead from the primer—the reagent turns pink in the presence of lead. The addition of hydrochloric acid causes the pink color to change to violet, confirming the presence of lead.

During opening statements in the 2007 trial of Phil Spector (center) for the murder of actor Lana Clarkson, Spector's defense attorneys used a photograph of a handgun being fired to show jurors how gunshot residue is deposited on the hand of the shooter. *(AP/Wide World Photos)*

Forensic scientists also use scanning electron microscopy to visualize GSR evidence. The scanning electron microscope (SEM) offers very high magnifications that allow the identification of GSR particles based on their characteristic shapes. Additionally, the SEM can be coupled to an energy-dispersive spectrometer (EDS), which enables determination of the elemental composition of the particles. The presence of lead, antimony, and barium from the primer is considered to be characteristic of GSR.

Ruth Waddell Smith

Further Reading

Bell, Suzanne. *Forensic Chemistry*. Upper Saddle River, N.J.: Pearson Prentice Hall, 2006.

Houck, Max M., and Jay A. Siegel. *Fundamentals of Forensic Science*. Burlington, Mass.: Elsevier Academic Press, 2006.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007.

See also: Ballistic fingerprints; Ballistics; Bloody Sunday; Bullet-lead analysis; Bureau of Alcohol, Tobacco, Firearms and Explosives; Energy-dispersive spectroscopy; Firearms analysis; Integrated Ballistics Identification System; Physical evidence; Scanning electron microscopy; Trace and transfer evidence.

Gunshot wounds

Definition: Wounds caused by projectiles fired from firearms.

Significance: By analyzing the physical characteristics of gunshot wounds, forensic scientists can determine such elements of a crime as the shooter's approximate distance from the victim at the time the gun was fired, the positions of the victim and the shooter, and the caliber or type of bullet.

Since the first treatise on gunshot wound forensics was published in France in 1857, the technologies used to analyze the wounds made by firearms have advanced a great deal. For example, the chemical analysis of gunshot residues on wounds and clothing has been increasingly displaced by more precise analysis using scanning electron microscopes. Simple tools still have their place, however; among these are the blunt probes used to track wound channels.

Forensic analysis of gunshot wounds is made much easier when emergency rooms take photographs and X rays before surgery is performed on shooting victims. X rays can reveal not only bullets or pellets that have not exited but also small lead fragments that can show a bullet's path through the body (the wound channel). X rays can also help an analyst determine the caliber of an embedded bullet.

During autopsies on shooting victims, many photographs are taken of the wounds. These are supplemented with detailed notes about the conditions of any skin, hair, and clothing around the wounds.

Projectile Paths

The wound channel can reveal the angle, height, and distance from which a projectile was fired, allowing analysts to determine the locations and body postures of the shooter and the person who was shot. This information can support or debunk a claim of self-defense. Blood spatter patterns at the crime scene can also reveal a great deal about the positions of the shooter and the victim.

Often, a projectile shot from a firearm does not take a straight path from entry to exit; for example, it may be deflected by bones. Pistol bullets tend to make a straighter path through a body than rifle bullets because pistol bullets are generally shorter than rifle bullets. A bullet that enters a body after having ricocheted off some surface will usually penetrate less deeply and take a deviated path.

Shotgun pellets disperse in a regular conical pattern before they hit a target; the exact pattern depends on the type of gun, the ammunition, and the setting of the gun's choke (which widens or narrows the dispersal pattern). Accordingly, the location of pellets in the victim's body can indicate the distance from which the shotgun was fired. In the case of high-powered rifle bullets, the wound channel may reveal destruction not only from the bullet itself but also from the "temporary wound cavity" that rapidly expands and then contracts as the body absorbs the bullet's energy.

Sequencing

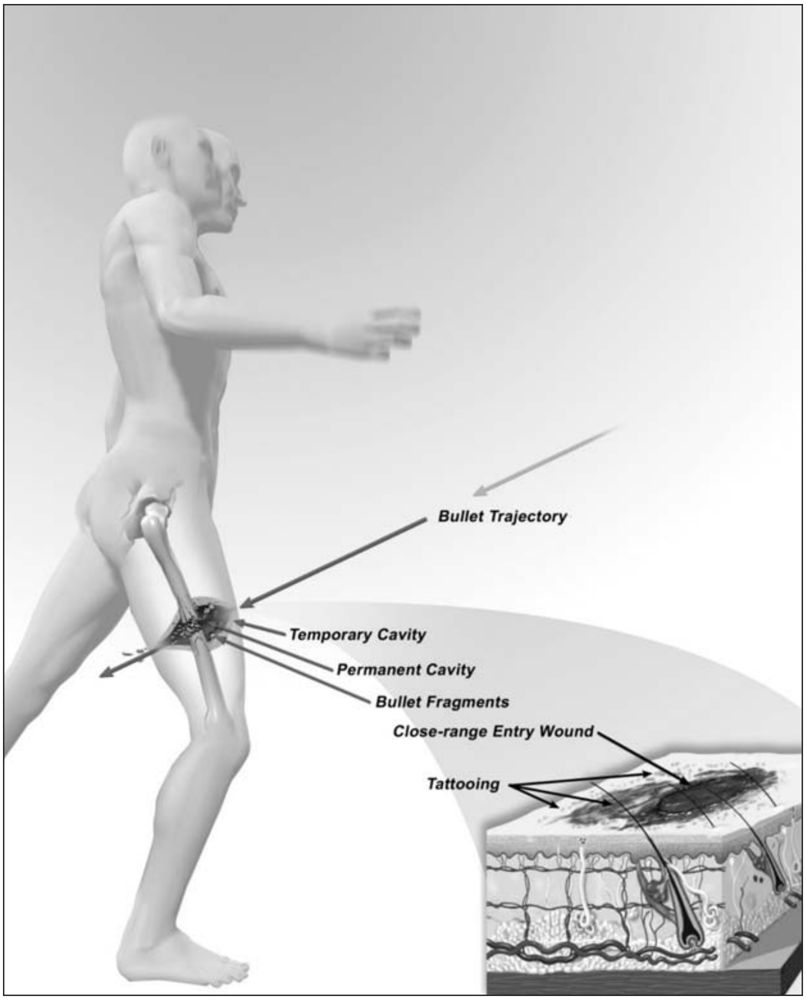
When a victim has been shot multiple times, forensic scientists can determine the order in which the shots were fired by examining the wounds. According to "Puppe's rule," if the bone fracture lines from one shot are interrupted by fracture lines from another shot, the interrupted fracture occurred after the other fracture.

The cleanliness of the wounds offers additional information about the order of the shots. As a bullet travels down the barrel of a gun, it may get coated with sooty material; this sooty "bullet wipe" will be deposited on an entrance wound. Because the first bullet from a clean gun is cleaner than subsequent shots, the absence of bullet wipe on a wound may indicate that the wound came from the first shot.

Entrance and Exit Wounds

The shape and other characteristics of an entrance wound can reveal much about the distance from which the gun was fired and the type of gun used. For example, a contact wound (from a gun placed on or very close to the skin) is more likely to be circular than is a wound from a shot fired at a distance. A contact wound is more likely to show stellate (star-shaped) tearing than is a distant shot, especially if the weapon used is a handgun.

A "shored" entry or exit wound reveals that the skin was reinforced by something else. Shoring may show, for example, that the victim was positioned with an arm in front of the chest, and the same bullet that entered and exited the arm then entered the chest. Shoring on an exit wound might reveal, for example, that the victim was lying on pavement.



Artist's depiction of the effects of a gunshot wound to a human leg. *(Custom Medical Stock Photo)*

The shape of the hole in the victim's clothing may indicate the type of bullet (for example, pointed or hollow point), and gunpowder residue analysis can determine whether the muzzle was next to or very close to the victim's body. Forensic examiners also look for scorching or blackening of the skin or clothing, for unburned or partially burned propellant particles, and (if an electron microscope is available) for metallic components of the primer (the device used to ignite the gunpowder). Charring on an entry wound is one of the signs that the gun's muzzle was in contact with the victim's skin. There may be evidence of the escaping gas from the burning gunpowder, such as bruising from a brief but violent ballooning of the skin. At "hard contact" range, the muzzle of the gun leaves an imprint in the skin.

At very close but nonadjacent distances, known as "near contact," a gunshot will still leave forensically useful gas traces on the skin or clothing. If the projectile travels through the victim's clothing, especially heavy clothing such as a leather jacket, the skin wound on the body may look very different from a wound in which the projectile struck the skin directly.

If a shotgun has been fired at close range, forensic experts are likely to find impact evidence from the wadding (a small petaled plastic cup that separates the pellets from the gunpowder). Because the wadding unfolds after exiting the barrel, the impression left by the wadding may provide good information about the distance between the shooter and the victim. Sometimes the wadding will be found in the victim.

Exit wounds are usually, but not always, larger than entry wounds, in part because some bullet points (hollow points) expand after impact. Hard-contact shots, however, can produce large entry wounds.

David B. Kopel

Further Reading

Dodd, Malcolm J. *Terminal Ballistics: A Text and Atlas of Gunshot Wounds*. Boca Raton, Fla.: CRC Press, 2006. Very thorough treatment of the topic provides clear explanations supplemented by many gruesome color photographs.

Haag, Lucien C. *Shooting Incident Reconstruction*. Burlington, Mass.: Academic Press, 2006. Larger discussion of shooting crime scenes includes in chapter 10 a solid overview of gunshot wound forensics.

Heard, Brian J. *Handbook of Firearms and Ballistics: Examining and Interpreting Forensic Evidence*. New York: John Wiley & Sons, 1997. Excellent survey of the subject includes a good introduction to wound analysis.

Parker, Leroy. *Workbook on Crime Scene Reconstruction of Shooting Incidents*. Bloomington, Ind.: Author House, 2005. Provides information on how investigators use basic trigonometry and other techniques to estimate the location of the muzzle after the entry and exit points for a bullet are known.

Warlow, Tom. *Firearms, the Law, and Forensic Ballistics*. 2d ed. Boca Raton, Fla.: CRC Press, 2005. Volume by a British police expert includes several good chapters on the forensics of gunshot wounds.

See also: Autopsies; Ballistics; Blood spatter analysis; Blood volume testing; Bullet-lead analysis; Defensive wounds; Firearms analysis; Gunshot residue; Kennedy assassination; Knife wounds; Puncture wounds.

H

Habeas corpus

Definition: Writ or court order to a public official directing that a person in custody be brought before a judge to determine whether the detention is legitimate (the literal translation of the Latin phrase *habeas corpus* is "you have the body").

Significance: When forensic evidence that might exonerate an incarcerated person becomes available, the use of a writ of habeas corpus is one legal strategy by which that person might get the evidence before a court and, as a result, might be freed.

Forensic evidence may determine the guilt or innocence of individuals accused of crimes, but such evidence is not self-executing—appropriate methods for presenting the evidence to the relevant courts must be found. Defendants who wish to present forensic evidence that may exonerate them may find the process difficult, especially if the evidence becomes available only after the defendants have been convicted. Writs of habeas corpus may be necessary to allow convicted persons to present evidence to the courts in order to establish that they did not commit the crimes of which they have been convicted.

The privilege to obtain a writ of habeas corpus is an ancient right in English common law, and the Founding Fathers of the United States considered this privilege to be of such great importance that they included it in the body of the U.S. Constitution, in Article I, section 9. This underscores its significance, given that even those constitutional Framers who did not believe a bill of rights was necessary thought that habeas corpus deserved constitutional protection. Habeas corpus is not an absolutely inviolable right in the United States, however; the language of the Constitution explicitly allows for the suspension of habeas corpus in certain cases. Only incarcerated individuals who have completed the regular appeals process may use this action.

Technically, habeas corpus is a civil action, not a criminal one, and guilt or innocence is not at issue. Successful claimants are not normally freed; rather, they are granted new trials. The use of habeas corpus petitions, however, may be the only way convicted persons can get forensic evidence that exonerates them in front of judges if the evidence becomes available years after conviction, when all other appeals have been exhausted.

The conservative majorities on the U.S. Supreme Courts headed by Chief Justices Warren E. Burger (1969-1986) and William H. Rehnquist (1986-2005) successfully limited the use of habeas corpus petitions even in cases in which the convicted parties can use forensic evidence for exoneration. Given that habeas corpus petitions are filed in federal court and allege that either federal or state court convictions were flawed, these Supreme Court limitations are significant. Because the federal rules have been so inhospitable, those who attempt to use forensic evidence to establish the innocence of convicts have increasingly sought relief first from more agreeable state legislatures and courts.

Richard L. Wilson

Further Reading

Abraham, Henry J. *The Judicial Process*. 7th ed. New York: Oxford University Press, 1998.

Habeas Corpus in the U.S. Constitution

The common-law principle of habeas corpus is clearly acknowledged in the U.S. Constitution in Article I, section 9:

The Privilege of the Writ of Habeas Corpus shall not be suspended, unless when in Cases of Rebellion or Invasion the public Safety may require it.

Epstein, Lee, and Thomas G. Walker. *Constitutional Law for a Changing America: Rights, Liberties, and Justice*. 6th ed. Washington, D.C.: Congressional Quarterly Press, 2007.

Ivers, Gregg. *American Constitutional Law: Power and Politics*. Boston: Houghton Mifflin, 2001.

See also: Class versus individual evidence; Courts and forensic evidence; Direct versus circumstantial evidence; Federal Rules of Evidence; Innocence Project; Postconviction DNA analysis; Wrongful convictions.

Hair analysis

Definition: Comparison of hair from a questioned source to hair from a known source to determine the possible source of the questioned hair.

Significance: Hair analysis can provide useful information during a criminal investigation, as forensic scientists can determine whether hairs found at a crime scene came from an animal or a person and whether the hairs could have come from the victim of the crime or a possible suspect.

During the commission of a crime, hairs from the perpetrator's head or clothing are often transferred to the crime scene. Because different types of hair have different characteristics, the analysis of hairs recovered from crime scenes can provide investigators with information on the persons who were present at the scene.

Hair Characteristics

Hair is produced from a structure in the skin known as the follicle. The part of a hair embedded in the follicle is known as the root, and the shaft of the hair is what protrudes from the skin, ending in the tip. The shaft generally consists of three layers known as the medulla, the cortex, and the cuticle.

The medulla is a series of cells down the center of the hair shaft that gives the appearance of being a hollow channel. Medullae can be continuous (which means that the channel appears along the entire length of the hair), discontinuous (which means that sections of medulla appear throughout the length of the hair), or absent entirely. The appearance of the medulla can be highly useful to the forensic scientist in differentiating different species of hairs, as various animals have patterned medullae. For example, a cat medulla has an appearance similar to a string of beads. Different hairs from the same person can have different types of medullae.

The cortex is the area surrounding the medulla; it consists of spindlelike cells that contain pigment granules. It is these granules that determine the color of the hair. The granules can vary greatly in shape and distribution throughout the cortex. As is the case with the medulla, cortex characteristics can vary among hairs coming from the same source.

The cuticle, the waxy outermost layer of the hair shaft, consists mainly of flattened cells that form a scalelike pattern on the surface of the shaft. These patterns do not vary greatly between individuals within a species; however, they can provide a wealth of information about the species of the hair.

Limitations of the Technique

Hair analysis can provide information about the type of hair found by means of direct visual comparison. It can be determined with a reasonable degree of certainty the type of animal from which a hair came and, if it is a human head hair, the ancestry of the person. It is also possible to differentiate different types of human hair, such as a head hair from a pubic hair or beard hair, by examining the shape of the cross section. Forensic scientists are also able to determine whether a hair has recently been cut, whether it has been dyed, and whether it was forcibly removed or shed naturally.

If a single hair is found at a crime scene and a forensic scientist wishes to compare it to a known source, it is imperative that many hairs be taken from the known source for comparison purposes. This is because of the high degree of variation within hairs from a single source.

Hair evidence is not individualizing. That is, it is not possible to determine the exact source of a hair by visual examination. If a forensic scientist deems a questioned hair to be consistent with known hairs, the scientist's report should state that the questioned hair cannot be excluded as having come from the known source.

Other Types of Hair Analyses

In addition to species analysis and visual examinations and comparisons, much research has been done in the area of toxicological analyses on hair, and it has been found that many drugs and toxins can be detected in hair. Drug testing on hair rather than on body fluids (urine, saliva, or blood) has gained popularity because a drug retained in the hair is detectable until the part of the hair containing the drug is cut or naturally shed, whereas body fluids retain evidence of drug usage only for a few hours to a few months.

When a hair found at a crime scene includes a root tag, forensic scientists can extract DNA (deoxyribonucleic acid) from the root tag for analysis. DNA comparison can afford an exact match to a suspect rather than the possible association usually afforded by visual hair analysis.

Lisa LaGoo

Further Reading

Gardner, Ross M. *Practical Crime Scene Processing and Investigation*. Boca Raton, Fla.: CRC Press, 2005. Guide to investigating crime scenes focuses on the practical application of techniques such as hair and fiber analysis.

Houck, Max M., and Jay A. Siegel. *Fundamentals of Forensic Science*. Burlington, Mass.: Elsevier Academic Press, 2006. Basic text includes information on microscopy of hair.

Kintz, Pascal, ed. *Drug Testing in Hair*. Boca Raton, Fla.: CRC Press, 1996. Describes all aspects of the analysis of hair for the presence of drugs, including the biology of the process, how the hair is tested, and the legal and ethical issues associated with the procedure.

Robertson, James, ed. *Forensic Examination of Hair*. Philadelphia: Taylor & Francis, 1999. Details hair biology, types of hair, species differentiation, the comparison process, and how to report analysis results.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007. Excellent introductory textbook contains several sections on hair analysis and the preservation of hair evidence.

See also: Animal evidence; Beethoven's death; Child abuse; Control samples; Direct versus circumstantial evidence; DNA extraction from hair, bodily fluids, and tissues; DNA isolation methods; Fibers and filaments; Locard's exchange principle; Louis XVII remains identification; Microscopes; Napoleon's death; Quantitative and qualitative analysis of chemicals; Toxicological analysis; Wildlife forensics.

Halcion

Definition: Trade name for a tranquilizing benzodiazepine drug prescribed mostly for short-term treatment of insomnia.

Significance: Halcion is normally a safe drug when confined to its prescribed uses and limits. However, when it is taken in large amounts, it can cause aggressive and eccentric behavior, bring on unconsciousness, and even cause death. It is thus a drug that forensic investigators look for in many cases of abnormal behavior and suspicious death.

Halcion is part of a family of commonly prescribed tranquilizers called benzodiazepines. It is intended for oral administration in tablets containing between one-eighth and one-quarter of a milligram of triazolam, the generic name for Halcion's active ingredient. Outside the United States, triazolam is distributed under such brand names as Dumozolam, Novidorm, Nuctane, Somese, Somniton, Songar, Tialam, and Trialam.

As with all benzodiazepines, Halcion can cause users to experience uneven degrees of sedation, anxiety relief, and muscle relaxation by slowing the activities of their central nervous systems. These properties account for the drug's popular use in treating insomnia and anxiety, as well as seizures, muscle spasms, and alcohol withdrawal. However, Halcion can present a special problem because habitual users of benzodiazepines tend to become dependent on the drugs. For this reason, medical professionals advise that patients ingest the smallest possible doses of Halcion over the briefest possible periods that will still provide acceptable levels of symptomatic relief.

Despite their tranquilizing powers, Halcion and other benzodiazepine drugs are often suspected agents in cases of excessive aggressiveness, bizarre behavior, hallucinations, increasing depression, and suicidal tendencies. Indeed, concerns about the psychological side effects caused by high dosages of triazolam have prompted several countries temporarily to remove the drug from their pharmaceutical markets. However, the Food and Drug Administration of the U.S. government and similar agencies of most other countries consider the drug safe when taken in small doses.

Although most users of Halcion take the drug without problems, some users claim that it has brought them to the edge of insanity. Such claims are almost impossible to confirm because of the difficulty of distinguishing between cause and effect in patients exhibiting such symptoms. Nevertheless, problems of withdrawal from Halcion use are painfully real. Addicted users must overcome withdrawal syndrome when attempting to escape the drug's physical dependence. Ironically, the symptoms of withdrawal syndrome typically include anxiety, panic, and insomnia—the very same symptoms that lead users to Halcion in the first place. In order to distinguish between natural symptoms and those induced by withdrawal, medical care providers generally wait about six months after patients discontinue use of the drug before revisiting their diagnoses. Other possible symptoms of benzodiazepine withdrawal include convulsions, tremors, vomiting, sweating, feeling ill, cramps, hallucinations, seizures, and muscular spasms.

Because of the problems associated with withdrawal, some Halcion users slip into dependence-abuse cycles, taking the drug not for its therapeutic benefits but to avoid the torments of withdrawal. Doctors warn against abrupt discontinuation of Halcion because of the attendant withdrawal symptoms. Instead, they recommend gradually reducing dosages over seven to ten days for patients who have been taking more than the lowest doses of Halcion for periods longer than a few weeks.

Abnormal Behaviors

It is not always possible to determine the causes of abnormal behavior, but the use of Halcion and other benzodiazepine drugs is often suspected in cases of excessive aggressiveness, agitation, depersonalization, bizarre behavior, hallucinations, increasing depression, and thoughts of suicide. Therefore, even when the exact cause is uncertain, abnormal changes in the behavior of a person taking one of these drugs are reason for prompt evaluation. One thing that is clear is that triazolam depresses the central nervous system. Halcion patients are thus warned against engaging in potentially dangerous activities that require mental alertness. They are also warned against using other drugs that depress the central nervous system, such as alcohol, psychotropic medications, anticonvulsants, and antihistamines, which can compound the depressive effect.

Halcion is normally safe when used within prescribed limits; however, if taken in large amounts, especially in combination with alcohol, it can cause users to slip into comas, stop breathing, and die. Halcion overdoses at less-than-fatal levels may result in confusion, slurred speech, deep or excessive sleep, slowed reflexes, and clumsiness. Overdose may also cause shallow, difficult, or arrested breathing (apnea) as well as seizures and loss of consciousness.

Reports of "sleep driving" while on Halcion are particularly disturbing. In such cases, patients get out of bed and drive off in their cars although not fully awake. Afterward, they have no memory of what they have done. It is usually difficult to ascribe some of these behaviors to either Halcion alone or some underlying mental disturbance. In either case, the drug's manufacturer urges patients experiencing such episodes to seek professional evaluation.

Richard S. Spira

Further Reading

Drummond, L. M., and H. P. Matthews. "Obsessive-Compulsive Disorder Occurring as a Complication in Benzodiazepine Withdrawal." *Journal of Nervous and Mental Disease* 176 (1988): 688-691. Presents a case history of withdrawal from a benzodiazepine drug in a thirty-two-year-old woman.

Golombok S., P. Moodley, and M. Lader. "Cognitive Impairment in Long-Term Benzodiazepine Users." *Psychological Medicine* 18 (1988): 365-374. Examines the nature and extent of impairment of cognitive functioning that may be caused by use of benzodiazepines over long periods.

Hecker R., M. Burr, and G. Newbury. "Risk of Benzodiazepine Dependence Resulting from Hospital Admission." *Drug and Alcohol Review* 11 (1992): 131-135. Addresses the occurrence of dependence in benzodiazepine users after relatively brief use of the drug.

Levine, B., ed. *Principles of Forensic Toxicology*. 2d ed., rev. Washington, D.C.: American Association for Clinical Chemistry, 2006. Introductory textbook describes the analytical, chemical, and pharmacological aspects of a variety of drugs, including benzodiazepines.

Vermeeren, A. "Residual Effects of Hypnotics: Epidemiology and Clinical Implications." *CNS Drugs* 18, no. 5 (2004): 297-328. Compares the duration and severity of side effects from the use of various drugs classified as hypnotics.

See also: Alcohol-related offenses; Antianxiety agents; Antipsychotics; Club drugs; Drug abuse and dependence; Food and Drug Administration, U.S.; Forensic psychiatry; Forensic psychology; Forensic toxicology; Opioids; Psychotropic drugs; Toxicological analysis.

Hallucinogens

Definition: Substances that cause alterations of perception, including but not limited to changing what users see, hear, feel, taste, smell, and experience about themselves and their relationship to the world and others.

Significance: Hallucinogenic drugs are widely used in the United States, despite the fact that such use can be dangerous and even life-threatening. Law-enforcement agencies expend significant resources in efforts to reduce the illegal manufacture, sale, and use of such drugs.

Hallucinogenic drugs, or hallucinogens, are capable of altering the perceptions of those who ingest them. Historically, some hallucinogens have been important parts of cultural rituals, particularly spiritual ceremonies and developmental rites of passage, and their use has been socially sanctioned because of these associations. Most hallucinogen use in the United States, however, is recreational in nature.

Effects

As the name implies, hallucinations—internal perceptions that separate the individual from reality and that are not perceptible to others—are common effects of hallucinogen usage. The hallucinatory experiences associated with these drugs may include increased awareness of surroundings and perceptual distortions, such as perceived heightened visual ability or changes in the way motion is perceived. Any and all of the senses may be affected simultaneously, creating often illogical and nonlinear observations. Some users of hallucinogens have reported experiencing synesthesia, a phenomenon in which one sense overlaps with another. For instance, the notes, melodies, and harmonies of music may be perceived both as sounds and as colors.

Users of hallucinogens may also experience a different sense of themselves as persons, with the drugs affecting their perceptions of consciousness and their bodies in relationship to others. Some experience greatly increased empathy and feelings of connection to others and the environment. In fact, in some users, the perceived dissolution of personal boundaries may proceed to such an extent that they cannot perceive any sense of self—in essence, they feel they become their surroundings.

The experience of taking a hallucinogen is often referred to as a trip. Some trips are brief; others are long. Experiences can vary substantially from one use session to the next in terms of length of time a person is affected, the quality of the experience (pleasurable or upsetting), the number of senses affected, and so on. Some of this variation may be accounted for by the specific drugs used, the dosages taken, the quality or purity of the drugs, and the physical and environmental circumstances or contexts under which the drugs are taken.

Substances

Hallucinogens include human-made drugs, such as psychedelic "club drugs," as well as substances derived from certain plants and fungi. In the United States, these substances are classified as having no medical uses, although this is a matter of some debate. Some have argued that particular hallucinogens may be useful for treating trauma, psychopathology, and even conditions such as headaches.

Common hallucinogens include lysergic acid diethylamide (LSD), 2,5-dimethoxy-4-methylamphetamine (known as DOM or STP), and 3,4-methylenedioxymethamphetamine (also known as MDMA or ecstasy). Also popular are psilocybin, a hallucinogen derived from mushrooms (sometimes known as magic mushrooms), and peyote. Peyote, which is derived from the mescal cactus and contains mescaline, has a long history of being used in Native American spiritual ceremonies. Dimethyltryptamine (DMT), another substance found in plants and seeds but that also may be synthesized, is used for its hallucinogenic properties.

Users seeking hallucinogenic properties in their recreational drugs of choice also sometimes abuse substances that were originally seen as anesthetics, such as ketamine (known as special K) and phencyclidine (known as PCP or angel dust). These drugs' dissociative properties lead users to experience feelings of being detached from themselves or their experiences.

Associated Problems

The experiences, or trips, that individuals have when they take hallucinogens can be pleasant or unpleasant. When pleasant, a trip can be a memorable experience, but when unpleasant, it can be like living trapped in a nightmare. Either circumstance can be dangerous, particularly if the individual under the influence is unsupervised. When experiencing pleasant hallucinations, users of hallucinogens may believe they can do things they cannot physically do (such as fly), and this may result in accidental injury or even death. Negative hallucinations may lead to aggression and paranoia that can spur attacks on others or objects, which may result in property damage, injuries, or—in extreme cases—deaths. In addition, users have reported the phenomenon of flashbacks—that is, the reexperiencing of trips well after the drugs' initial effects have passed. Such unexpected experiences may lead to confusion, aggression, and accidental injury.

Hallucinogen use disorders follow the same pattern of problems as do use disorders associated with other substances of abuse. The use of hallucinogens may lead to daily functioning problems at work, home, or school, as trips and their associated recovery times may be lengthy. Hallucinogens can sometimes exacerbate preexisting psychological problems, and research indicates that they may even cause psychological problems, such as psychosis, in some users.

How Hallucinogens Work

In a 2001 research report, the National Institute on Drug Abuse describes the different ways in which hallucinogens and dissociative drugs work in the human body.

Hallucinogens cause their effects by disrupting the interaction of nerve cells and the neurotransmitter serotonin. Distributed throughout the brain and spinal cord, the serotonin system is involved in the control of behavioral, perceptual, and regulatory systems, including mood, hunger, body temperature, sexual behavior, muscle control, and sensory perception. . . .

The dissociative drugs act by altering distribution of the neurotransmitter glutamate throughout the brain. Glutamate is involved in perception of pain, responses to the environment, and memory.

Like other substances of abuse, hallucinogens pose problems for law-enforcement agencies, which must expend significant resources to combat the illegal manufacture, sale, and use of these drugs as well as other crimes that stem from the actions of persons under the influence of hallucinogens. The production and distribution of hallucinogens and their components are particularly noteworthy growing problems, as manufacturers and drug traffickers increasingly conduct their business using the Internet.

Nancy A. Piotrowski

Further Reading

Holland, Julie. *Ecstasy: The Complete Guide—A Comprehensive Look at the Risks and Benefits of MDMA*. Rochester, Vt.: Inner Traditions International, 2001. Presents data and arguments pertaining to the typical risks that may be expected from ecstasy and other club drugs. Includes discussion of research perspectives on the potential benefits of these drugs.

Street Names for Hallucinogens and Dissociative Drugs

LSD (lysergic acid diethylamide)
- acid
- blotter
- blotter acid
- boomers
- dots
- microdot
- pane
- paper acid
- sugar
- sugar cubes
- trip
- window glass
- windowpane
- yellow sunshine
- Zen

Ketamine
- bump
- cat Valium
- green
- honey oil
- jet
- K
- purple
- Special K
- special la coke
- super acid
- super C
- vitamin K

PCP
- angel
- angel dust
- boat
- dummy dust
- love boat
- peace
- superglass
- zombie

Jansen, Karl. *Ketamine: Dreams and Realities*. Ben Lomond, Calif.: Multidisciplinary Association for Psychedelic Studies, 2004. Provides a historical perspective on the uses of ketamine, a hallucinogenic substance, and addresses the risks and benefits related to the drug.

Julien, Robert M. *A Primer of Drug Action: A Comprehensive Guide to the Actions, Uses, and Side Effects of Psychoactive Drugs*. 10th ed. New York: Worth, 2005. Presents full coverage of the topic of hallucinogens, including information on these drugs' effects on mind and body and at the level of neurotransmitters.

Schultes, Richard Evans. *Hallucinogenic Plants*. New York: Golden Press, 1976. Illustrated field guide describes many different kinds of hallucinogenic plants and offers a historical perspective on their use.

Stafford, Peter. *Psychedelics*. Oakland, Calif.: Ronin, 2003. Provides broad descriptions of drugs that affect perception, focusing on what these substances may look like and how they may affect users. Also discusses the drugs' individual and societal impacts.

Weil, Andrew, and Winifred Rosen. *From Chocolate to Morphine: Everything You Need to Know About Mind-Altering Drugs*. Rev. ed. Boston: Houghton Mifflin, 2004. Presents a down-to-earth discussion of drugs that affect the mind. Easy to read.

See also: Amphetamines; Antianxiety agents; Antipsychotics; Club drugs; *Diagnostic and Statistical Manual of Mental Disorders*; Drug abuse and dependence; Drug classification; Forgery; Illicit substances; Psychotropic drugs; Stimulants.

Handwriting analysis

Definition: Examination of samples of handwriting, usually to establish validity, fraud, or forgery.

Significance: Forensic experts who examine handwritten as well as typed materials assist in law-enforcement investigations by comparing handwriting or signatures, analyzing disputed documentation, and examining and identifying legal documents. These experts, who often specialize in particular kinds of writings, such as real-estate records, wills, or medical and dental records, are often called upon to present testimony on their findings in court.

The field of questioned document analysis, of which handwriting analysis is a subset, is one of the oldest disciplines in the field of forensic sciences. The practice of forgery is as old as written communication: Under the Code of Justinian in 539 C.E., Roman law contained rules for identifying and comparing handwriting. A questioned document is any document the authenticity of which is questioned, either entirely or partially. Questioned documents can include concert tickets, postage stamps, bus passes, and dollar bills. Expert handwriting examiners are concerned primarily with anything written by hand in questioned documents; they apply basic rules of document analysis and their own experience to distinguish real writing from forged.

During forensic handwriting analysis, samples of signatures may be compared, alterations and obliterations of documents may be scrutinized, and ink may be subjected to microscopic analysis. Document examiners may be asked to testify in disputes regarding written threats, unsigned letters, attempts to extort or defraud, contract disagreements, or identity theft. Many document examiners work for government agencies; others are in private practice, often providing their services to investigations of medical malpractice or insurance fraud. A document examiner may be called upon to verify a person's signature on a sign-in sheet to prove or disprove that person's claim to have been at a particular place at a particular time. Document examiners also determine who signed checks, credit card invoices, and contracts in investigations of fraudulent activities. By identifying who added an addendum to a murder victim's will, a document examiner may free the spouse from suspicion.

In analyzing handwriting, document examiners determine only the physical characteristics of the handwriting. Traits of the writers' personalities are not addressed, nor can document examiners ascertain from handwriting such other aspects of the writers as age, sex, race, or educational status.

Handwriting Development

In the United States, children have traditionally been trained in whatever handwriting style is in favor when they are in elementary school. Depending on geographic location, children might be taught one of a variety of copybook styles of penmanship, such as Palmer or Zaner-Bloser. In the early days of learning to write, children focus attention on how to write the letters of the alphabet correctly. As schooling continues, these methods become increasingly automatic, and individuals' writing begins to deviate from the standards originally learned as the focus of writing shifts toward what is being written and away from how it is written.

As the brain matures, an individual's neuromuscular coordination and visual perceptions become unique to that person. By the late teenage years, a person's handwriting has matured, but it has not stopped changing. As people progress through life and even through various emotional or physical upheavals, their handwriting changes as well, and sometimes not in subtle ways. Despite such long-term variations, a person's handwriting retains features that identify its author.

Collecting Samples

Before comparisons can be done, the handwriting examiner must have samples of known, standard writing—unquestioned samples—from the individual of interest. Good standards are essential for valid results.

As much as possible, the conditions under which the known standards are produced should duplicate the conditions under which the questioned material was written—with the same or similar writing instrument, in the same writing position and on the same kind of surface, and on the same type of paper (lined or not, same kind of stock). If the questioned material was written in cursive, the known standards must be written in cursive.

At least one of two kinds of writing standards are obtained: nonrequest and requested writing. Nonrequest writing is also known as spontaneous or undictated writing, and samples of requested writing are also known as dictated exemplars. Nonrequest writing is usually material written previously by the individual; such material is much more likely than requested writing to reveal the individual's normal, unforced writing habits. As the writer was ignorant of the way the writing would eventually be used, conscious or unconscious attempts to alter, disguise, or even improve the writing are lacking. Nonrequest writing may be difficult to get authenticated for court, however. In addition, the examiner may not be able to obtain enough nonrequest writing for good comparison, and such material may have been written under conditions different from those of the questioned material.

Requested exemplars are standards produced by request, usually in the presence of one or more witnesses. Using such exemplars can be advantageous in that they allow for better duplication of the conditions under which the questioned material was written and authentication for court is often easier. Collecting requested exemplars, however, calls attention to the writing process, and regardless of innocence most writers tense up, changing their handwriting subtly or not so subtly.

Most examiners prefer to receive both requested and nonrequest writing standards for comparison to questioned material. Nonrequest writing standards can be obtained from many places, including job applications, bank records, business and real estate agreements, employment records, tax returns, wills, and letters. Most of these kinds of sources, however, provide signatures only, and signatures are not well suited for handwriting comparisons because they are of insufficient length and often do not bear much resemblance to the rest of their writers' handwriting.

Comparison

Common features of handwriting, such as slant and letter formation, are class characteristics—attributes learned in grade school. Uncommon handwriting features are individual characteristics that are distinctive and peculiar to one person's writing. Document examiners look beyond class characteristics as they use both vision and microscopy to compare questioned handwriting or signatures to known standards. Experienced examiners recognize common traits and refrain from making identifications from these; instead, examiners rely chiefly on individual characteristics.

Examiners inspect handwriting for minute details, looking at traits such as letter size; how letters are connected; how beginning and ending strokes are formed; height ratio of capital to small letters; spacing between letters, words, and lines; spacing on the page; skill level of the writing; and speed and pressure of the writing instrument on the page. They also observe execution—in general, does the writing in the known sample look natural or does it show characteristics lacking in the original? Experienced examiners can discern patterns in the consistent combination of less-common traits with more-common ones. When the questioned sample begins to diverge too much from the standards, it is likely false.

No two persons write exactly alike. It is also true, however, that no one person writes identically twice. People hold their pens or pencils at varying angles, and they write at different speeds at different times. In one person's writing, not every instance of any letter will be identical; beginning and terminal strokes will vary. These variations in one person's handwriting, however, still constitute a range that is recognizable to experienced examiners. For example, in the letter combination *th*, some people tend to make the *t* or the *h* higher, and some usually make the two letters of equal height. When such details vary within an individual's known standards, a skilled examiner notes the differences among the standards and compares the pattern with the questioned material. In a study of two hundred people, it was found that 5.5 percent made the *t* taller than the *h*, 78 percent made the *t* shorter than the *h*, 15 percent showed no pattern, and 1.5 percent made the *t* and the *h* equally high. Such seemingly trivial (and sometimes tedious) details are carefully noted by handwriting examiners.

Forgery Types

Generally, forgeries are freehand simulations, tracings, or normal-hand simulations. For freehand simulations to be done well, correct letter formations and height ratios must be written at the same speed and with the same pen pressure as in the original, and all at once. At the same time, the forger must suppress his or her own natural individual writing traits, which can be very difficult. If the forger concentrates on making letter formations like those in the original, the pen pressure will likely be different from and the speed will almost always be much slower than the original. If the forger concentrates instead on speed and pressure, letter formations and connecting strokes revert to the forger's.

Even if the forger practices the to-be-forged writing, it is likely that very subtle details, such as line quality and placement of pen lifts, will diverge from the original. A signature that when genuine is illegible may suddenly when forged become legible, or it may appear hesitant or drawn instead of dashed off in a well-practiced manner. Microscopic examination of such a forged signature reveals "patching"—the retouching of a line or blunt starts and stops indicative of slow, concentrated copying. Examined competently, freehand simulations seldom have much chance of deceiving the examiner.

Forgeries involving tracings have their own shortcomings. A forger can use carbon paper or graphite to copy an original signature or handwriting, but remnants of the carbon paper or graphite are often microscopically detectable. A forger might place a page over the sample or signature and trace it, but when tracing is done atop the original, the line quality of the tracing is generally poor. Where the original appeared smooth and fast, the tracing appears slow, its lines wavy and drawn. Instead of being relatively consistent, the pen pressure varies, and natural differences in line shading disappear. If a forger makes an impression of a signature or handwriting with a pointed object and then uses a

A forensic document examiner works to verify the signature of Michael Fletcher, a candidate for the Florida State Senate in 2004. After questions were raised concerning the authenticity of the signature on candidate qualification papers, the examiner was called in; he concluded that, based on comparison samples of Fletcher's signature, the signature on the papers was not Fletcher's. *(AP/Wide World Photos)* pen to fill in the impression, the indent in the paper is detectable. If the original or a copy of the original writing is available and the writing being examined mirrors it exactly, it had to be traced or somehow reproduced; no two handwritten samples are identical.

In normal-hand forgery, forgers write normally or change their writing so that they can later deny authorship. To disguise their writing, forgers may change the slant or size of it, add strokes to letters, or alternate between uppercase and lowercase letters. It is relatively easy for individuals to disguise their handwriting, at least to a degree that may not be detected by the uninformed, but it is difficult to maintain such changes, as the writers' own tendencies ceaselessly assert themselves. Writing is a well-learned process, and years of practice leave their mark.

Legal Challenges

Handwriting examination is not an exact science. The methods used by different experts vary, and training techniques differ as well. In 1989, a lawyer published an article that criticized the the use of expert handwriting examiners in court, stating that evidence was lacking to prove that document examiners perform any better than nonexperts and that the error rate of document examiners was high. Challenges to the validity of forensic handwriting analysis ensued, and one court ruled handwriting analysis inadmissible, calling the comparison of known writings with questioned ones entirely subjective and lacking standards.

Evidence to the contrary appeared, however. In a 1997 study of experts and nonexperts asked to identify handwriting, the error rate for the experts was 6.5 percent, whereas that for the nonexperts was 38.3 percent. The nonexperts had incorrectly matched documents made by different writers at almost six times the rate of the experts. In a 2001 study, the error rate of document examiners in determining false signatures was found to be less than 1 percent (0.49 percent), whereas that of nonexperts was 6.47 percent. In the same study, the rate at which experts declared genuine signatures false was 7.05 percent, and the error rate for nonexperts was 26.1 percent. A professor of computer science at a New York university reported that the writer of a sample could be determined correctly in 96 percent of fifteen hundred samples scanned into a computer programmed to measure such aspects as letter dimensions and pen pressure. In 1999, the U.S. Court of Appeals found that the lawyer who in 1989 questioned the overall reliability of handwriting examinations had no standing to do so, lacking training or education in the field, and handwriting analysis was again admissible in the courts.

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Further Reading

Ellen, David. *Scientific Examination of Documents: Methods and Techniques*. 3d ed. Boca Raton, Fla.: CRC Press, 2006. Comprehensive text discusses many technical advances in the field. Intended for readers with some background in document examination.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005. Provides an excellent overview for students of forensic science. Includes numerous real case studies.

Kelly, Jan Seaman, and Brian S. Lindblom, eds. *Scientific Examination of Questioned Documents*. 2d ed. Boca Raton, Fla.: CRC Press, 2006. Thorough guide to the topic focuses on developments in forensic examination of written communications since 1982.

Morris, Ron N. *Forensic Handwriting Identification: Fundamental Concepts and Principles*. New York: Academic Press, 2000. Illustrated text useful for both students and practitioners includes discussion of physiological effects on writing.

Slyter, Steven A. *Forensic Signature Examination*. Springfield, Ill.: Charles C Thomas, 1996. Brief volume offers a useful introduction to signature identification.

See also: Check alteration and washing; Document examination; Expert witnesses; Forensic linguistics and stylistics; Forgery; Hitler diaries hoax; Hughes will hoax; Lindbergh baby kidnapping; Paper; Questioned document analysis; Sports memorabilia fraud; Typewriter analysis; Writing instrument analysis.

Hanging

Definition: Means of causing death by suspending a person by the neck, thus compressing blood vessels in the neck and cutting off oxygen and blood flow.

Significance: When attempting to determine whether a death has been caused by hanging, forensic scientists must look at several different types of evidence, including ligature marks around the neck. Investigators must also be aware of the kinds of evidence that indicate whether a death by hanging was intentional or accidental, and whether the death resulted from the actions of the deceased or those of some other person.

Deaths by hanging may be criminal, intentional, or accidental acts; many hangings are suicidal. Forensic scientists have several means of determining whether a death has been caused by hanging. The most obvious clues are when a body is found suspended from some object above the head, with some type of ligature around the neck, and with the body in a fully erect position and the feet off the ground. A person does not have to be in an erect position to cause a hanging, however; people have been known to hang themselves from sitting positions by using doors or other means to cause the necessary neck compression that results in death by hanging.

In investigating a suspected hanging, forensic scientists look for marks around the neck and determine whether these were caused by some type of ligature or by some means of strangulation. Soft ligatures, such as those made from bedsheets, do not leave much in the way of a line on the neck, so in such cases forensic scientists must look for additional evidence, such as a congested face and compression of the carotid artery or jugular vein. Another way forensic scientists detect a hanging is by looking for a fracture of the hyoid bone, which is the highest bone in the larynx section of the neck. Strangulation may also result in a fractured hyoid bone, however, so this is not a definitive measure for detecting a hanging. A hanging death may also result in a break in the cervical spine. Forensic scientists also look for footprints and other evidence at the death scene that may indicate whether the decedent was lifted or suspended into the air by another person for purposes of carrying out the hanging.

Governments have used hanging as a method of execution for centuries. Some U.S. states that once used this method of carrying out death sentences later concluded that hanging violates the prohibition against cruel and unusual punishment in the Eighth Amendment to the U.S. Constitution, particularly given that hanging is not always immediately successful in causing death. Hanging is rarely used in the United States as a means of carrying out the death penalty (the method is officially sanctioned only in the states of New Hampshire and Washington), but many other nations still use this method. When hanging is used to carry out a sentence of death in the United States, a medical practitioner or forensic scientist must be present to determine that the prisoner is dead by checking vital signs.

Carol A. Rolf

Further Reading

Duff, Charles. *A Handbook on Hanging*. 1928. Reprint. New York: New York Review of Books, 2001.

Owen, David. *Hidden Evidence: Forty True Crimes and How Forensic Science Helped Solve Them*. Richmond Hill, Ont.: Firefly Books, 2000.

Sachs, Jessica Snyder. *Corpse: Nature, Forensics, and the Struggle to Pinpoint Time of Death*. Cambridge, Mass.: Perseus, 2002.

See also: Asphyxiation; Autoerotic and erotic asphyxiation; Choking; Hesitation wounds and suicide; Petechial hemorrhage; Strangulation; Suffocation; Suicide.

Hantavirus

Definition: Member of a group of viruses that are part of the Bunyaviridae viral family.

Significance: Hantaviruses, which are transmitted by rodents and their bodily fluids, can have deadly effects. Because forensic scientists frequently come into contact with items from crime scenes where rodent infestation is likely, these professionals are at elevated risk for exposure to hantaviruses. In the United States, the predominant virus of this group is the Sin Nombre virus, which causes hantavirus pulmonary syndrome.

Although hantaviruses have been known to exist since the 1950s, the first reported case of hantavirus pulmonary syndrome (HPS) occurred in May of 1993 in the American Southwest. Over the next fourteen years, according to the Centers for Disease Control and Prevention, more than 450 confirmed cases of HPS occurred in the United States, and at least 35 percent of these resulted in death. Most of the incidents took place in the southwestern United States, but cases of HPS have been confirmed in thirty states.

The Sin Nombre virus (SNV) is transmitted primarily through the inhalation of aerosolized droplets of rodent saliva, urine, or feces. The deer mouse has been implicated as the primary carrier, although other carriers have been identified, including the cotton rat, the rice rat, and the white-footed mouse. It is possible that other rodents carry the virus as well. Transmission of the virus by other methods is rare, but cases have been found in which infected persons contracted the virus by being bitten by infected rodents, by eating foods contaminated with infected rodent bodily fluids, or by touching contaminated surfaces and then touching mucous membranes, such as inside the mouth.

Hantaviruses are composed of a spherical

Health officials of the Centers for Disease Control and Prevention inspect rodent specimens suspected of being connected with a hantavirus outbreak. In the United States, the deer mouse is the primary reservoir of the Sin Nombre hantavirus, which causes hantavirus pulmonary syndrome. *(Centers for Disease Control and Prevention)* fatty envelope surrounding a three-segmented RNA (ribonucleic acid) genome. HPS has an incubation period of one to five weeks; early symptoms can include a high fever, headache, aching, dizziness, chills, coughing, nausea, and vomiting. As the disease progresses, the victim experiences shortness of breath and accumulation of fluid in the lungs. Anyone can contract HPS.

Forensic scientists are at high risk for contracting HPS by exposure to SNV through varied means. Crime scene specialists, for example, often spend hours at crime scenes where rodent infestations are likely. The act of sifting through debris and other materials in such places can aerosolize any rodent urine, feces, or saliva present, which can then be inhaled by the investigators. In addition, items sent to forensics laboratories for analysis might contain rodent saliva or excrement, which could then infect the people working in these labs.

No defined treatment has yet been established for HPS. Persons with suspected HPS should be hospitalized immediately for monitoring. Intubation and oxygen therapy have yielded some success against the disease, and the use of antiviral drugs against it is being investigated.

Forensic scientists can reduce their risk of exposure to SNV by wearing masks with high-efficiency particulate air (HEPA) filters when working in areas that might be infested with rodents. Also, personal protective equipment such as latex gloves, safety spectacles, long-sleeved shirts, and full-length pants with closed-toe shoes can aid in exposure risk reduction. Disinfectant has been shown to be successful for decontamination of SNV-contaminated items.

Lisa LaGoo

Further Reading

Casil, Amy Sterling. *Hantavirus*. New York: Rosen, 2005.

Fleming, Diane O., and Debra Long Hunt. *Biological Safety: Principles and Practices*. Washington, D.C.: ASM Press, 2000.

Schmaljohn, Connie S., and Stuart T. Nichol. *Hantaviruses*. New York: Springer, 2001.

See also: Centers for Disease Control and Prevention; Crime scene protective gear; Epidemiology; Hemorrhagic fevers; Nipah virus; Pathogen genomic sequencing; Pathogen transmission; Smallpox; Tularemia; Viral biology.

Harrison Narcotic Drug Act of 1914

Date: Enacted on December 14, 1914

The Law: Federal legislation that required producers, importers, and distributors of opium and cocaine products to register and pay special taxes.

Significance: The Harrison Narcotic Drug Act was the first federal legislation in the United States to regulate the importation and distribution of opium, cocaine, and products derived from them and to impose criminal penalties for noncompliance. It marked a radical change in public policy and the official beginning of the domestic war on drugs.

The Harrison Narcotic Drug Act (also known as the Harrison Narcotics Tax Act) of 1914 mandated that anyone importing or distributing opium or other narcotic drugs (including cocaine, which was erroneously labeled a narcotic in the act) in the United States register with the Internal Revenue Service (IRS) and pay a tax of $1 per year. In addition, transfers of drugs covered by the act, whether by sale, barter, exchange, or gift, could be done only by written order on forms designed by the IRS. Exceptions were made for physicians, dentists, and veterinarians, who could distribute to patients in their presence, but even they had to maintain records that were subject to government scrutiny; each such record of a drug transfer had to include the receiving person's name and address and the amount of the drug given. The penalties for violation of the law were a fine of two thousand dollars and imprisonment of not more than five years.

A confluence of factors, both international and domestic, led to the adoption of the Harrison Act. Abroad, at the beginning of the twentieth century, the United States took governance of the Philippine Islands, where the Spanish government had previously supplied narcotics addicts with drugs. Also, Britain was selling Indian opium in China for silver bullion, which traders argued could better be spent on American goods; at the same time, American missionaries in China were publicizing the deleterious effects of opium consumption there. In 1912, under the auspices of the United States, the first international agreement limiting the sale of opium was signed.

At home, other issues surfaced. Among these were a growing recognition of the undesirability of opium addiction and increasing opposition to the widespread consumption of unregulated patent medicines that contained opiates and cocaine. Another issue was racism, manifested primarily against Chinese immigrants and African Americans, coupled with elitist attempts to protect lower-class morality, although addiction crossed all economic, racial, and social lines. Although lobbying both for and against the Harrison Act—by pharmacists, physicians, producers of patent medicines, and reformers—was intense, President Woodrow Wilson signed the compromise bill into law in December, 1914.

The act came under immediate attack as to its constitutionality. Opponents of the act argued that if it had truly been a revenue measure, its enactment would have been a proper exercise of the taxing power of Congress; however, they asserted, the act was really intended to suppress drugs and addiction, so it was an exercise of police power, which is within the province of the states. Courts split on the law's intent, but in *United States v. Jin Fuey Moy* (1916), the U.S. Supreme Court upheld the constitutionality of the legislation.

Susan Coleman

Further Reading

"The Harrison Narcotic Act." *Virginia Law Review* 6 (April, 1920): 534-540.

Musto, David F. *The American Disease: Origins of Narcotic Control*. 3d ed. New York: Oxford University Press, 1999.

Musto, David F., and Pamela Korsmeyer. *The Quest for Drug Control: Politics and Federal Policy in a Period of Increasing Substance Abuse, 1963-1981*. New Haven, Conn.: Yale University Press, 2002.

See also: Club drugs; Controlled Substances Act of 1970; Drug abuse and dependence; Drug classification; Drug confirmation tests; Drug Enforcement Administration, U.S.; Illicit substances; Meth labs; Narcotics; Opioids.

Hemorrhagic fevers

Definition: Viral diseases characterized by sudden onset, fever, aching, and bleeding in internal organs.

Significance: Because some hemorrhagic fevers can cause high rates of morbidity and mortality and are easily transmitted, the viruses that cause these diseases have great potential to be used as biological weapons. Given increasing attention to international terrorism, forensic scientists have focused awareness on the pathology and symptoms of such potential threats.

Hemorrhagic fevers, which are often transmitted by insects and rodents, are relatively rare. Symptoms of hemorrhagic fevers can progress in a few hours, and although some hemorrhagic fever viruses cause relatively mild symptoms that improve in a short period, others cause life-threatening disease. Initial signs and symptoms of infection are vague and include fever, fatigue, dizziness, muscle aches, weakness, and exhaustion. As the disease progresses, bleeding becomes pronounced and leads to shock, coma, seizures, and organ failure. Treatment for hemorrhagic fevers includes isolation of infected persons; those who care for infected persons must wear protective clothing (gowns, gloves, and face masks), and all items used by infected persons must be sterilized.

Four families of viruses are associated with hemorrhagic fevers. Viruses of the family Arenaviridae (known as arenaviruses) cause Argentine, Bolivian, and Venezuelan hemorrhagic fevers as well as Lassa fever and Sabiaassociated hemorrhagic fever. Viruses of the family Filoviridae (filoviruses) cause Ebola and Marburg hemorrhagic fevers. Those of the family Buyaviridae (bunyaviruses) cause Crimean-Congo hemorrhagic fever, hantavirus pulmonary syndrome, and Rift Valley fever. Viruses of the family Flaviviridae (flaviviruses) cause Dengue and Omsk hemorrhagic fevers, Kyasanur Forest disease, and yellow fever.

Hemorrhagic fevers can be spread by the bites of infected insects, such as mosquitoes and ticks, by human contact with body secretions of infected rodents, and from person to person through body fluid contact. Humans can also become infected when they care for or slaughter animals that have been exposed. The viruses that cause hemorrhagic fevers and diseases occur worldwide, but in industrialized countries the chance of contracting hemorrhagic fevers or diseases is low because the viruses usually reside in remote areas, and individual viruses are spread by specific hosts that live in specific geographic areas.

Of the diseases caused by these viruses, vaccines have been developed only for yellow fever and Argentine hemorrhagic fever. Because of the possibly fatal nature of many hemorrhagic diseases, plans for the prevention of these diseases and for the control of their spread when outbreaks do occur can be important to the survival of a population. The precautions recommended by public health authorities in the United States include eradicating rodent and insect infestations, screening for early signs of disease, and educating the public about how such diseases are spread and the means that can be used to control their spread. In addition, cases of hemorrhagic disease should be reported to local and state health departments so that speedy action can be taken to secure the public safety and minimize exposure. Because of the potential for hemorrhagic fever viruses to be used as bioweapons, scientists are devoting a great deal of time and effort to the investigation of the origins and behaviors of these viruses.

Sharon W. Stark

Further Reading

Breeze, Roger G., Bruce Budowle, and Steven E. Schutzer, eds. *Microbial Forensics*. Burlington, Mass.: Elsevier Academic Press, 2005.

Close, William T. *Ebola: Through the Eyes of the People*. Marbleton, Wyo.: Meadowlark Springs, 2002.

Cormican, Martin G., and Michael A. Pfaller. "Molecular Pathology of Infectious Diseases." In *Clinical Diagnosis and Management by Laboratory Methods*, edited by John Bernard Henry. 20th ed. Philadelphia: W. B. Saunders, 2001.

Zubay, Geoffrey L. *Agents of Bioterrorism: Pathogens and Their Weaponization*. New York: Columbia University Press, 2005.

See also: Biological warfare diagnosis; Biological weapon identification; Biotoxins; Bubonic plague; Centers for Disease Control and Prevention; Ebola virus; Hantavirus; Nipah virus; Petechial hemorrhage; Viral biology.

Hesitation wounds and suicide

Definition: Tentative, superficial, self-inflicted wounds made before the final wounds that cause death by suicide.

Significance: The presence of hesitation wounds made before fatal wounds were inflicted nearly always indicates death by suicide as opposed to death from another source, such as accident or homicide. Not all deaths from suicide involve hesitation wounds, however.

The superficial, self-inflicted hesitation wounds sometimes seen in cases of death by suicide are usually found in the wrists or neck, although sometimes they may be found at the elbow or near the heart. These wounds may appear as cuts, stabs, or punctures. They are most often found near or at the same site of the wound that actually caused death and may appear as rough, jagged wounds that are more superficial than the fatal wound. They often appear tentative and uneven, as the person may have been trembling or may have had difficulty holding the weapon and inflicting the wounds with any strength because of shaking hands. These wounds occur when a person is getting up the courage to self-inflict a wound with enough damage to cause death, as it takes more effort than is generally thought to cause a deadly wound.

A forensic pathologist examines wounds in any death that appears to be a suicide but could potentially be a homicide. In such a case, the pathologist looks for evidence that the wounds were self-inflicted. As with any wounds, the angles and directions of the injuries are helpful in determining whether the injuries were self-inflicted. Self-inflicted wounds have a distinctive downward direction that results from the angle of the arm in relationship to the body as the wounds are inflicted. Hesitation wounds also have these distinctive patterns, often mimicking the final wound.

Hesitation wounds are commonly caused by the same instruments often used in suicides. They include objects generally found around the home, including knives (kitchen, garden, or pocket), razors, hatchets or axes, and screwdrivers.

The term "hesitation wounds" also applies to wounds that are self-inflicted in suicide attempts in which death does not actually occur. These types of wounds are also tentative, shallow, and superficial, and they occur near the places on the body where a suicidal person might attempt to inflict a fatal wound, such as the wrists or neck. These wounds sometimes are present when a person does not actually intend to commit suicide, in which case they should be viewed as a cry for help, or when a person does intend to commit suicide but the pain or injury caused by the hesitation wounds is too great to continue.

Marianne M. Madsen

Further Reading

Picton, Bernard. *Murder, Suicide, or Accident: The Forensic Pathologist at Work*. London: Hale, 1971.

Shkrum, Michael J., and David A. Ramsay. *Forensic Pathology of Trauma: Common Problems for the Pathologist*. Totowa, N.J.: Humana Press, 2007.

Williams, Mark. *Suicide and Attempted Suicide*. 2d rev. ed. New York: Penguin Books, 2002.

See also: Autopsies; Knife wounds; Psychological autopsy; Puncture wounds; Suicide.

High-performance liquid chromatography

Definition: Technique used in the separation, detection, and identification of the pure compounds that are present in a mixture.

Significance: Forensic scientists can use high-performance liquid chromatography to determine the identity of an unknown substance or to establish a match between two different samples. The technique is particularly useful in forensic analysis of drugs.

Analysis by high-performance liquid chromatography (HPLC) begins with the injection of a liquid sample onto a chromatography column. The sample is then carried through the column by a high-pressure liquid solvent commonly referred to as the mobile phase. Because the individual pure compounds that are present in the sample have different chemical or physical properties, they travel through the column at different rates and exit the column at different times. Typically, the compounds are detected through the measurement of the absorption of a specific wavelength of ultraviolet light. However, the use of a diode array detector allows simultaneous measurement of absorption across the entire ultraviolet and visible spectra and thus is particularly useful for identification of unknown compounds.

An HPLC instrument, which consists of the injector, pump, column, and detector, consumes relatively large amounts of solvents. For this reason, HPLC is generally not a field-portable technique, so samples to be analyzed by HPLC must be carefully collected and handled prior to analysis. The analysis itself typically requires less than one hour, but often a good deal of sample preparation and method optimization must

High-performance liquid chromatography equipment (left to right): a pumping device for generating a gradient of two different solvents, a steel-enforced column, and an apparatus for measuring absorbance. *(Kjaergaard)*

be done before the sample can be injected. The process must be conducted by a knowledgeable and experienced forensic chemist.

HPLC is particularly useful for the identification of drugs because of its ability to detect a small amount of a specific chemical substance in a mixture of many other substances. It is thus useful in detecting small amounts of drugs in blood or urine. Because HPLC can also identify and quantify the other substances in the mixture, it is useful in establishing a match between two different samples. For example, HPLC can be used not only to identify a drug definitively but also to identify impurities that may link that drug to a specific laboratory.

David A. Rusak

Further Reading

Bell, Suzanne. *Forensic Chemistry*. Upper Saddle River, N.J.: Pearson Prentice Hall, 2006.

Houck, Max M., and Jay A. Siegel. *Fundamentals of Forensic Science*. Burlington, Mass.: Elsevier Academic Press, 2006.

Skoog, Douglas A., F. James Holler, and Stanley R. Crouch. *Principles of Instrumental Analysis*. 6th ed. Belmont, Calif.: Thomson Brooks/Cole, 2007.

See also: Analytical instrumentation; Barbiturates; Chromatography; Column chromatography; Drug confirmation tests; Forensic toxicology; Mass spectrometry; Quantitative and qualitative analysis of chemicals; Toxicological analysis; Ultraviolet spectrophotometry.

Hit-and-run vehicle offenses

Definition: Situations in which the operators of motor vehicles cause damage to other people or property with their vehicles and flee the scenes.

Significance: Hit-and-run vehicle offenses encompass a wide variety of situations, from incidents in which only minor damage occurs to cases involving serious injuries or deaths. What all hit-and-run offenses have in common is that the operators of the vehicles that caused the damage flee the scenes. Law-enforcement investigators must thus determine not only what happened at these scenes but also the identities of the vehicles and their operators responsible for the damage.

Hit-and-run vehicle offenses are extremely serious. Leaving the scene of an accident is punishable by law, even if the accident is only minor. Fleeing the scene of an accident that involves injury to another party is an even more serious offense. In many U.S. states, it is a felony for any driver involved in a motor vehicle accident in which injuries occurred to leave the scene before law-enforcement authorities arrive. Investigations of hit-and-run offenses are often complicated by the fact that police need to determine not only which vehicle caused the damage but also which individual was driving the vehicle at that time. Investigators also need to determine whether a hit-and-run incident was in fact an accident or if the responsible driver had malicious intent.

The Crime Scene

When investigators are called to the scene of a hit-and-run incident, the first thing they must do is secure the area. Much of the evidence that can be gathered from the scene of a vehicle accident is fragile and can be easily disturbed. Investigators use a variety of different methods to record the evidence the scene provides. The placement of vehicles and injured individuals may be marked with chalk, outlined, sketched, or photographed. Distances are measured so that forensic scientists can make determinations regarding the speeds and traveling directions of the vehicles involved. Witnesses are sought out and interviewed.

The purposes of investigating the scene of a hit-and-run incident are to determine what occurred during the incident, to collect information about any factors that were likely involved in causing it (such as possible driver distractions or bad road conditions), and to gather clues to the identities of the responsible vehicle and its driver. Evidence at the scene such as skid marks and tire tread marks can help investigators determine whether the driver of the responsible vehicle braked before impact and tried to take evasive action or maintained speed or even sped up. This kind of information can be important, as it may indicate whether the damage was caused on purpose.

Identifying the Vehicle and Driver

The major challenge in the investigation of a hit-and-run incident is that of identifying the vehicle involved and its driver. Investigators at the scene not only collect evidence present at the scene but also alert other members of law enforcement in the area to look out for any vehicles with damage that could have been caused by the incident. Investigators may also call automotive body shops and insurance companies to find out if repairs have been done or claims have been filed on any vehicles matching the description of the one believed to be involved. After a significant collision, investigators may even call area hospitals and clinics to see if anyone has received treatment for injuries similar to those believed to have been caused by the accident.

Investigators use the information collected at the scene to determine the make and model of the vehicle involved and to identify the driver. They question witnesses to try to gain information about the sex, hair color, age, and other attributes of the driver and any passengers as well as information about the vehicle. Physical evidence gathered at the scene—such as paint chipped or scraped off the vehicle, leaked fluids, tire markings, and broken glass from headlights, turn signals, or windows—is also examined in the effort to identify the vehicle involved. Even very small amounts of paint left on an object after a collision can help investigators determine the color of the vehicle involved, and by comparing the chemical properties of the paint against extensive databases of information on the paints used by different vehicle manufacturers, forensic scientists can help narrow the search further.

After investigators have found the particular vehicle involved in a hit-and-run incident, they must determine who was driving the vehicle and whether that person caused the injury or property damage accidentally or deliberately. Although in many cases the identity of the driver may be straightforward—such as when no one but the owner of the vehicle ever drives it—in other cases this issue can become complicated. The owner of the vehicle may claim that it had been stolen, for example, or that it had been borrowed by a friend or relative. In such cases, investigators must use the evidence gathered from eyewitnesses combined with other traditional investigative techniques, such as checking alibis, to determine the identity of the driver.

After both the vehicle and the driver have been identified, the question of intent remains. If the crime scene reveals evidence, such as skid marks, indicating hard braking and evasive action, the event may be ruled an accident. When no such evidence exists, however, the matter of the driver's intent may be much less clear. The driver may claim that he or she was distracted and so did not notice the person or property that was damaged in time to take evasive action. In such a case, investigators must research any possible motives the driver may have had to harm the victim, connections between the victim and the driver, and other information to arrive at the truth.

Helen Davidson

Further Reading

Burke, Michael P. *Forensic Medical Investigation of Motor Vehicle Incidents*. Boca Raton, Fla.: CRC Press, 2007. Addresses many different aspects of forensic accident investigation. Includes a variety of accident scenarios and more than one hundred photographs.

Fish, Jacqueline T., Larry S. Miller, and Michael C. Braswell. *Crime Scene Investigation: An Introduction*. Newark, N.J.: LexisNexis/Anderson, 2007. Provides an introduction to the basics of crime scene investigation, including securing the scene and documenting the evidence. Offers specific information on techniques as they apply to a variety of types of crimes.

Robins, Patrick J. *Eyewitness Reliability in Motor Vehicle Accident Reconstruction and Litigation*. Tucson, Ariz.: Lawyers & Judges Publishing, 2001. Discusses the uses and limitations of eyewitness accounts of motor vehicle accidents, including information on the legal implications of eyewitness evidence.

Sullivan, Wilson T. *Crime Scene Analysis: Practical Procedures and Techniques*. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007. Comprehensive text presents basic introductions to a variety of techniques used in crime scene investigation. Includes review questions for each chapter.

Van Kirk, Donald, J. *Vehicular Accident Investigation and Reconstruction*. Boca Raton, Fla.: CRC Press, 2001. Covers all aspects of accident investigation, using interesting real-life cases to illustrate central points.

See also: Accident investigation and reconstruction; Crime scene documentation; Crime scene investigation; Crime scene measurement; Crime scene sketching and diagramming; Glass; Paint; Trace and transfer evidence.

Hitler diaries hoax

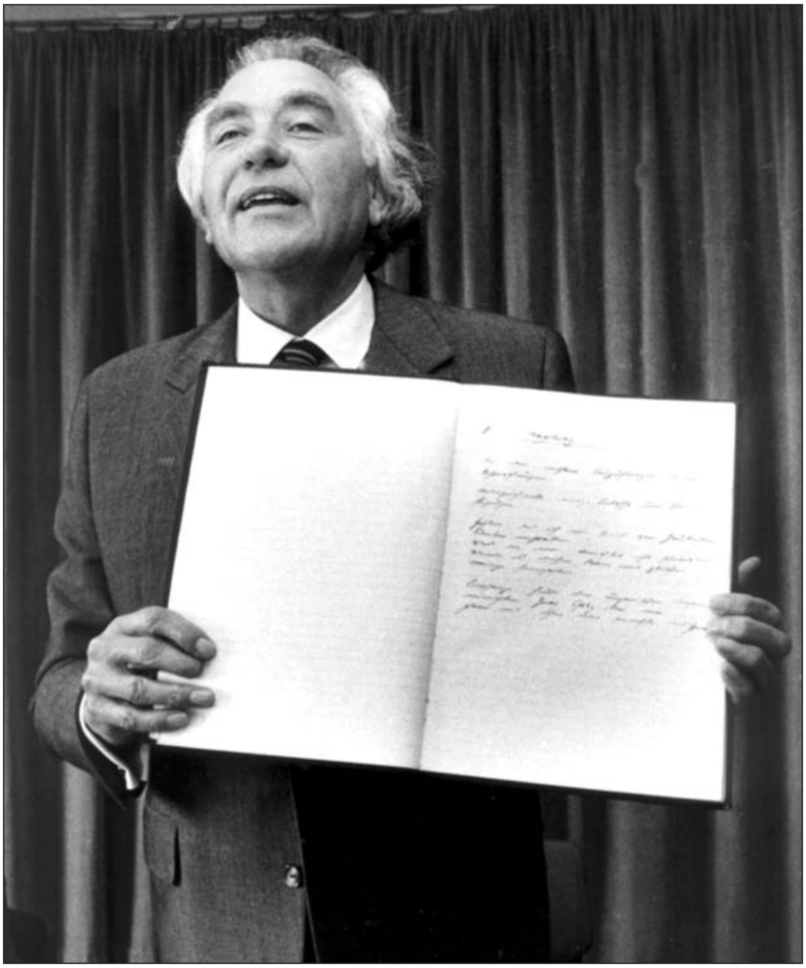
Date: Planned publication announced in April, 1983

The Event: A major German newsmagazine's announcement that it was about to publish voluminous and previously unknown diaries written by Nazi chancellor Adolf Hitler (1889-1945) stunned the world. Several distinguished historians initially endorsed the authenticity of the diaries, but the documents were soon shown to be fakes, and the credibility of German journalism was badly shaken.

Significance: The Hitler diaries constituted perhaps the most significant forgery fraud ever perpetrated. The forensic techniques used to prove they were fakes involved several tests that have become standard methods of authenticating historical documents.

According to the backstory invented by Konrad Paul Kujau, the East German man who faked them, the diaries were among other Hitler documents being flown out of Berlin in early 1945 in a plane that was shot down over Bornersdorf, near Dresden. After being rescued from the crashed plane, the diaries remained hidden for many years and were later smuggled into West Germany, where collecting Nazi-era memorabilia was illegal. The story had a certain plausibility because it was known that a plane carrying Hitler's papers did indeed leave Berlin and crash in Bornersdorf. The fact that collecting Nazi memorabilia was illegal made it easier for Kujau to sell his forgeries without attracting public attention.

Born in 1938, Kujau grew up in communist-ruled East Germany, where he later held a series of low-paying jobs, committed petty crimes, and pulled off a series of small forgeries. He also developed an interest in outlawed Nazi-era collectibles and began selling some genuine pieces along with forged items that he manufactured. His forgeries included a handwritten copy of Hitler's manifesto *Mein Kampf* (1925) as well as poems and paintings that he attributed to Hitler. After succeeding with these forgeries during the late 1970's, Kujau undertook a much more ambitious forgery: completely fabricated diaries supposedly written in Hitler's own hand. To account for their existence, he invented the story about their being saved from the Bornersdorf plane crash in 1945.



Hans Booms, the head of West Germany's federal archives in 1983, holds up a copy of one of the diaries alleged to have been written by Adolf Hitler as he announces that the works have been determined to be forgeries. *(AP/Wide World Photos)*

Kujau's initially secret scheme started to come to light when one of his customers, a collector of Nazi memorabilia named Fritz Stiefel, bought one of the forged diary volumes, thinking it authentic. In 1979, Stiefel showed his collection to Gerd Heidemann, another collector who was also a reporter for the popular West German magazine *Der Stern*. Amazed by Stiefel's collection, Heidemann spent a great deal of time trying to verify the story of the crashed plane and the diaries.

In April, 1983, *Der Stern* publicly announced that it had purchased sixty-two volumes of Hitler's diaries, covering the years 1932 to 1945—a period encompassing the years when Hitler was Germany's chancellor. The magazine's purchase price was equivalent to about 4.5 million U.S. dollars—a huge sum at the time. Initially, both historians and collectors of war memorabilia were excited by *Der Stern*'s announcement. The diaries were considered an amazing discovery because Hitler had not been known to have written much about himself. The diaries were thus expected to fill important gaps in the historical record about both Hitler's life and World War II.

A prominent British scholar of Hitler, Hugh Trevor-Roper, initially stated that the diaries were authentic but backed away from that judgment as the murky circumstances surrounding the diaries' recovery and purchase came to light. After the diaries were subjected to the professional scrutiny that is standard in the authentication of historical documents, it became obvious that they were fakes.

The Application of Forensic Science

To establish the authenticity of the Hitler diaries, experts examined the documents from several perspectives. Three primary kinds of tests were made. First, the content of the diaries was checked for consistency with what was already known about Hitler's life and the historical events in which he was involved. Historians familiar with Hitler and World War II were able to establish with great certainty that the diaries were faked because they contained many significant historical inaccuracies.

The second kind of testing was done by document analysts who examined the physical paper and ink used in the diaries to determine if they were consistent with the writing materials available to Hitler at the time he supposedly wrote the diaries. Chemical tests found that both the paper and the ink used in the diaries were of post-World War II manufacture. Those tests alone proved that the diaries could not be authentic.

Finally, the handwriting in the documents was examined to determine if it matched authenticated samples of Hitler's writing. Handwriting experts concluded that it did not. They noted, for example, that strokes in the diaries' words were not as boldly written as those in Hitler's known writings and that the ends of sentences in the diaries did not fall off as they did in Hitler's authenticated writings.

After the diaries were proven to be fakes, Heidemann, Kujau, and Kujau's wife, Edith Lieblang, were prosecuted for fraud. Their trial centered less on the question of the whether the diaries were fakes—it was a given that they were—than on the issue of who was responsible for perpetrating the fraud. At trial, Kujau never denied that he had forged the diaries. He did, however, deny that he acted alone in defrauding *Der Stern*. He maintained that the magazine's reporter, Heidemann, had been aware that the diaries were forgeries from the beginning. In the end, all three defendants were found guilty. Kujau and Heidemann were sentenced to four years in prison; Lieblang was sentenced to probation. Meanwhile, the credibility of *Der Stern* and German journalism generally was badly damaged, and an air of greater skepticism would greet future discoveries of sensational manuscripts.

Ayn Embar-Seddon and Allan D. Pass

Further Reading

Brayer, Ruth. *Detecting Forgery in Fraud Investigations: The Insider's Guide*. New York: ASIS International, 2000. Designed for readers with some background in the area of forgery, this introduction to how forged documents are examined discusses how to find forensic document examiners and how to deal with legal issues in court. Clearly outlines how forgery and fraud examinations are conducted in the field.

Hamilton, Charles. *The Hitler Diaries: Fakes That Fooled the World*. Lexington: University Press of Kentucky, 1991. Provides an interesting overview of the facts surrounding the diary fraud and focuses on handwriting analysis. Written for a general audience.

Harris, Robert. *Selling Hitler*. New York: Pantheon Books, 1986. Centers on the controversial revisionist historian David Irving and how he spoke out against the diaries from the very beginning, stating that they were fakes. Provides detailed information about the people involved in the hoax. Written for a general audience.

Innes, Brian. *Fakes and Forgeries: The True Crime Stories of History's Greatest Deceptions—The Criminals, the Scams, and the Victims*. Pleasantville, N.Y.: Reader's Digest Association, 2005. Offers a broad discussion of many types of forgeries and covers a variety of scientific techniques used to detect them in many fields. Includes numerous photographs and art reproductions.

Nickell, Joe. *Detecting Forgery: Forensic Investigation of Documents*. 1996. Reprint. Lexington: University Press of Kentucky, 2005. Excellent introduction to the topic approaches forgery from an investigative perspective. Presents the technical aspects of analyzing documents while discussing several famous forgery cases, including Howard Hughes's will.

See also: Document examination; Forensic linguistics and stylistics; Forgery; Handwriting analysis; Holocaust investigation; Hughes will hoax; Paper; Questioned document analysis; Writing instrument analysis.

Holland v. United States

Date: Ruling issued on December 6, 1954

Court: U.S. Supreme Court

Significance: In *Holland v. United States*, the U.S. Supreme Court upheld the use of circumstantial evidence as a basis for conviction in a criminal case. Specifically, the Court upheld the use of the "net worth method of proof" as a basis for convicting the defendants under the Internal Revenue Code.

In the case that led eventually to the U.S. Supreme Court's decision in *Holland v. United States*, the defendants were convicted of willfully attempting to defeat and evade income taxes, and the U.S. Court of Appeals for the Tenth Circuit affirmed the conviction. On appeal, the Supreme Court held that where the government introduced proof of a likely source of taxable income from which a jury could reasonably find that net worth increases came from, the government's failure to negate all possible nontaxable sources as the source of the increase of the alleged net worth was not fatal to a conviction.

The net worth method of proof is based on the assumption that an individual's assets derive from a taxable source of income. If this is not the case, then the taxpayer should be able to explain the discrepancy between the assets and the reported income. Courts have expressed discomfort over the use of this method of proof in criminal cases because it may be taken to imply guilt and apparently violates a tenet of criminal law, which is that the prosecution is required to prove guilt beyond a reasonable doubt.

The Supreme Court explained that in a typical net worth prosecution, the government concludes that the taxpayer's records are inadequate as a basis for determining income tax liability. It then attempts to establish an "opening net worth" or total net value of the taxpayer's assets at the beginning of a given year. It then proves the increases in the taxpayer's net worth for each succeeding year during the period under examination and calculates the difference between the adjusted net values of the taxpayer's assets at the beginning and end of each of the years involved. The taxpayer's nondeductible expenditures, such as living expenses, are added to these increases. If the resulting figure for any year is substantially greater than the taxable income reported by the taxpayer for that year, the government claims that the excess represents unreported taxable income.

The Supreme Court approved the use of the net worth method in *United States v. Johnson* (1943), but only as a last resort for the government. In *Holland*, the Court noted that the government now uses the net worth method evolved at the first opportunity even in ordinary tax cases. Although the net worth system had inherent dangers, the Supreme Court did not find reason to prevent its use, saying instead that it should be used with great care and restraint. The Court cautioned trial courts to approach each case of this type knowing that the taxpayer "may be ensnared in a system which, though difficult for the prosecution to utilize, is equally hard for the defendant to refute." Appellate courts were told to review the cases, bearing in mind the difficulties that arise when circumstantial evidence as to guilt is the chief weapon of a method that is itself only an approximation.

In *Holland*, the Supreme Court found that the government had applied the net worth method properly. The Court also emphasized that the government must still prove every element of the offense beyond a reasonable doubt, although not to a mathematical certainty. In this case, evidence existed of a consistent pattern of underreporting large amounts of income and of failure on the petitioners' part to include all of their income in their books and records. Because the jurors could have found that these acts supported an inference of willfulness, the Court ruled, their verdict must stand.

Dante B. Gatmaytan

Further Reading

Comisky, Ian M. "The Likely Source: An Unexplored Weakness in the Net Worth Method of Proof." *University of Miami Law Review* 36, no. 1 (1981): 1-40.

U.S. Internal Revenue Service. *Financial Investigations: A Financial Approach to Detecting and Resolving Crimes*. Washington, D.C.: Government Printing Office, 1993.

See also: Direct versus circumstantial evidence; Federal Rules of Evidence; Forensic accounting.

Holocaust investigation

Date: Began in 1945

The Event: The Holocaust is the name given to the programmed genocide of some six million Jews by the German government during World War II. Instruments of the Holocaust included forced marches, ghettoization, deliberate starvation, beatings, concentration camps, and random and systematic murder.

Significance: The Holocaust is a watershed in human history, marking a time when a civilized nation deliberately and systematically undertook the destruction of a specific people. The ultimate goal of the Nazis was to eliminate Jews from all of Europe, or at least all of the territory occupied by the Nazis during World War II. It has been estimated that six million Jews, along with hundreds of thousands of other "undesirables," were murdered during this period of genocide; some estimates place the death toll as high as eleven million. Following the war, forensic scientists were involved in efforts to bring the perpetrators of the Holocaust to justice and to identify as many of their victims as possible.

The Holocaust was proposed, planned, and undertaken by German chancellor Adolf Hitler and other members of the Nazi Party (National Socialist German Workers' Party) hierarchy as part of the so-called final solution to the "Jewish question." Hitler proposed the need for a "solution" to the Jewish problem early in his political career. Following his military successes in the early years of World War II, he and high-ranking members of the Nazi leadership met to determine the fate of European Jews. Heinrich Himmler, commander of the Schutzstaffel (SS), and SS lieutenant general Reinhard Heydrich were appointed architects of the "final solution," a program that sought the elimination of all of the Jews of Europe.

Under their direction, the Holocaust began almost immediately in Germany and in German-occupied Poland. Jews were rounded up and forced to live in ghettos; many were beaten, tortured, and starved to death. The genocide program expanded to include groups such as homosexuals, Roma (Gypsies), political opponents, and prisoners of war. As Germany's military conquests extended into Eastern Europe and Russia, special squads called *Einsatzgruppen* entered each newly conquered town to round up all ethnic Jews along with other "undesirables." At first, the prisoners were either immediately shot or taken on forced marches to isolated areas where they were all shot and buried in mass graves.

Although hundreds of thousands were killed in this way, it proved too slow and cumbersome for the Nazi leadership, and a more efficient method of mass murder was sought and found in concentration camps, which could handle thousands of prisoners at a time. Jews from all over Europe, including the newly occupied countries of France, Belgium, and Holland, were transported to concentration camps in special freight trains to work as slaves or to be destroyed en masse.

The shootings and burials could not keep pace with the huge numbers arriving in the camps daily, and the Nazis began to consider alternative methods of mass murder. Preliminary experiments suggested that poison gas could provide the mechanism for mass killing. The effectiveness of poison gas was first tested in vans, but the numbers that could be killed at one time were too small. To counter this problem, the Nazis built large gas chambers that could hold hundreds of people at a time at major concentration camps such as Auschwitz and Treblinka. These proved deadly efficient for their intended purpose, gassing thousands every day. The dead were placed in crematoriums, and the remains were buried in nearby fields or in pits dug especially for disposal.

As the tide of war turned against them, the Nazis tried to conceal the evidence of the Holocaust and its victims. In some areas they were able to dismantle and destroy a number of concentration camps before Allied forces arrived. They also excavated many mass graves, cremated the remains, and either reburied the ashes or scattered them.

Forensic Investigation

Forensic scientists began to investigate the facts of the Holocaust immediately after the war. They faced two primary tasks: first, to prove that Holocaust victims were murdered using poison gas, and, second, to attempt to identify victims based on the meager remains. Beginning in 1945, the International Military Tribunal conducted the postwar investigation of the crimes committed in the concentration camps and other mass killings that became known as the Holocaust. The investigation focused on the remains found in the gas chambers at the concentration camps that had been captured intact by the Allies. In spite of the Nazi authorities' strict secrecy regarding their genocidal activities, the investigators were able to gather from survivors detailed testimonies of gassings and other atrocities. German officials countered the witnesses by claiming that the gas chambers were used only for delousing prisoners.

At Auschwitz, forensic toxicology tests conducted in the gas chambers and on the remains determined that hydrogen cyanide (Zyklon B) was most likely used to murder the prisoners, but this conclusion was again challenged because cyanide was also the gas used for delousing clothing. Further forensic analysis performed by the Institute for Forensic Research in Kraków, Poland, in 1945 detected the presence of Prussian blue, a derivative of hydrogen cyanide, in the gas chambers; this was consistent with the probable use of the gas as a weapon of mass murder. Traces of Prussian blue found in the hair of victims also helped confirm the use of poison gas.

The second task of the forensic scientists was to locate the remains of Holocaust victims and excavate them so that they could try to identify individuals using techniques such as forensic odontology and anthropometry. Identification proved almost impossible, however, as most of the remains were in the form of fragments that had been burned, buried, and reburied, often several times. In those instances where sufficient remains were found to allow examination of the teeth, identification through forensic odontology proved difficult, as any dental records that may once have existed for the victims had been destroyed during the war.

It is possible that modern forensic techniques, including DNA (deoxyribonucleic acid) analysis and other molecular-based techniques, may yet provide some degree of kinship identification of the sparse remains. For this reason, the Nazi extermination facilities at Auschwitz-Birkenau have been preserved in the hope that they may yet yield forensic evidence needed to provide additional useful information about both the victims of the Holocaust and their destruction.

Dwight G. Smith

Further Reading

Hoffman, Eva. *After Such Knowledge: Memory, History, and the Legacy of the Holocaust*. New York: PublicAffairs, 2004. Discusses the social, cultural, and political history and continuing impact of the Holocaust.

Pelt, Robert Jan van. *The Case for Auschwitz: Evidence from the Irving Trial*. Bloomington: Indiana University Press, 2002. Presents the findings of an exhaustive forensic examination of the evidence that Auschwitz was an extermination camp where gas chambers were used as instruments of mass killing.

Shermer, Michael, and Alex Grobman. *Denying History: Who Says the Holocaust Never Happened and Why Do They Say It?* Berkeley: University of California Press, 2000. Focuses on the reasons some people continue to assert that the Holocaust did not take place. Includes discussion of the evidence that shows the Nazis used gas chambers to commit mass murder.

See also: Anthropometry; Buried body locating; Chemical agents; Forensic anthropology; Forensic odontology; Genocide; Hitler diaries hoax; Mass graves; Skeletal analysis.

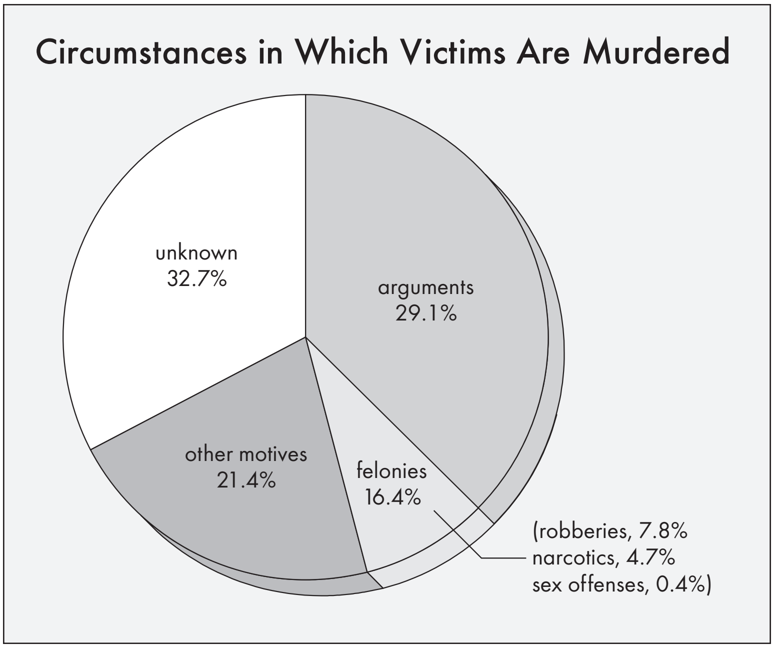
Homicide

Definition: Death of a human when caused by the act of another. Homicide includes both civil and criminal definitions, which vary according to the individual acts or intentions of the person acting.

Significance: The ability to identify and classify the nature of the deaths of human beings is an important part of civilized society. Unjustified deaths create social concern and can interfere with a society's growth or prosperity. The work of forensic scientists can help to explain unattended deaths and can aid in efforts to provide legal remedy for deaths where appropriate.

In the broadest terms, all deaths that are caused by persons other than the decedents are considered homicide, but not all may be criminal homicide. The major distinguishing factor between a criminal homicide and other kinds of homicide is the intent of the person who caused the death. Examples of noncriminal homicide include acts by soldiers during time of war, acts of the state in imposing and enforcing mandates, and deaths that occur within the strict law of excuse or justification.

In the United States, most unattended deaths are classified as homicide until such time as an investigation determines the cause and manner of death. An unattended death is one that occurs outside the treatment or supervision of a physician. In most instances, deaths



Source: Federal Bureau of Investigation, *Crime in the United States*. Figures reflect a total of 14,274 murders in the United States in 2002. Due to rounding of figures for unseen subcategories, percentages do not total 100.

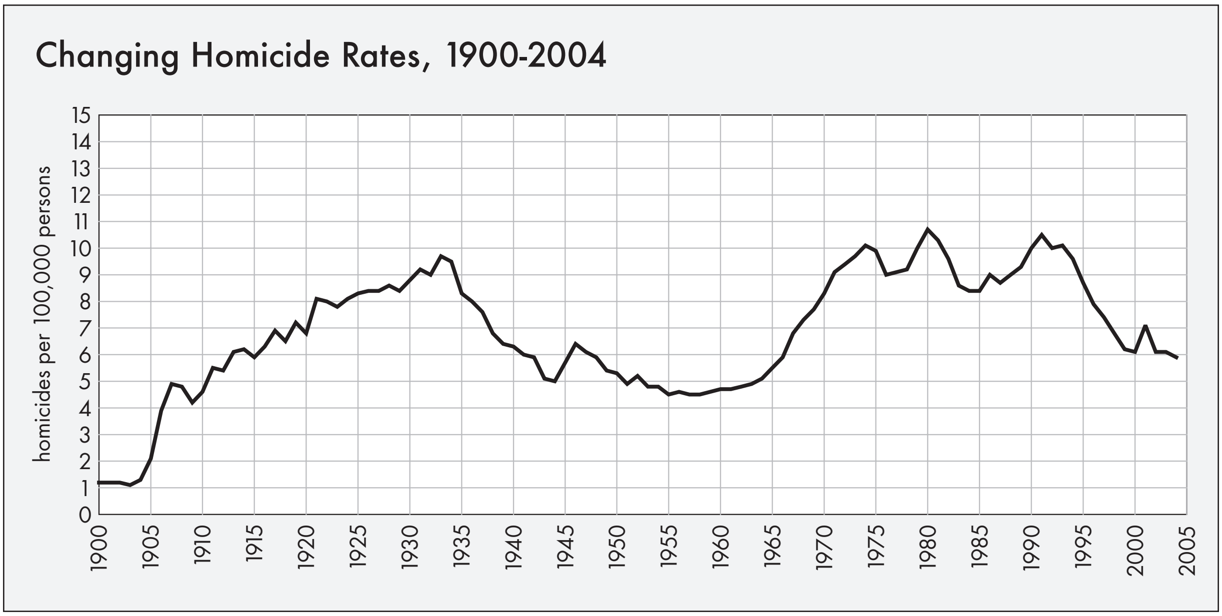
are categorized into four major types: accidental death, natural death, suicide, and murder.

Elements of Criminal Homicide

The crimes involving homicide require specific elements to be proven through the investigation and prosecution. The first group of crimes includes murder, which is commonly divided into two subcategories: first-degree murder and second-degree murder. First-degree murder (also known as aggravated murder in some jurisdictions) is committed by a person who knowingly causes the death of another person with deliberation and intent. The terms "premeditation" and "deliberation" are often applied in defining the highest level of murder. Premeditation is commonly defined as consideration or planning of an act beforehand. In the case of homicide, the premeditation is the mental element (*mens rea*) within which the perpetrator contemplates or gives forethought to the acts in question. This does not mean that a perpetrator must have a specific plan ahead of time; only mere moments of forethought need pass for the mental element to be met. The detail of proof is in the ability to show an intent to cause an act that has a planned result of death.

Second-degree murder occurs when a person knowingly causes the death of another without premeditation but with intent to act. In this subcategory the person commits the crime if he or she knowingly causes the death of another while committing a criminal act or when there is intent to act in a reckless or harmful manner. The major distinctions between first- and second-degree murder are the intent and the deliberation of the person causing the murder to actually cause the death. In second-degree murder the concentration is on the intent to act; the intent to cause the death is absent.

Criminal homicide may include the lesser crime of manslaughter, which is often divided between voluntary and involuntary manslaughter. Voluntary manslaughter arises when an intentional act is done without malice (malevolence) or premeditation and while in the heat of passion or on sudden provocation. Involuntary manslaughter arises from the failure to perform a legal duty expressly required to safeguard human life, from the commission of an unlawful act not amounting to a felony, or from the commission of a lawful act involving a risk of injury or death that is done in an unlawful, reckless, or grossly negligent manner.

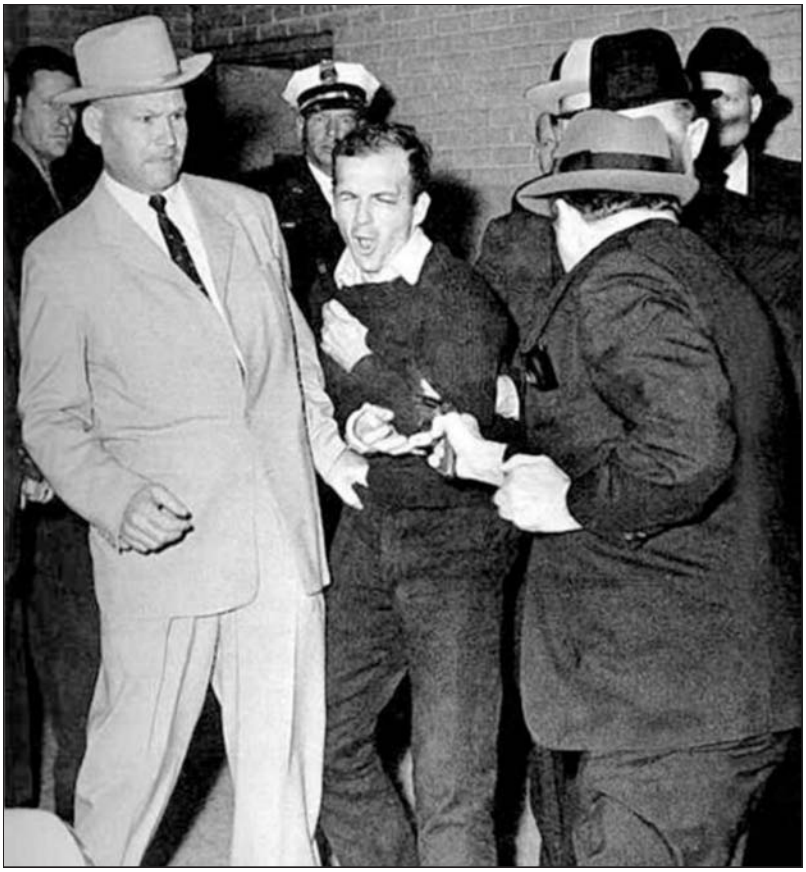


Source: U.S. Bureau of Justice Statistics, 2008. Note that the rate for the year 2001 includes nearly 3,000 victims of the September 11 terrorist attacks.

Investigation of Homicide

The investigation of death focuses primarily on the cause of death as well as on the underlying acts of the person who caused the death. Whether the matter is one of criminal or civil interest relies heavily on the evidence that proves aggravation or mitigation of the actions. In both instances the use of forensic evidence establishes the cause of death as well as the method or manner.

The methods of determining civil or criminal homicide include four primary areas of emphasis. The first of these is the scene investigation, and this may occur in both civil and criminal cases. The primary focus of the scene investigation is the identification, securing, and initial analysis of evidence. This may include preliminary determination of cause or nature of death as well as surrounding circumstances.



What may be the most famous example in history of instantaneous discovery of a homicide occurred in Dallas, Texas, on November 24, 1963—two days after President John F. Kennedy was assassinated in the same city. While Kennedy's suspected assassin, Lee Harvey Oswald (center), was being escorted by officers through the basement of the Dallas city jail, a local nightclub owner named Jack Ruby (right) stepped in front of Oswald and fired a pistol into his stomach in full view of police officers, reporters, photographers, and a live television audience. Oswald died shortly afterward. Ruby was eventually convicted of Oswald's murder and was sentenced to be executed. He managed to win a retrial but died in 1967 before a trial could take place. It is ironic that while there can be no uncertainty whatever about who shot Oswald, the question of who shot Kennedy is still unsettled in the minds of many. *(Library of Congress)*

The second area is crime scene pattern analysis, also known as crime scene reconstruction. In this phase the investigator or technician concentrates on the critical analysis of evidence in order to re-create the potential acts that led to the death in question. The nature and cause of the injury leading to death constitute an important part of this phase, as does the relationship or interaction between victim and perpetrator.

The third area is that of the forensic analysis, which may include both laboratory and nontechnical investigative techniques. Through the application of both scientific method and investigative technique, evidence related to the acts or issues in question is analyzed. This may include analysis of evidence from the scene, from a weapon or cause of injury, and from the victim through medical and scientific analysis.

The final area is the legal presentation of proof through evidence and ultimate application to the elements of the crime. In this stage the three investigative and forensic areas come together under the umbrella of law to draw conclusions about the nature and cause of death. In a criminal case the prosecution must prove the

Serial Offenders

Serial offending is generally defined as the commission of three or more separate but related crimes with "cooling off" periods between the acts. The most widely recognized form of serial crime is serial murder, but serial crimes may also involve rape, burglary, robbery, arson, or other offenses. Advances in serial crime investigation since the late 1970's have led to the closure of a number of otherwise unsolvable criminal cases. A significant factor in this success has been the use of the Federal Bureau of Investigation's National Center for the Analysis of Violent Crime (NCAVC), which provides a profiling program as well as research and development, training, and support services.

The generally accepted theory is that serial offenders are specifically motivated by a variety of psychological urges, which include compulsion, power issues, and sociopathic tendencies. Serial offenders compensate for perceived internal deficiencies by committing crimes, through which they gain a sense of potency, revenge, or other forms of gratification.

The modern approach to serial offenders places them into one of two distinct categories: organized (nonsocial) offenders or disorganized (asocial) offenders. Organized offenders often have above-average intelligence and a tendency toward methodical planning of their crimes. An example is Ted Bundy, who used a fake plaster cast on his arm to fool women into thinking he had an injury so that they would help him with loading groceries into his car. Organized offenders usually maintain a high level of control over their victims and are often knowledgeable in forensic science and investigative techniques.

Disorganized offenders are usually of relatively low intelligence and often act impulsively. Crimes committed by these offenders are often crimes of opportunity rather than the result of planning. These offenders may certainly know of their desire to commit crimes (thus they meet the requirement for the mental element of premeditation), but they do not always have particular targets selected or plans laid out; instead, they act spontaneously or impetuously.

The motives of serial offenders vary greatly, depending on the crimes and the characteristics of the perpetrators. Based on their motives, serial offenders have been classified into four categories: visionary (driven by hallucination or delusions), hedonistic (driven by the desire for personal pleasure), gain-oriented (driven by the desire for material gain), and power- or control-oriented (driven by the desire to gain and exert power over victims).

physical acts (*actus reus*) of the crime as well as the mental elements (*mens rea*).

Homicide and Forensic Science

The nature of homicide cases often determines the types of forensic investigation that may occur. Common questions to be answered during the homicide investigation include those regarding the time, manner, and nature of death. The discovery and identification of the victim may also involve a great deal of forensic science.

In some instances the discovery of the crime is almost instantaneous, as there may be witnesses to the actual acts. In other cases the discovery of the victim adds dramatically to the complexity of the investigation. Types of crime scene investigations vary greatly depending on the nature of the crimes as well as the conditions of the crime scenes.

Forensic science has contributed significantly to the investigation of homicide. Two broad areas of forensics help investigators to narrow the evidence and its application. The first of these encompasses the methods used to estimate time of death. Investigators and forensic experts can make relatively accurate predictions regarding time of death when they know several important factors, including the condition of the body, the type of location where the body was found, and the external factors related to the condition of the body.

The nature of the injury causing death is the second important area where forensic science contributes to homicide investigation. By defining the type of injury, the cause, and the potential effect it has on the human body, forensic scientists help determine potential suspects as well as reasons for the homicide.

Carl Franklin

Further Reading

Geberth, Vernon J. *Practical Homicide Investigation: Tactics, Procedures, and Forensic Techniques*. 4th ed. Boca Raton, Fla.: CRC Press, 2006. Text used in many U.S. police academies provides full coverage of all aspects of homicide investigations.

Hanzlick, Randy. *Death Investigation: Systems and Procedures*. Boca Raton, Fla.: CRC Press, 2007. Focuses on the investigation of deaths from a legal perspective. Includes information on the procedures followed by medical examiners and coroners in the United States.

Snow, Robert L. *Murder 101: Homicide and Its Investigation*. Westport, Conn.: Praeger, 2005. Seasoned homicide detective discusses all the steps taken in a murder investigation, using real-life cases as examples.

Snyder, LeMoyne. *Homicide Investigation: Practical Information for Coroners, Police Officers, and Other Investigators*. 3d ed. Springfield, Ill.: Charles C Thomas. 1977. Classic work intended for law-enforcement professionals presents comprehensive coverage of the topic.

See also: Ancient criminal cases and mysteries; Autopsies; Buried body locating; Chain of custody; Coroners; Crime scene documentation; Crime scene investigation; Crime scene reconstruction and staging; Criminalistics; Decomposition of bodies; Evidence processing; Forensic anthropology; Forensic archaeology; Ritual killing; Simpson murder trial.

Homogeneous enzyme immunoassay

Definition: Immunological test used to detect substances such as illicit drugs in bodily fluids.

Significance: Forensic scientists often use the homogeneous enzyme immunoassay process to screen samples of urine, plasma, or blood serum for the presence of illicit substances. This method has some distinct advantages over other assay methods: It is low in cost, requires only a small sample size, and is highly sensitive. In addition, automated instrumentation provides speed and precision.

Immunoassays combine biochemistry with the specific binding tendency of antibody to antigen to produce a measurable signal. Immunoassays may be heterogeneous or homogeneous. Heterogeneous immunoassay requires the additional step of separating bound and unbound components, whereas homogeneous immunoassay returns a measurement without separating the antigen and antibody. Enzyme assays use an enzyme-bound antibody to detect the antigen. The enzyme then signals with a color reaction when exposed to the substrate. Because the homogeneous assay is quicker and easier, it is often the test preferred by forensic scientists in cases involving drugs of abuse.

In response to an antigen, which is any substance the body considers as foreign, specific antibodies bind in lock-and-key fashion, forming a complex that awaits destruction by other components of the immune system. Immunoassays take advantage of this binding specificity. The analyte (that is, the substance being analyzed) may be either antibody or antigen. Analytes may be hormones (such as testosterone or cortisol), markers of cardiovascular damage (such as creatinine or myoglobin), hepatitis strains (such as hepatitis B), tumor markers (such as certain proteins), congenital infectious agents (such as rubella), or metabolics (such as folate or vitamin B_{12}). Examples of drugs of abuse that are amenable to homogeneous immunoassay are opiates, amphetamines, barbiturates, benzodiazepines, and cocaine metabolites. In addition to testing for drugs of abuse, immunoassays are useful in testing for therapeutic drug levels in the blood.

Typically, a toxicologist must use a screening process to determine the presence and identity of unknown drugs in a sample. A number of immunoassay screening techniques are suitable for this purpose. These include radioimmunoassay (RIA), enzyme-multiplied immunoassay technique (EMIT), enzyme-linked immunosor-

A research scientist runs immunoassays on a diagnostic machine manufactured by BD (formerly Becton Dickinson) in Franklin Lakes, New Jersey. *(AP/Wide World Photos)*

bent assay (ELISA), cloned enzyme donor immunoassay (CEDIA), and fluorescence polarization immunoassay (FPIA). Automated ELISA screening has largely replaced older immunoassay techniques such as RIA and EMIT.

Although immunoassays are cost-effective and quick screening tools, they may fall short in revealing the potency, amount, and time of use of any drug found to be present. Further, these tests may give false positives and in some cases lack specificity. In addition, cross-reactivity can occur when the chemical properties of legitimate pharmaceuticals resemble the chemical properties of illicit drugs. Immunoassays are most useful for discriminating between the presence and absence of suspected drugs, although improvements in detection equipment and increasingly sensitive labels are advancing the sensitivity of immunoassay systems, allowing for the accurate measurement of an ever-increasing range of analytes. Confirmation testing, however, may need to rely on gas chromatography-mass spectrometry (GC-MS) tests, which are both more accurate and more expensive than immunoassay tests.

Richard S. Spira

Further Reading

Jenkins, Amanda J., and Bruce A. Goldberger, eds. *On-Site Drug Testing*. Totowa, N.J.: Humana Press, 2002.

Mieczkowski, Tom, ed. *Drug Testing Technology: Assessment of Field Applications*. Boca Raton, Fla.: CRC Press, 1999.

Smith, Frederick P., ed. *Handbook of Forensic Drug Analysis*. Burlington, Mass.: Elsevier Academic Press, 2005.

See also: Barbiturates; Chromatography; Drug confirmation tests; Electrophoresis; Forensic toxicology; Illicit substances; Toxicological analysis.

Hostage negotiations

Definition: Law-enforcement attempts to resolve peacefully situations in which persons are holding others against their will in barricaded locations.

Significance: When lawbreakers endanger lives by taking hostages, law-enforcement personnel must take the safety of the hostages into account in attempting to apprehend the perpetrators. The field of forensic psychology has been influential in the development of techniques that can improve the ways in which law-enforcement officers communicate with hostage takers.

In ancient usage, the term "hostage" referred to a person who was given by one of the parties in an antagonistic situation to be held by the other party to ensure the carrying out of an agreement between the parties. In modern times, hostages are generally individuals whom lawbreakers seize and hold captive to force others—often law-enforcement personnel, but sometimes relatives or employers of those seized—to do something under the threat of death or serious harm to the hostages. Occasionally, the persons held are semivoluntary participants in the lawbreakers' actions—in those cases, the hostage takers are more properly referred to as the "hosts."

The taking of hostages may occur in the course of another crime, but it is also itself a crime; depending on the situation, it may be classified as kidnapping or as a terrorist act. Hostages may be taken to be held for ransom or for some political purpose, as when hostage takers seek the release of persons held prisoner by others.

Early History

Prior to 1970, the typical law-enforcement response to hostage situations in the United States was simply to demand that the hostage takers surrender. If the hostage takers did not give up immediately, then the police would kill the hostage takers. Unfortunately, this usually resulted in the deaths of the hostages as well, and sometimes in the deaths of police officers. In the early 1970's, Captain Frank Bolz of the New York Police Department and Dr. Harvey Schlossberg started to develop the first formalized hostage negotiation process for use by law enforcement. Widespread criticism of the disastrous outcome of the hostage situation that took place at the Olympic Village during the 1972 Summer Olympic Games in Munich, Germany, provided a major impetus to law-enforcement attempts to apply advanced behavioral science-based techniques to such events. In what became known as the Munich Massacre, eleven Israeli athlete hostages died as well as five of their Palestinian hostage takers and one German police officer.

In 1983, the Federal Bureau of Investigation (FBI) created its Hostage Rescue Team (HRT). Although the FBI stated that the HRT was trained in the most advanced negotiating techniques, the team's initial approach relied heavily on the rapid use of lethal force. In this, the HRT apparently sought to duplicate the relative success of the Israeli commandos who carried out a raid to rescue hostages held by Palestinian hostage takers at the airport in Entebbe, Uganda, in 1976. In the Israeli raid, three hostages and one Israeli commando were killed, but more than one hundred hostages were successfully liberated. The hostage takers and dozens of Ugandan soldiers acting in support of them were killed.

False Beginnings

The FBI's use of HRT tactics modeled on those of Israeli commandos had disastrous results in the hostage situations that took place in Ruby Ridge, Idaho, in 1992 and at the Branch Davidian compound in Waco, Texas, in 1993, in which, altogether, dozens of innocent women and children died. Critics have maintained that in these incidents the FBI lacked patience and put a high priority on the quick use of lethal force.

The behavior of local police forces in hostage situations has paralleled that of the FBI. One incident that took place in Sacramento, California, in 1991 provides an example. Four men robbed a retail electronics store, but before they could leave the store, the police arrived, and the robbers took customers and store employees hostage. Critics of the actions of the police in this incident later argued that initially the police were negotiating successfully, and the crisis might have ended without any loss of life. The police soon decided to use force, however; they authorized a sniper to signal the onset of a lethal attack by firing if he had a "clear shot" at any one of the hostage takers. Believing he had such an opportunity, the sniper fired at one of the perpetrators. The shot missed its target, possibly because a glass door swung closed at an inopportune moment and deflected the bullet. When the sniper's shot was fired, the hostage takers began shooting hostages and the police attacked. Altogether, three of the hostages and three of the hostage takers died and several more persons were wounded. The police defended themselves by pointing out that most of the hostages were liberated, but some observers criticized what they perceived to be an overly aggressive use of force by the police.

In part as a result of events such as this one, from the early 1990's onward law-enforcement agencies have placed emphasis on doing everything they can to resolve hostage crises peacefully. Given this change in emphasis, and given that many situations that appear to be hostage crises might more properly be described as situations in which the perpetrators are determined to commit "suicide by cop," many law-enforcement agencies refer to the teams that deal with hostage situations as crisis negotiation teams (CNTs) rather than as hostage rescue or hostage negotiation teams.

Equipment and Techniques

Law-enforcement agencies have increasingly criticized the news media for interfering with crisis negotiations; in some cases, this interference has taken the form of the media's gaining access to the telephone lines police are using to communicate with hostage takers. Because of this, CNTs often use "throw phones," self-contained communication devices that provide hard-line communications between the hostage taker and the negotiators (they are called throw phones because they are generally thrown by the police into hostage takers' barricaded locations). By disconnecting any telephone landline and using a throw phone, a crisis negotiator can block any third party from tapping into the line and listening in. If throw phones cannot be used, CNTs use bullhorns, telephone landlines, or cellular phones to communicate with hostage takers, as

The FBI's Hostage Rescue Team

This description of the mission and activities of the Federal Bureau of Investigation's Hostage Rescue Team is provided on the bureau's Web site.

The Federal Bureau of Investigation's Hostage Rescue Team (HRT), part of the Tactical Support Branch of CIRG [Critical Incident Response Group], is a full time, national-level tactical team, headquartered in Quantico, Virginia. The mission of the HRT is to be prepared to deploy to any location within four hours of notification by the Director of the FBI or his designated representative, and conduct a successful rescue of United States persons and others who may be held illegally by a hostile force, either terrorist or criminal in nature. The HRT is also prepared to deploy to any location and perform other law enforcement activities as directed by appropriate authorities.

The HRT operationally deploys in support of FBI field divisions and performs a number of law enforcement tactical functions in all environments and under a variety of conditions. . . . HRT has performed missions involving hostage rescue, barricaded subjects, high-risk arrest and warrant service (raids), and dive search. Additionally, the HRT has performed traditional law enforcement roles during hurricane relief operations, dignitary protection missions, tactical surveys, and on occasion, pre-positions in support of special events such as the Olympic Games, presidential inaugurations, and political conventions. . . .

Assignment to the HRT is voluntary, and is open to all Special Agents of the FBI. HRT operators are selected based upon their background and experience, as well as their demonstrated performance during a rigorous two week selection course. Once selected, operators undergo a four month initial training program.

City police and agents of the Federal Bureau of Investigation lead hostages to safety during a standoff at a bank in Albany, New York, in August, 2005. Negotiators were able to secure the safe release of the four people who were held hostage in the bank for five hours. After releasing the hostages, the suspect committed suicide. *(AP/Wide World Photos)*

such communication is critical to the negotiation process.

The development of the application of forensic psychology to hostage negotiations came out of the FBI's efforts to construct psychological profiles for the various types of personalities its agents might confront in barricade situations. Negotiators attempt to profile hostage takers so that they can determine the best ways to communicate with them to secure the safety of all persons involved, hostages and hostage takers alike. Much that is included in the manuals and training for law-enforcement crisis negotiators, however, is based on science that is still being developed. Currently, the success of crisis negotiations relies to a considerable degree on the practical experience of those involved in these endeavors.

Richard L. Wilson

Further Reading

Faubion, James D. *The Shadows and Lights of Waco: Millennialism Today*. Princeton, N.J.: Princeton University Press, 2001. An anthropologist challenges the government's view that the Waco standoff was a genuine hostage situation and argues that a greater awareness of religious diversity would have helped hostage negotiators to avoid the violent end to that situation.

Jonas, George. *Vengeance: The True Story of an Israeli Team*. New York: Simon & Schuster, 2005. Presents a comprehensive account of the 1972 Munich Olympics tragedy.

Klein, Aaron J. *Striking Back: The 1972 Munich Olympics Massacre and Israel's Deadly Response*. Translated by Mitch Ginsburg. New York: Random House, 2005. Places the Munich Olympics tragedy in the context of the subsequent Israeli military response against the Palestinian terrorists and their supporters.

Lewis, James R. *From The Ashes: Making Sense of Waco*. Lanham, Md.: Rowman & Littlefield, 1994. Account of the events at Waco seeks to understand the religious beliefs of the Branch Davidians and examines how the tragedy might have been avoided.

Reeve, Simon. *One Day in September: The Full Story of the 1972 Munich Olympic Massacre and Israeli Revenge Operation "Wrath of God."* New York: Arcade, 2006. Thorough report on the Munich Olympics tragedy and the subsequent Israeli military response was the basis for an important documentary film on the events.

Rogan, Randall, Mitchell R. Hammer, and Clinton R. Van Zandt, eds. *Dynamic Processes of Crisis Negotiation*. Westport, Conn.: Praeger, 1997. Collection of scholarly articles discusses the psychological nature and practice of hostage negotiations.

Van Zandt, Clinton R. *Facing Down Evil: Life on the Edge as an FBI Hostage Negotiator*. New York: Putnam, 2006. Highly readable account of the author's years as one of the FBI's chief hostage negotiators offers many insights into hostage negotiations.

Wright, Stuart A., ed. *Armageddon at Waco: Critical Perspectives on the Branch Davidian Conflict*. Chicago: University of Chicago Press, 1995. Makes a strong case against the FBI hostage negotiation techniques used at Waco.

See also: Beslan hostage crisis victim identification; Child abduction and kidnapping; Child abuse; Criminal personality profiling; Federal Bureau of Investigation; Federal Bureau of Investigation Forensic Science Research and Training Center; Federal Law Enforcement Training Center; Forensic psychology; Interrogation; Police psychology; Psychopathic personality disorder.

Hughes will hoax

Date: Will filed in 1976

The Event: When billionaire recluse Howard Hughes died in 1976, no one could locate his will. Soon, however, a will was found that would have made gas station owner Melvin Dummar very rich. The authenticity of the will, purportedly handwritten by Hughes, was challenged.

Significance: Forensic scientists played a major role in shedding light on the fraudulent nature of the will. After forensic evidence was presented regarding fingerprint analysis as well as analysis of the will's handwriting and ink, the court ruled the will a forgery.

A will is a document executed by an individual that specifies who will receive that person's property upon the person's death. In the United States, if a person dies intestate—that is, without having made a will—state law determines how the deceased's estate is divided among persons related to the deceased by blood, marriage, or adoption. In some cases, forensic analysis is necessary to confirm that a will is authentic in order to avoid the application of intestacy law.

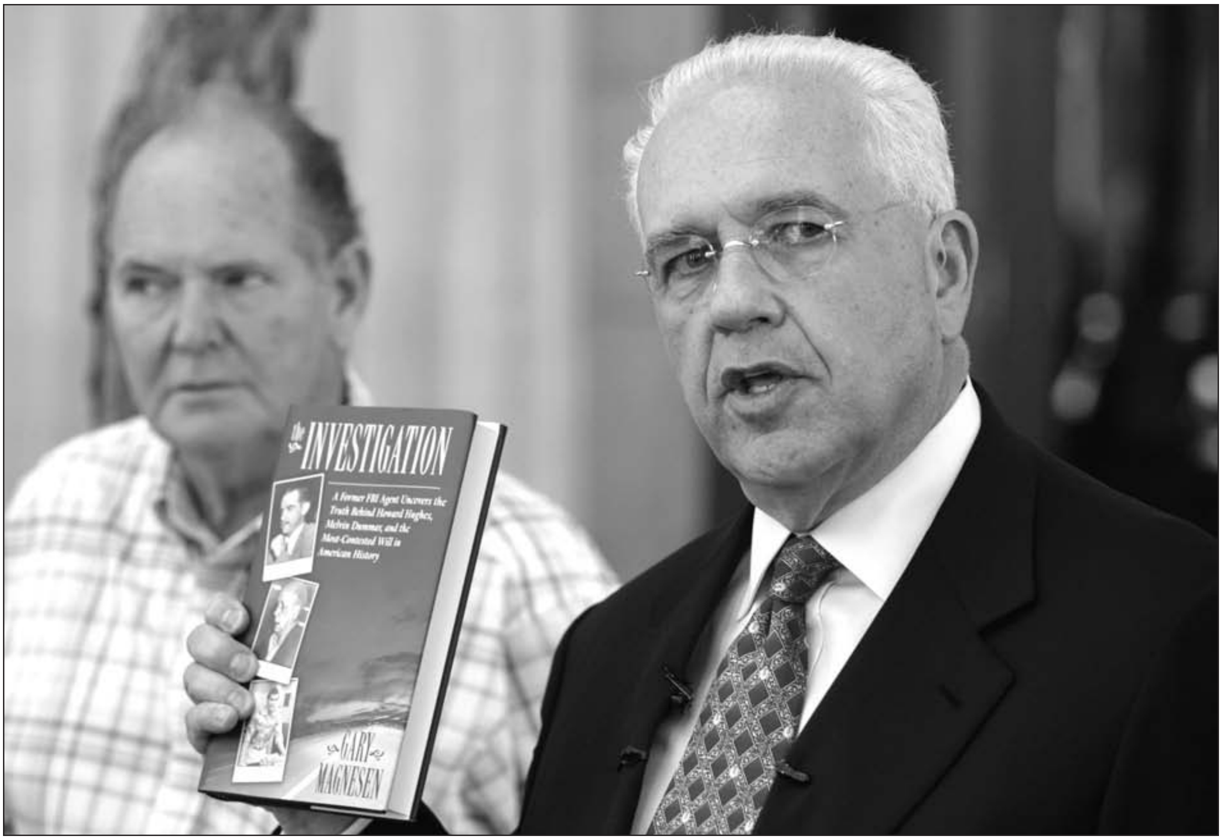
After Howard Hughes's death in April, 1976, a holographic (that is, handwritten) will allegedly written by Hughes was filed by the Church of Jesus Christ of Latter-day Saints with a county court located in Las Vegas, Nevada. The will had been left anonymously at the Church's headquarters in Salt Lake City, Utah. One provision in the will bequeathed one-sixteenth of Hughes's estate, an amount of more than $150 million, to Melvin Dummar. Dummar, the owner of a small gas station in Utah, claimed that before Hughes's death, he had picked up a man from the desert roadside north of Las Vegas and given the man a ride to Las Vegas; Dummar said that the man told him he was Howard Hughes. Dummar had no legal relationship to Hughes that would have entitled him to receive a portion of the Hughes's estate under intestacy law, so Dummar could inherit only if the court determined that the will was authentic.

An investigation concerning the legitimacy of the will took place. One piece of evidence presented in court was a fingerprint match between Dummar and a fingerprint found on a library copy of Clifford Irving's book *What Really Happened* (1972; later retitled *Hoax!*); this book concerned Irving's own fraudulent autobiography of Howard Hughes, and it contained some examples of Hughes's handwriting. Forensic document examiners determined that Hughes had not written the purported holographic will, as his handwriting had changed significantly in the few years before his death and the handwriting of the will resembled that depicted in Irving's book.

In addition, research chemists for the Federal Bureau of Investigation (FBI) conducted an ink analysis, comparing the ink used on the holographic will with inks that would have been available on the date the will was allegedly written. Because the Paper Mate pen company had made an ink that matched the ink on the date of the purported will, the ink evidence was not conclusive in proving the will was a fraud.

Based on the handwriting, the forensic investigators deemed the holographic will a crude forgery, and after a lengthy and costly court fight, the judge agreed and found that the will was not authentic. An authentic will for Howard Hughes was never found, and Hughes's estate passed under the state intestacy laws. No criminal charges were filed against Dummar or any other party regarding the creation of the fraudulent will.

Carol A. Rolf



Melvin Dummar (left), and his attorney, Stuart Stein, at a news conference in June, 2006, announcing they have filed a lawsuit in federal court claiming Dummar is entitled to $156 million from the Howard Hughes estate. Stein holds up a book that they say supports Dummar's claim. A judge threw out the lawsuit in January, 2007, saying that the case had been "fully and fairly litigated" in 1978. *(AP/Wide World Photos)*

Further Reading

Freese, Paul L. "Howard Hughes and Melvin Dummar: Forensic Science Fact Versus Film Fiction." *Journal of Forensic Sciences* 31 (January, 1986): 342-359.

Frehner, Veri L., and Chuck Waldron. *The Mysterious Howard Hughes Revealed*. Victoria, B.C.: Trafford, 2004.

Rhoden, Harold. *High Stakes: The Gamble for the Howard Hughes Will*. New York: Crown, 1980.

See also: Document examination; Forensic linguistics and stylistics; Forgery; Handwriting analysis; Hitler diaries hoax; Paper; Questioned document analysis.

Hypothermia

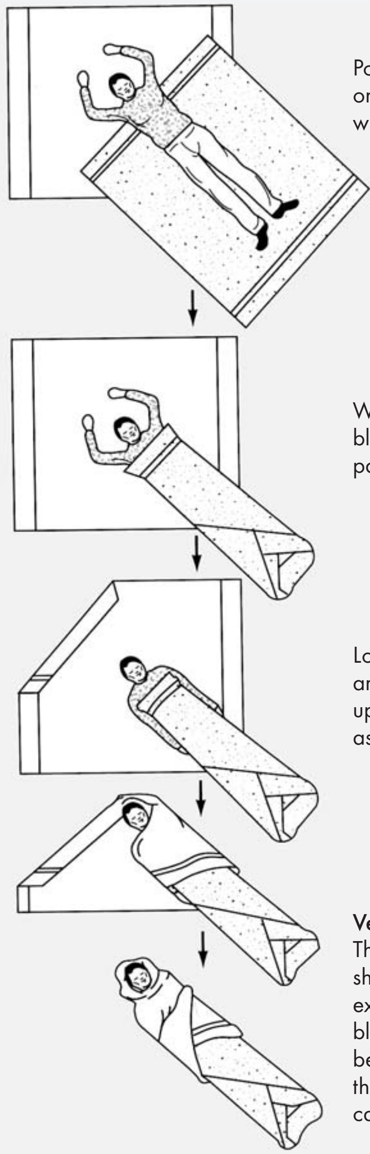
Definition: Decrease in human core body temperature below 95 degrees Fahrenheit (35 degrees Celsius), which sometimes results in death.

Significance: Each year in the United States, hundreds of deaths are attributed to accidental hypothermia. Law-enforcement agencies and emergency medical personnel must be aware of the signs and recommended treatments for this life-threatening condition.

Hypothermia is a medical emergency. Early recognition of the signs and symptoms of hypothermia can prevent morbidity and mortality from this condition. In cases of mild hypothermia (core body temperature between 90 and 95 degrees Fahrenheit, or 32 to 35 degrees Celsius), symptoms include changes in mental status (confusion, impaired judgment, slurred speech), increased shivering, shortness of breath, and rapid heartbeat. The symptoms of moderate hypothermia (core body temperature between 82 and 90 degrees Fahrenheit, or 28 to 32 degrees Celsius) consist of reduced shivering, hardened muscles, decreased breathing, and abnormal drowsiness. Severe hypothermia (core body temperature below 82 degrees Fahrenheit, or 28 degrees Celsius) is characterized by decline in brain activity, low blood pressure, diminished heart activity, and transient cessation of breathing; the person may appear dead and may have false rigor mortis.

Between 1979 and 2002, a total of 16,555 deaths resulted from accidental hypothermia in the United States, an average of 690 annual fa-

First Aid for Hypothermia



Position patient on two blankets with arms raised.

Wrap lower blanket around patient's body.

Lower patient's arms and prepare upper blanket as shown.

Very Important: The patient's face should be left exposed, and blankets should be loose enough that the patient can move.

talities. Although most of the U.S. fatalities from hypothermia occur in states that experience severe winters (particularly Alaska, Montana, and Wyoming), hypothermia has been documented in states with milder winters (including North Carolina and Mississippi), in Atlanta, Georgia, during the summer, and in hospitalized individuals. Forensic scientists need to be aware of the signs of death from hypothermia even in regions where such deaths are not common.

Untreated complications of hypothermia (cardiac arrest, shock, lethargy and coma) can lead to a fatal event, so it is important that if hypothermia is suspected, the person receive first aid and emergency medical treatment immediately. The individual should be taken to a warmer environment and covered with blankets or any other available material to prevent further loss of body heat and to provide insulation from the cold. Any wet, cold clothes the person is wearing should be removed, and the skin should be checked for frostbite. Direct heat should not be used for warming the individual because this can cause a sudden dangerous core body temperature drop.

Some kinds of people are more susceptible to hypothermia than others; these include the very old and the very young, individuals who are under the influence of alcohol or illicit drugs, and persons with certain chronic conditions, especially mental illness, malnutrition, dehydration, diabetes, hypothyroidism, or heart and blood circulation problems. Victims of accidents involving exposure to cold water may become hypothermic, as may persons wearing inadequate clothing for protection from extremely cold or windy weather. Identification of these high-risk individuals can help prevent hypothermia and its possible fatal consequences. It has been recommended that family members and friends of high-risk individuals should regularly monitor them to ensure that they are adequately protected from high winds and extreme cold temperatures and that they are satisfactorily treated for their chronic illnesses.

Miriam E. Schwartz and Shawkat Dhanani

Further Reading

Collins, K. J. *Hypothermia: The Facts*. New York: Oxford University Press, 1983.

Giesbrecht, Gordon G., and James A. Wilkerson. *Hypothermia, Frostbite, and Other Cold Injuries: Prevention, Recognition, Rescue, and Treatment*. 2d ed. Seattle: Mountaineers Books, 2006.

Pozos, Robert S., and Lorentz E. Wittmers, Jr., eds. *The Nature and Treatment of Hypothermia*. Minneapolis: University of Minnesota Press, 1983.

See also: Algor mortis; Centers for Disease Control and Prevention; Drowning; Drug abuse and dependence; Illicit substances; Livor mortis; Nervous system; Rigor mortis.

I

IAFIS. *See* Integrated Automated Fingerprint Identification System

IBIS. *See* Integrated Ballistics Identification System

Identity theft

Definition: Illegal appropriation of another person's personal data for the purpose of gain or profit.

Significance: According to the U.S. Department of Justice, identity theft has become one of the fastest-growing crimes in the United States. For law-enforcement personnel, the complexity of identity theft makes tracking, investigating, and prosecuting the perpetrators extremely difficult.

The Identity Theft and Assumption Deterrence Act of 1998 made it a federal crime when someone "knowingly transfers or uses, without lawful authority, a means of identification of another person with the intent to commit, or to aid or abet, any unlawful activity that constitutes . . . a felony." In simpler terms, identity theft occurs when individuals, without permission, transfer, take, or use for their own benefit the personal or financial information of others. After 1998, almost all U.S. states, following the federal government's lead, enacted versions of identity theft legislation to deal with this growing problem. Most states constructed their laws hastily, however, and the results for investigation and prosecution of identity theft cases have been mediocre at best.

Identity theft is not typically a stand-alone crime; rather, it is almost always a component of one or more types of fraud, such as credit card fraud, passport fraud, or counterfeiting. In fact, identity theft is typically categorized as a gateway crime, because after individuals steal others' information, this opens possibilities for more criminal activity to take place. Stolen personal information is often used to create new or false identities. Criminals use stolen personal information such as Social Security numbers to establish credit, run up debt, and take over existing financial accounts.

In establishing the criminal intent they must prove to convict the perpetrators of identity theft, prosecutors focus on the willful and purposeful taking or transferring of others' information for the sole purpose of committing other crimes. In other words, they must show that the perpetrators were fully aware of their actions when they took the information and were cognizant that their actions were in direct violation of known law. Crimes of identity theft are becoming increasingly difficult to investigate and to prosecute because of the complexity and sophistication of the technologies that have become available.

Identity Thieves: Why, What, and How

The most common cause of identity theft in the United States is personal greed. Most identity thieves are motivated by the opportunity for quick credit or monetary gain. Technological advances, especially the introduction of the Internet, have made it easy and profitable for identity thieves to operate and to steal from multiple victims. Using the Internet, they can bring in thousands of dollars while taking minimal chances that they will be detected and investigated; the benefits to these criminals thus far outweigh the potential risks.

Identity thieves vary in the types of information they seek to steal, but very often they are after some if not all of the following: Social Security numbers, driver's license data, bank and other financial statement information, insurance records, tax return information, passport or other citizenship information, credit card numbers and corresponding account information, military records, and birth, marriage, and death records. They are also interested in any other forms of information, particularly financial information, that they might ultimately use for some sort of personal gain.

Identity thieves are known to use several common techniques. Some criminals literally go through trash cans and larger refuse receptacles to find copies of checks, credit card and bank statements, credit card solicitations, or other records that contain personal information; this is known as Dumpster diving. They can use such information to assume the identities of those whose information they have stolen and then take control of active accounts or even establish new accounts in the victims' names.

In a second technique, known as shoulder surfing, perpetrators literally watch over the shoulders of potential victims as these persons enter personal information into phones, computers, or automated teller machines (ATMs). Identity thieves also sometimes watch and wait for people to leave credit card receipts on tables in restaurants or to throw receipts away near ATMs and banks. With their victims' personal identification numbers (PINs) and other passwords as well as their account information, the thieves can begin the process of posing as their victims and gaining access to their accounts.

One of the most innovative techniques used by identity thieves is the electronic method known as phishing. With the ever-growing use

Pretexting and Identity Theft

The Federal Trade Commission provides this information about one common method used by identity thieves.

Pretexting is the practice of getting your personal information under false pretenses. Pretexters sell your information to people who may use it to get credit in your name, to steal your assets, or to investigate or sue you. Pretexting is against the law.

How Pretexting Works

Pretexters use a variety of tactics to get your personal information. For example, a pretexter may call, claim he's from a survey firm, and ask you a few questions. When the pretexter has the information he wants, he uses it to call your financial institution. He pretends to be you or someone with authorized access to your account. He might claim that he's forgotten his checkbook and needs information about his account. In this way, the pretexter may be able to obtain personal information about you such as your SSN [Social Security number], bank and credit card account numbers, information in your credit report, and the existence and size of your savings and investment portfolios.

Keep in mind that some information about you may be a matter of public record, such as whether you own a home, pay your real estate taxes, or have ever filed for bankruptcy. It is not pretexting for another person to collect this kind of information.

There Ought to Be a Law—There Is

Under federal law—the Gramm-Leach-Bliley Act—it's illegal for anyone to:

- use false, fictitious, or fraudulent statements or documents to get customer information from a financial institution or directly from a customer of a financial institution.
- use forged, counterfeit, lost, or stolen documents to get customer information from a financial institution or directly from a customer of a financial institution.
- ask another person to get someone else's customer information using false, fictitious, or fraudulent statements or using false, fictitious, or fraudulent documents or forged, counterfeit, lost, or stolen documents.

The Federal Trade Commission Act also generally prohibits pretexting for sensitive consumer information.

of the Internet around the world, this technique has made the crime of identity theft a global concern. In phishing, criminals send out unsolicited e-mail messages (spam) advertising various products or services; the messages state that in order to receive the products or services advertised, the recipient needs to provide a credit card number as well as other personal information.

Prevalence and Scope of the Problem

The true prevalence of identity theft victimization in the United States is unknown, but it has been estimated that between 500,000 and 750,000 people, from all fifty states, filed criminal complaints stating that they were victims of identity theft in fiscal year 2006. The overall prevalence of this crime is difficult to track, as the theft of a single identity is often the means by which criminals commit numerous other crimes. Most victims of identity theft, moreover, do not even come to realize they have been victimized until months after the fact. The U.S. Department of Justice has estimated that, on average, identity theft victims may not know that have become victims for fourteen to sixteen months after their information has been stolen. Many, because of embarrassment or shame that they were victimized, will not file criminal complaints. The federal government estimates that the crime of identity theft costs U.S. taxpayers close to fifty billion dollars per year.

It has been estimated that close to ten million people in the United States become victims of identity theft every year. One of the principal credit-reporting bureaus, TransUnion, has reported receiving on average more than one thousand calls per day from known victims of identity theft. In fact, credit bureaus now estimate that two-thirds of all their consumer complaints relate to identity theft, more than 500,000 per year.

In addition to any financial losses they may suffer, victims of identity theft often have trouble proving their own identities when they have business transactions to conduct. To help documented victims of the crime, the Consumer Protection Division of Mississippi's Attorney General's Office began issuing special "Identity Theft Passport" cards in 2004. *(AP/Wide World Photos)*

Most Common Forms of Identity Theft

Rank	*Type*	*Percentage of Victims*
1	**Credit card:** Establishing new accounts and defrauding existing accounts	33
2	**Phone or utilities:** Establishing new telecommunications accounts and defrauding existing accounts	21
3	**Other:** Includes medical, Internet-related, rental, bankruptcy, and insurance fraud	19
4	**Bank:** Establishing new accounts and defrauding existing accounts	17
5	**Employment-related:** Taking of confidential personal or corporate identities	11
6	**Loans:** Includes fraudulent business, personal, student, and auto loans	6

Source: Federal Trade Commission, 2003. Percentages are based on 500,000 complaints received. Percentages add to more than 100 because some victims reported more than one type of identity theft.

Investigation and Prosecution

On the federal level, violations of the 1998 Identity Theft and Assumption Deterrence Act and the 2004 Identity Theft Penalty Enhancement Act are investigated by several law-enforcement agencies, including the Social Security Administration, the Federal Bureau of Investigation, the Secret Service, the Office of the Inspector General, the Immigration and Naturalization Service, and the U.S. Postal Inspection Service. These federal agencies usually tend to focus only on high-profile cases or on those cases involving very high dollar amounts, however. Most victims in the United States must rely on state and local authorities to assist them in restoring their good names. This can be quite problematic, as many local and state agencies lack sufficient personnel who have the training, education, and general skills needed to investigate and prosecute these complex offenses.

In the investigation of identity theft, one of the most difficult issues facing law-enforcement agencies on all levels is that of jurisdiction—it is not always clear which agencies have the authority to pursue particular cases. In addition, law-enforcement personnel and prosecutors may be unfamiliar with the relevant state and federal statutes concerning identity theft. For these reasons, arrests and prosecutions for identity theft are rare, a fact that can be tremendously frustrating for victims.

Since 1999, the U.S. Department of Justice has spearheaded the Identity Theft Subcommittee of the Attorney General's Council on White-Collar Crime. The subcommittee brings together members from federal, state, and local law-enforcement and regulatory agencies on a monthly basis to share data about identity theft issues and to discuss new developments in an attempt to promote a united interagency front to help in combating this fast-growing crime.

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Further Reading

Arnold, Tom. *Internet Identity Theft: A Tragedy for Victims*. Mountain View, Calif.: Software and Information Industry Association, 2000. Describes the differences between identity theft committed online and "traditional" identity theft and offers suggestions for prevention.

Collins, Judith M. *Investigating Identity Theft: A Guide for Businesses, Law Enforcement, and Victims*. Hoboken, N.J.: John Wiley & Sons, 2006. Presents comprehensive information on the investigation of crimes of identity theft. Includes interesting case studies.

Hammond, Robert J., Jr. *Identity Theft: How to Protect Your Most Valuable Asset*. Franklin Lakes, N.J.: Career Press, 2003. General guide for laypersons focuses on identity theft prevention and awareness.

Hayward, Claudia L., ed. *Identity Theft*. New York: Novinka Books, 2004. Brief collection of articles covers a variety of aspects of identity theft.

Sullivan, Bob. *Your Evil Twin: Behind the Identity Theft Epidemic*. New York: John Wiley & Sons, 2004. Presents a comprehensive examination of the scope of identity theft investigation, prevention, and education.

See also: Computer crimes; Computer forensics; Computer hacking; Computer viruses and worms; Document examination; Forgery; Handwriting analysis; Secret Service, U.S..

Illicit substances

Definition: Materials the ownership, possession, sale, or use of which has been restricted or prohibited outright by law.

Significance: Illicit substances comprise a broad range of chemicals and products with which forensic scientists come into contact on a regular basis. The illicit materials seen most frequently in forensic laboratories are drugs, but with the rise of domestic and international terrorism, forensic scientists are increasingly encountering another category of illicit substances: homemade explosive mixtures.

Illicit substances are essentially any substances that are illegal to purchase, possess, or sell. They can be outright dangerous, such as a volatile liquid peroxide explosive, or they can be more silently dangerous, such as a pure fix of heroin. The majority of illicit substances encountered by most forensic science laboratories are drugs.

LSD

LSD, or lysergic acid diethylamide, is a powerful hallucinogenic drug. Users of LSD experience visual and auditory hallucinations. Often, they describe "hearing" colors and "seeing" sounds. Getting high on LSD is known as tripping. Whether users experience good trips or bad trips depends on their mental states, their surroundings, and the strength of the dosage. Bad trips can result in feelings of fear, anxiety, and paranoia. If users begin to panic during bad trips, they can be at risk of physically injuring themselves. The usual treatment for bad trips includes reassuring the users that they are safe, that the effects of the drug will soon wear off, and that they will return to normal. No evidence has been found that LSD is physically addictive, but tolerance to the drug can develop within three to six days of continued use.

Most users of LSD ingest the drug by placing a square of blotter paper containing the drug on the tongue. Saliva in the mouth dissolves the drug so it can be absorbed through the mucous membranes. LSD can be added to pills, sugar cubes, foods, or liquids—it is readily absorbed in the gastrointestinal tract. Alternatively, liquid LSD can be dripped into the eye.

LSD is produced both synthetically and agriculturally. Synthetic routes for the production of LSD have been published in the scientific literature as well as by the U.S. Patent Office. These processes are complex, and operators of clandestine LSD laboratories need to have knowledge of organic chemistry. The agricultural method of producing LSD involves infecting rye grain plants with the ergot fungus. One acre of infected rye plants will produce more than one hundred pounds of fungus, resulting in the production of one-half pound of lysergic acid. One ounce of pure LSD is enough for 567,000 hits of 50 micrograms each.

Ecstasy

Known alternatively as X, XTC, and the love drug, ecstasy is commonly known as a drug used by many who attend the all-night dance parties known as raves. Effects of ecstasy include feelings of euphoria and relaxation, increased openness, lowering of defenses and reservations, and enhanced sense of touch. Users of ecstasy experience a false sense of emotional closeness and will freely touch and hug other people, even strangers.

The chemical name for ecstasy is 3,4, methylenedioxymethamphetamine, or MDMA. The majority of MDMA available in the United States is produced in clandestine laboratories in

Belgium and the Netherlands. More than twenty methods of manufacturing MDMA have been published. Production of this drug is complex and requires many hazardous chemicals.

MDMA is available in both powder and pill form. Ecstasy tablets come in a variety of sizes, shapes, and colors and carry a variety of imprints, such as hearts, cartoon characters, or letters. Each tablet may cost only twenty-five cents to produce, but the drug can sell for ten to sixty dollars per pill on the street.

The most common route of ingestion of ecstasy is oral, but it can also be smoked, snorted, or injected. Physical effects of the drug are felt within thirty minutes of oral ingestion. Typically, effects of MDMA persist for from four to six hours. In the brain, MDMA causes the release of large quantities of the neurotransmitter serotonin while simultaneously blocking its reuptake. An overdose of MDMA can result in serotonin toxicity, which causes elevated body temperature, muscle spasms, coma, and death. These effects can be intensified when the user fails to drink adequate fluids or to cool down from long periods of exertion, such as dancing. Many deaths associated with MDMA are attributed to heatstroke or abnormal fluid or electrolyte imbalance.

Cocaine

Derived from coca plants, which are native to South America, cocaine is a powerful central nervous system stimulant. Peru, Bolivia, and Colombia are the primary sources of illicit coca plants. Cocaine is extracted from the coca leaves in a three-step process. In the first step, the dried coca leaves are steeped in strong base (such as lime), and a solvent such as kerosene is added to dissolve the cocaine alkaloids. In the second step, the leaves are removed, and a water/acid mixture is added to the solvent. The cocaine alkaloids move into the water layer from the kerosene layer. In the third step, strong base is again added to the mixture. This causes the cocaine alkaloids to precipitate out of solution to form a cocaine paste that has a purity of 40 to 60 percent. Generally, the cocaine paste is further processed at makeshift laboratories to remove contaminants and improve the purity.

Cocaine can be found in several forms: cocaine hydrochloride, freebase, and crack. Cocaine hydrochloride is generally a white, crystalline powder that resembles granulated sugar in appearance. This may not be the case, however, if the drug has been cut with other chemicals to reduce the purity and the price. Freebase is the purest form of cocaine. Crack cocaine usually takes the form of an off-white to yellowish-white solid. Cocaine hydrochloride is usually snorted or injected into the veins, whereas freebase and crack are usually smoked.

A person under the influence of cocaine may display anxiety, euphoria, high energy level, loss of appetite, mental alertness, and unpredictable behavior. Many of these effects are the same as those that result from methamphetamine abuse. Cocaine produces euphoric, physical, and addictive effects because it interferes with the normal release and reuptake of the neurotransmitters dopamine, serotonin, and norepinephrine.

Studying Drugs of Abuse

When suspected drug evidence is brought into a forensic laboratory for analysis, the scientists there must determine, first, whether or not a drug is present; if they determine that a drug is present, they must further determine what the drug is and how much of it is in the sample. Research scientists are continually working to improve the ways in which these questions are answered. Such scientists may work for police laboratories, for private companies, or even for universities. They may study cocaine, methamphetamine, or a variety of other illicit drugs. Any researcher who chooses to study these drugs must have a license to do so from the U.S. Drug Enforcement Administration (DEA). DEA-licensed researchers must follow strict protocols that outline how they must store and handle the illicit drugs they study, who may have access to those drugs, and how they must dispose of the drugs when their research is finished. Research scientists who fail to keep complete and accurate records of their storage and use of these drugs can lose their DEA licenses.

Amphetamine and Methamphetamine

Almost all of the illicit amphetamine sold by street dealers is actually methamphetamine, also known as meth or crank. Compared with amphetamine, meth has much stronger effects on the body, and the effects last longer. Both drugs relieve fatigue, increase energy and confidence levels, and result in a general feeling of exhilaration. Users of this type of drug may appear anxious, talkative, sweaty, and euphoric. Chronic amphetamine or methamphetamine abuse can result in severe mental and physical problems. Meth addicts may experience delusions, hallucinations, and violent behavior. One common effect that long-term methamphetamine abusers experience is the sensation that bugs are crawling under their skin. Users may injure themselves trying to dig the "crank bugs" out of their bodies.

Amphetamines may be injected, snorted, smoked, or taken orally. Ice is a very pure form of methamphetamine that is ingested by smoking. The physical and mental effects of smoking ice are similar to those caused by crack cocaine use. The primary difference is that the effects of crack wear off in ten to twenty minutes, whereas those of ice last eight to sixteen hours.

For many years, production and distribution of street methamphetamine in the United States was controlled by motorcycle gangs. During the early 1990's, however, Mexican drug traffickers gained control of the U.S. market. It is believed that up to 90 percent of the meth sold in the United States is distributed by Mexican cartels. Most of this illicit meth is produced in small clandestine laboratories. The production processes are widely known, the chemicals are easily obtained, and minimal chemical knowledge is required to produce the drug. Production of methamphetamine can be dangerous because of the caustic nature of many of the required chemicals. Meth "cooks" frequently suffer serious chemical burns. Meth production is also harmful to the environment: Production of one pound of methamphetamine results in the production of five to seven pounds of hazardous waste; this waste is often dumped on the ground or into sewage systems.

Heroin

Heroin belongs to the class of drugs known as opiates. These are natural or semisynthetic drugs made from the opium poppy. Illicit opium poppies are grown in many countries, including Afghanistan, Mexico, Burma, and Laos. Opium is produced in the root system of the plant and distributed to all of its tissues, with the majority of the opium collecting in the seedpods. Opium farmers make small cuts in the sides of the pods so that the milky opium sap bleeds from the incisions. Once this sap dries and hardens, the farmers scrape it off the seedpods. Bricks of this dried opium can be processed to extract morphine, which is then chemically converted to heroin.

One of the most common methods of ingesting heroin is through injection of the drug into a vein. Prior to injection, the heroin must be "cooked": a small amount of the drug is mixed with water in a metal spoon, and the mixture is heated from below with a cigarette lighter to dissolve the drug. Most users inject the drug into the inside of the elbow. Over time, this can cause scarring, resulting in telltale "track marks."

The effects of heroin use include pain relief, euphoria, respiratory depression, nausea, vomiting, and constipation. Heroin is extremely addictive. Long-term users risk physical dependence, infection of the heart lining and valves, and skin abscesses. Because they often share needles, they are also at great risk for contracting human immunodeficiency virus (HIV) and hepatitis C. The lifestyle of heroin addicts is often linked to crime, malnutrition, collapsed veins, and disease. Because of the high purity of some street heroin, users are continually at risk for overdosing.

GHB

Gamma-hydroxybutyrate, or GHB, is a member of a class of drugs often collectively termed "date rape" drugs. Date rape can be defined as rape or other nonconsensual sexual activity between people who are known to each other. Other chemicals often implicated in date rape include ketamine, rohypnol, and alcohol.

GHB has both sedative and amnesiac effects. Because the drug is rapidly absorbed by the body, it produces initial effects within five to fifteen minutes of ingestion. Maximum effects of the drug are reached within twenty to thirty minutes and can last for one to six hours. The effects of GHB include relaxation, euphoria, enhanced sexuality, interference with speech and motor control, and unrousable heavy sleep. These effects are dependent on the dosage.

Virtually all of the GHB sold on the streets is produced in clandestine laboratories. Methods for producing the drug are described in the scientific literature as well as on the Internet. GHB is available as both a salty-tasting liquid and in powder form. Both forms of the drug readily dissolve in alcohol. Sexual predators can add GHB to the drinks of unsuspecting victims, causing them to experience severe intoxication or sleepiness. Because these victims are often unconscious during the subsequent attacks and may have difficulty remembering the details after regaining consciousness hours later, such drug-facilitated sexual assaults can be difficult to prosecute. Tests designed to detect GHB in the blood and urine are available, but they must be performed within five to twelve hours of ingestion.

Peroxide Explosives

With increasingly tight restrictions on the sale, possession, and use of commercial high explosives in the United States, a number of terrorist organizations have begun making their own explosive mixtures for use in attacks against civilian, government, and commercial targets. Of particular concern to law-enforcement agencies are peroxide explosives, as these types of explosives are much more difficult to detect than traditional TNT (trinitrotoluene) or plastic explosives.

Peroxide-based explosives can be found in liquid, gel, or powder form. A powerful liquid peroxide explosive can be made with a mix of concentrated hydrogen peroxide and concentrated ethyl alcohol. A solid fuel such as sugar or flour can be mixed with concentrated hydrogen peroxide to make a slurry or gel-like explosive. Alternatively, acetone can be mixed with concentrated hydrogen peroxide to form a dangerous powder explosive. This mixture is known as triacetone triperoxide, or TATP; it takes the form of a yellowish-white crystalline powder. It has a high vapor pressure and can sublimate directly from solid to vapor at room temperature. Studies have shown that within twenty minutes of ignition of a small sample of TATP, all visible residues disappear. This makes the detection of TATP at postblast crime scenes very difficult. Investigators must be very careful when handling TATP because of its sensitivity to heat, friction, and shock.

Methods for the illicit production of peroxide explosives can be found on the Internet as well as in the scientific literature. It should be noted, however, that Internet-distributed recipes for TATP and other peroxide explosives may not be correct, complete, or safe. In any case, the production of this type of explosive is extremely dangerous. Bomb makers are frequently killed or maimed in the process of trying to manufacture, handle, or store peroxide explosives. Research scientists and law-enforcement personnel who work with such substances must take every possible precaution.

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Further Reading

Aretha, David. *Drugs: Ecstasy and Other Party Drugs*. Berkeley Heights, N.J.: Enslow, 2005. Focuses on how to recognize drugs such as ketamine, GHB, LSD, ecstasy, and rohypnol and discusses how to avoid them.

Laci, Miklos. *Illegal Drugs: America's Anguish*. Detroit: Thomson/Gale, 2004. Comprehensive guide to illegal drugs in the United States includes information on the origins and uses of various drugs and the effects of drug abuse. Offers interesting discussion of trends in drug use, routes of drug trafficking, drug addiction treatment programs, and debates concerning the merits of legalization of select illicit drugs.

LeVert, Suzanne. *Drugs: Facts About Cocaine*. Tarrytown, N.J.: Marshall Cavendish, 2006. Discusses cocaine use and abuse in detail, including issues such as cocaine and the law, powder versus rock cocaine, and how to live drug free. Personal stories of addiction and treatment provide a compelling narrative.

Menhard, Francha Roffé. *Drugs: Facts About Amphetamines*. Tarrytown, N.J.: Marshall Cavendish, 2006. Provides detailed information on the the history, use, and abuse of amphetamines and methamphetamine. Highlights the dangers of amphetamine abuse as well as the difficulty of treating addicts.

Monroe, Judy. *Drug Dangers: LSD, PCP, and Hallucinogens*. Berkeley Heights, N.J.: Enslow, 2000. Explores the social, legal, and medical aspects of hallucinogen abuse. Of particular interest are stories from actual users and addicts. Includes discussion of the effects of peyote, mescaline, and hallucinogenic mushrooms.

Sonder, Ben. *All About Heroin*. New York: Franklin Watts, 2002. Presents excellent discussion of the history of heroin use and the U.S. "war on drugs." Features personal stories of addiction and recovery as well as information on famous heroin users.

Torr, James D., ed. *Drug Abuse: Opposing Viewpoints*. San Diego, Calif.: Greenhaven Press, 1999. Collection of essays presents multiple thought-provoking points of view on topics related to drug abuse, including the severity of the drug-abuse problem, what programs are effective in reducing drug abuse, and whether select illegal drugs should be legalized.

See also: Club drugs; Crack cocaine; Crime scene screening tests; Drug abuse and dependence; Drug Enforcement Administration, U.S.; Drug paraphernalia; Hallucinogens; Homogeneous enzyme immunoassay; Mandatory drug testing; Meth labs; Opioids; Quantitative and qualitative analysis of chemicals; Stimulants.

Imaging

Definition: Capture and storage of both still and moving picture images that depict accurate impressions without compromising the image subjects.

Significance: Various imaging techniques enhance of the ability of crime scene investigators to preserve and analyze evidence in forms that help to protect it from damage or tampering. Image technicians are also trained in detecting forged and altered images.

During the often rushed work done during crime scene investigations, fragile details of evidence can be misinterpreted, tainted, or simply overlooked. Imaging helps to preserve original and uncontaminated visual details, making possible later analyses and graphic demonstrations for court presentations. The preserved images with which forensic scientists work are created with a variety of instruments, including still cameras, video cameras, night vision cameras, thermal imaging equipment, and imaging devices used primarily in the field of medicine.

So important is imaging to law-enforcement investigations generally that the techniques used and the legal implications of imaging are part of certification course work required of evidence technicians, surveillance personnel, arson investigators, and even patrol officers and other criminal justice professionals who are involved in preserving, documenting, and analyzing evidence. Modern imaging techniques often require the help of high-performance computer software and hardware for scanning and processing as well as forensic microscopes for analyses of handwriting images, fingerprints, and shoe prints and footprints.

Three types of camera systems are typically used at crime scenes: instant-print cameras, digital still-picture cameras, and video cameras. Each has certain advantages and disadvantages. For example, instant-print cameras make it possible for users to examine final images immediately; however, their image resolution and lens options are limited. Digital still cameras usually offer higher resolution than instant-print cameras; they also provide immediately viewable images, which can easily be transmitted. However, their storage media are vulnerable to electromagnetic damage, and they are completely dependent on power from batteries, which can fail. Video cameras offer the special advantage of being able to save images showing real-time motion; however, they also can fail if they are subjected to electromagnetic damage or their batteries give out. Another limitation of video cameras is that still images extracted from their moving pictures are usually of much poorer quality than those produced by still cameras.

Aided by image-processing algorithms, modern digital photography allows improvements in contrast and clarity over film images that can be achieved with little more than the click of a computer mouse. These processes facilitate not only image analysis but also data compression for storage and uncomplicated transmission of images. For example, the Federal Bureau of Investigation (FBI) uses a process called wavelet image compression to store and transmit fingerprints.

Imaging analysis is a growing science, and the courts require expert witnesses who draw on its tools to have had proper training. Qualified forensic imaging analysts must understand the laws regarding imaging evidence, and they are trained to prepare reports about visual evidence for possible presentation in court procedures. Analysts competent with video security systems have a basic understanding of imaging engineering standards. They can detect evidence of tampering on videotapes and can recover images from damaged tapes.

In addition to the recording of images at crime scenes, imaging techniques are applied in autopsy rooms, especially when signs of violence indicate soft-tissue damage or hemorrhage. This type of pathology is revealed through the use of multislice computed tomography (MSCT) and magnetic resonance imaging (MRI) prior to autopsy. As relatively new additions to the field of forensic imaging, these tools require more use by forensic investigators to establish their value. Nevertheless, they point to the power of computer-assisted enhancement and its growing importance in forensic science.

Richard S. Spira

Further Reading

Blitzer, Herbert L., and Jack Jacobia. *Forensic Digital Imaging and Photography*. San Diego, Calif.: Academic Press, 2002.

Buckley, Cara. "In Domestic Abuse, Digital Photos Can Say More Than Victims." *The New York Times*, May 7, 2007, p. B1.

Russ, John C. *Forensic Uses of Digital Imaging*. Boca Raton, Fla.: CRC Press, 2001.

See also: Biometric eye scanners; Composite drawing; Confocal microscopy; Crime scene documentation; Crime scene investigation; Facial recognition technology; Forensic photography; Iris recognition systems; Microscopes; Night vision devices; Oblique lighting analysis; Photograph alteration detection; Satellite surveillance technology; Scanning electron microscopy.

Immune system

Definition: Group of interacting cells and molecules inside a host organism whose function is to recognize and eliminate or neutralize foreign material such as pathogens or substances that enter the host organism.

Significance: Antibodies, which are products of the immune system, are used in many tests to detect, identify, and measure substances of interest—such as drugs, different types of biological evidence, and certain toxins—during criminal investigations. Without such antibody-based tests, some types of testing performed by forensic scientists would not be possible, and others would be much more expensive and time-consuming than they are.

The organization of the immune system can be described in various ways based on the physical and functional characteristics of the system's components. For example, the immune system can be divided into humoral (soluble molecules such as antibodies and complement) and cellular immune systems (white blood cells, or leukocytes). Another way to describe the immune system is to distinguish between the adaptive (or acquired) immune system and the innate (or natural) immune system.

The adaptive immune system exhibits a lag phase before response and great specificity for particular foreign materials; it has a "memory" for foreign materials and responds more quickly and strongly upon subsequent encounters. Prominent components of the adaptive immune system are white blood cells called T and B lymphocytes and molecules such as antibodies and T-cell antigen receptors. The natural immune system's response is immediate, does not alter in magnitude when reencountering foreign material, and operates against broad classes of materials. Prominent components of the innate immune system include molecules of the complement system and cells such as monocyte/macrophages, neutrophils, natural killer cells, eosinophils, mast cells, and basophils.

Cells and Functions

The cells of the immune system include different types of white blood cells that are also known as leukocytes. They all originate from the bone marrow and are found in tissues throughout the body as well as in specialized immune tissues such as lymph nodes and vessels, spleen, appendix, and tonsils. The cells have shared and unique functions such as engulfment of foreign particles (phagocytosis), release of microbe-killing molecules, and secretion of molecules called cytokines that affect leukocytes and other cells.

Cells such as B and T lymphocytes are capable of undergoing clonal expansion. That is, these lymphocytes consist of populations of distinct cells, each bearing a particular surface receptor capable of binding a particular foreign substance—an antigen. Upon binding a particular foreign substance, such a lymphocyte can divide to produce copies of itself (clones) that can produce more of the corresponding receptor for the foreign substance. In order to manipulate the immune system in the test tube or the body to produce substances useful in forensic testing, scientists employ detailed knowledge of the properties of immune system cells.

Antigens and Antibodies

Antigens are substances that provoke immune system responses, such as the generation of cells or antibodies that can specifically bind the antigens. Forensic scientists frequently encounter a number of antigens in their work, including hemoglobin, prostate-specific antigen (PSA), alpha amylase, and semenogelin. Other forensically significant antigens are carbohydrate substances such as ABO blood group antigens and Lewis antigens. Also of interest to forensic scientists are small parts of antigens known as haptens, which include drugs of abuse such as cannabis, heroin, cocaine, and amphetamines and their metabolites.

Antibodies are a class of proteins that are synthesized and secreted only by B lymphocytes, a subpopulation of white blood cells. The five classes of antibodies (termed IgG, IgM, IgA, IgE, and IgD) all have different structural and functional characteristics.

Antibodies are Y-shaped proteins, and the basic unit is composed of four polypeptide chains, two heavy chains and two light chains. Both light and heavy chains have "variable" regions that differ in composition among antibodies and "constant" regions that are identical or similar within a particular class of antibodies. The site on antibodies that binds antigen encompasses the tips of one heavy chain and one light chain in the arms of the Y-shaped antibody and involves the variable regions. The constant regions, depending on the class, may activate the complement system to lead to removal or destruction of materials foreign to the body or cause leukocytes to engulf antigens or secrete biologically active molecules.

To create antibodies for use as tools in forensic testing, a particular substance may be injected into an animal to elicit specific antibodies to that substance. (Among the animals commonly used for such purposes are mice, rats, rabbits, goats, and sheep.) The antibodies, termed polyclonals, can be isolated from the animal's blood and used as components in forensic tests for that substance. Such antibodies vary in potency.

Monoclonal antibodies are produced through the isolation of a particular lymphocyte secreting a particular antibody and propagation of the clones of that lymphocyte in culture. This provides unlimited amounts of a reproducible specific antibody to a particular antigen.

Forensic Applications of Immunology

In forensic science, antibodies are used extensively in the areas of serology and toxicology. In serology, antibodies are used in tests to detect and identify human blood, semen, and saliva stains. In toxicology, antibodies are used in tests for poisons and for drugs of abuse. (Like the drug tests performed by forensic scientists during criminal investigations, the tests widely used by some employers and sports leagues to screen employees and players for drugs of abuse and banned performance-enhancing substances are also antibody-based.)

Another example of the use of antibodies in forensic science is found in the area of DNA (deoxyribonucleic acid) analysis. Forensic scientists use a technique known as polymerase chain reaction (PCR) to make it possible to test minute quantities of DNA in evidence. In one version of the technique called hot-start PCR, the accuracy of the process is increased by the inclusion of an antibody to the DNA polymerase used.

Oluseyi A. Vanderpuye

Further Reading

Gaensslen, R. E. *Sourcebook in Forensic Serology, Immunology, and Biochemistry*. Washington, D.C.: National Institute of Justice, 1983. Comprehensive text covers all aspects of forensic serology.

Houck, Max M., and Jay A. Siegel. *Fundamentals of Forensic Science*. Burlington, Mass.: Elsevier Academic Press, 2006. Good source of information on the basics of biological fluids and techniques of serological analysis.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005. Introductory-level text provides illustrated explanations of forensic serology methods.

Kindt, Thomas J., Richard A. Goldsby, and Barbara A. Osborne. *Kuby Immunology*. 6th ed. New York : W. H. Freeman, 2007. Well-written text includes coverage of the scientific principles applied in forensic serology.

O'Gorman, Maurice R. G., and Albert D. Donnenberg, eds. *Handbook of Human Immunology*. 2d ed. Boca Raton, Fla.: CRC Press, 2008. Review of immunological basics includes discussion of techniques used in forensic serology.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007. Textbook discusses all subdisciplines within forensic science. Chapter 12 provides a general overview and history of forensic serology methods.

Sompayrac, Lauren. *How the Immune System Works*. 3d ed. Malden, Mass.: Blackwell, 2008. Very readable text on immunology includes discussion of forensic serology.

See also: Antibiotics; Biological terrorism; Biological warfare diagnosis; Biological weapon identification; Biosensors; Epidemiology; Homogeneous enzyme immunoassay; Presumptive tests for blood; Serology; Silicone breast implant cases.

Improvised explosive devices

Definition: Explosive weapons that are made of readily available materials and are concealed in some manner before detonation.

Significance: Improvised explosive devices are the main weapons used against conventional military forces during low-intensity conflicts. Such devices, which are used both to intimidate and to injure intended recipients, enable terrorists to inflict casualties without having to expose themselves to retaliation. Given the increasing threat of terrorism around the world, law-enforcement agencies must be familiar with the techniques used in the building and detonation of improvised explosive devices.

Improvised explosive devices (IEDs) are popular weapons among terrorists and insurgents. An IED consists of an explosive, a container to hold the different parts of the weapon, and a detonator. IEDs are effective and relatively easy to manufacture, requiring very little training to build. Persons who build IEDs often do so by following directions found in published manuals or on the Internet.

The use of IEDs was largely pioneered by T. E. Lawrence (known as Lawrence of Arabia), a British officer in the Middle East during World War I. Lawrence made effective use of mines, which he planted along railways to disrupt

After a bombing incident in Georgia in 1997, the Atlanta Bomb Task Force released this composite photograph showing the everyday items that had been used in the improvised explosive device. *(AP/Wide World Photos)*

transportation. IEDs have evolved since Lawrence's time to include a wider array of explosives and less conventional additions to the composition of the device. Many modern-day terrorists and insurgents plant IEDs along the sides of well-traveled roads to cause maximum damage to vehicles and personnel. Often, an IED explosion signals the onslaught of an ambush by armed insurgents or more IEDs.

IEDs are also employed by more traditional criminal offenders, who use them to intimidate or for the express purpose of killing or wounding their targets. In such cases, the IEDs are generally mailed or delivered to the homes or businesses of the intended targets.

IEDs can be triggered in a few different ways. When detonation is achieved by remote control or by cell phone, the individual setting off the weapon must be in the vicinity of the device. Alternatively, a timing mechanism may be employed, or the device may be booby-trapped so that it is triggered by the intended victim. In a method often used by insurgents, IEDs can be strung together and set to explode when any of the weapons in the string is detonated.

Very often, an IED explosion does not destroy all of the device's components. By examining all recovered remnants, forensic experts may be able to attribute the device to its source. Some IED makers leave "signatures" on their bombs that can help investigators link multiple bombings to the same suspect. In addition, investigators use infrared spectroscopy to examine residues left by an explosion to determine the elements that made up the explosive.

The type of triggering device used in an IED can provide investigators with a meaningful clue, particularly as to motive. If the bomb was booby-trapped, the intent was likely to kill the victim. In contrast, if the IED was triggered by a timer, it is possible that it was designed as a message to the recipient.

Michael W. Cheek

Further Reading

Beveridge, Alexander, ed. *Forensic Investigation of Explosions*. New York: Taylor & Francis, 1998.

Schubert, Hiltmar, and Andrey Kuznetsov, eds. *Detection and Disposal of Improvised Explosives*. Dordrecht, Netherlands: Springer, 2006.

Yinon, Jehuda, ed. *Counterterrorist Detection Techniques of Explosives*. New York: Elsevier, 2007.

See also: Airport security; Ballistics; Bloody Sunday; Bomb damage assessment; Bombings; Bureau of Alcohol, Tobacco, Firearms and Explosives; Driving injuries; Oklahoma City bombing; Unabomber case; World Trade Center bombing.

Infrared detection devices

Definition: Instruments capable of detecting the presence of infrared light.

Significance: Because infrared light is present in the heat given off by the human body, infrared detection devices are useful for law-enforcement and military personnel who need to locate persons who are hidden, whether by darkness or by line of sight. Such devices are also sometimes used to detect other sources of heat that may be of interest to law enforcement, such as the lamps that are often used in the growing of marijuana indoors.

Infrared light is the part of the electromagnetic spectrum that involves wavelengths longer than those that can be seen by the human eye (visible light) but shorter than microwaves. Infrared light is divided into three subcategories: near infrared, mid-infrared, and far infrared. Near infrared has the shortest wavelengths, and far infrared has the longest wavelengths. The heat given off by most objects as thermal energy is far infrared.

Most infrared detection devices are designed to detect the infrared waves given off by an object that is emitting heat, such as a live person or animal. Many such devices can detect objects as cold as –20 degrees Celsius (–4 degrees Fahrenheit) and as hot as 2,000 degrees Celsius (3,200 degrees Fahrenheit). Many are also extremely sensitive and can detect temperature differences of less than a single degree.

Infrared detection devices work by collecting the infrared waves that are emanating from the area in question and then analyzing the data received. The data are then presented in a user-friendly form, usually as a visual display in which different temperatures are represented by different colors. Many infrared detection devices also have complex software to help enhance the images for greater usability. Infrared detection devices are available in many sizes and types, from handheld devices and goggles to large machines that require constant cooling. Generally, smaller, portable devices are less accurate than larger ones, but they also tend to be less fragile. Some infrared detection devices include cameras that allow them to record infrared information.

Infrared detection devices have many different uses that can benefit law-enforcement personnel. Such instruments can be used to find persons who are hidden behind bushes, fences, or walls or who are otherwise obscured from view. They can also be used to search for suspects at night, especially when police officers do not want to give away their own locations by using flashlights and other visible search equipment. Law-enforcement personnel can also use infrared detection devices from helicopters to search the ground below, such as to follow fleeing suspects. These instruments are also sometimes used to scan rows of cars to determine if any of them have recently had their engines running.

Helen Davidson

Further Reading

Henini, Mohamed, and Manijeh Razeghi, eds. *Handbook of Infrared Detection Technologies*. New York: Elsevier, 2002.

Rogalski, Antoni, ed. *Selected Papers on Infrared Detectors: Developments*. Bellingham, Wash.: SPIE Press, 2004.

See also: Breathalyzer; Electromagnetic spectrum analysis; Federal Bureau of Investigation; Fourier transform infrared spectrophotometer; Micro-Fourier transform infrared spectrometry; Night vision devices.

Inhalant abuse

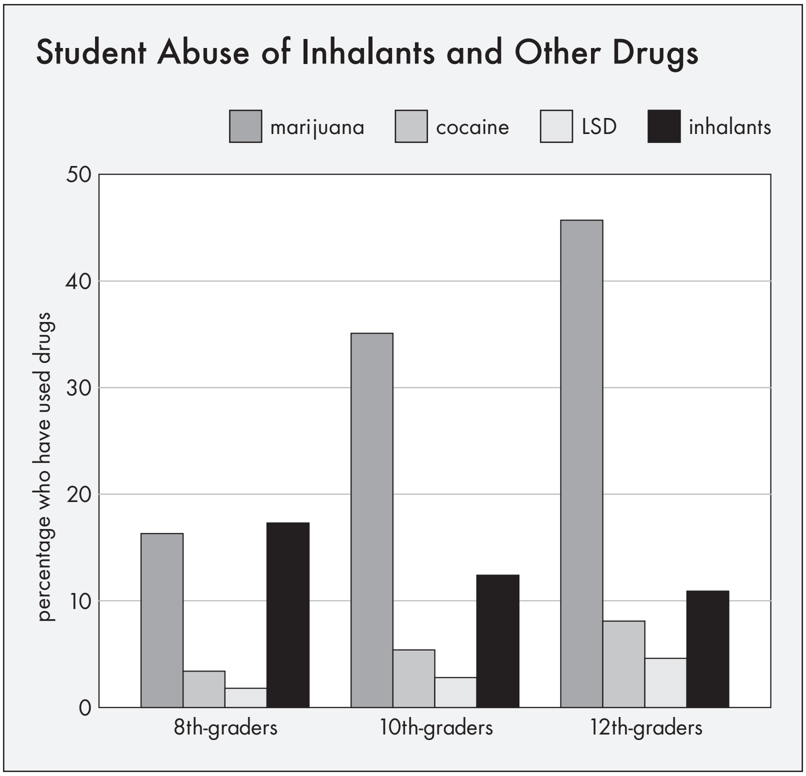
Definition: Form of illegal drug use involving the inhaling of otherwise legal chemicals to obtain a high.

Significance: Abuse of inhalants is a drug crime, but defining it as such presents a problem because almost all the substances typically involved in such abuse are completely legal. Illegal drugs are usually defined as illegal by their chemical makeup. In the case of inhalant abuse, however, it is not the inhaled substances that are illegal but the ways in which they are used. This makes the investigation of such abuse particularly difficult for law-enforcement agencies.

Inhalant abusers, many of whom are young people, may generally be described as falling into one of three categories: experimenters, intermittent users, or chronic users. Experimenters are those who have used inhalants on only one or a few occasions. Intermittent users use inhalants every once in a while but not on a regular basis. Chronic users are those who use inhalants on a weekly or daily basis; these users may form a psychological or physical dependence on the inhaled substances. Inhalant use is known by a number of colloquial terms, including huffing, sniffing, and bagging.

History

Inhalant abuse is common among young people in many countries throughout the world, including Mexico, Brazil, Japan, and the United Kingdom. It is often seen in countries that have high proportions of young people who are very poor, because the substances involved are readily available to anyone. In contrast, inhal-



Source: National Institute on Drug Abuse, Monitoring the Future Survey, 2004.

ant abuse is relatively rare in some Southeast Asian countries where hard-core drugs are readily available.

Inhalant abuse is known to have been present in the United States during the 1920's and 1930's during Prohibition, when alcohol was illegal, but it was not until the early 1960's that this behavior was perceived as a problem and law-enforcement agencies began making many arrests. A spike in inhalant use was perceived to take place during the mid-1990's, probably owing to a population increase among young teenagers—the age group most likely to use these substances. Because no federal guidelines have been established regarding inhalant abuse, individual U.S. states have been left to address the issue on their own. Many states have crafted specific statutes regarding inhalant use, but instead of focusing only on penalties for use, the statutes often stress education as a means of prevention.

Categories of Inhalants

The National Institute on Drug Abuse divides inhalants into the following categories:

Volatile Solvents

- Industrial or household solvents or solvent-containing products, including paint thinners or removers, degreasers, dry-cleaning fluids, gasoline, and glue.
- Art- or office-supply solvents, including correction fluids, felt-tip-marker fluid, and electronic contact cleaners.

Aerosols

- Household aerosol propellants and associated solvents in items such as spray paints, hair or deodorant sprays, fabric protector sprays, aerosol computer-cleaning products, and vegetable oil sprays.

Gases

- Gases used in household or commercial products, including butane lighters and propane tanks, whipping cream aerosols or dispensers (whippets), and refrigerant gases.
- Medical anesthetic gases, such as ether, chloroform, halothane, and nitrous oxide ("laughing gas").

Nitrites

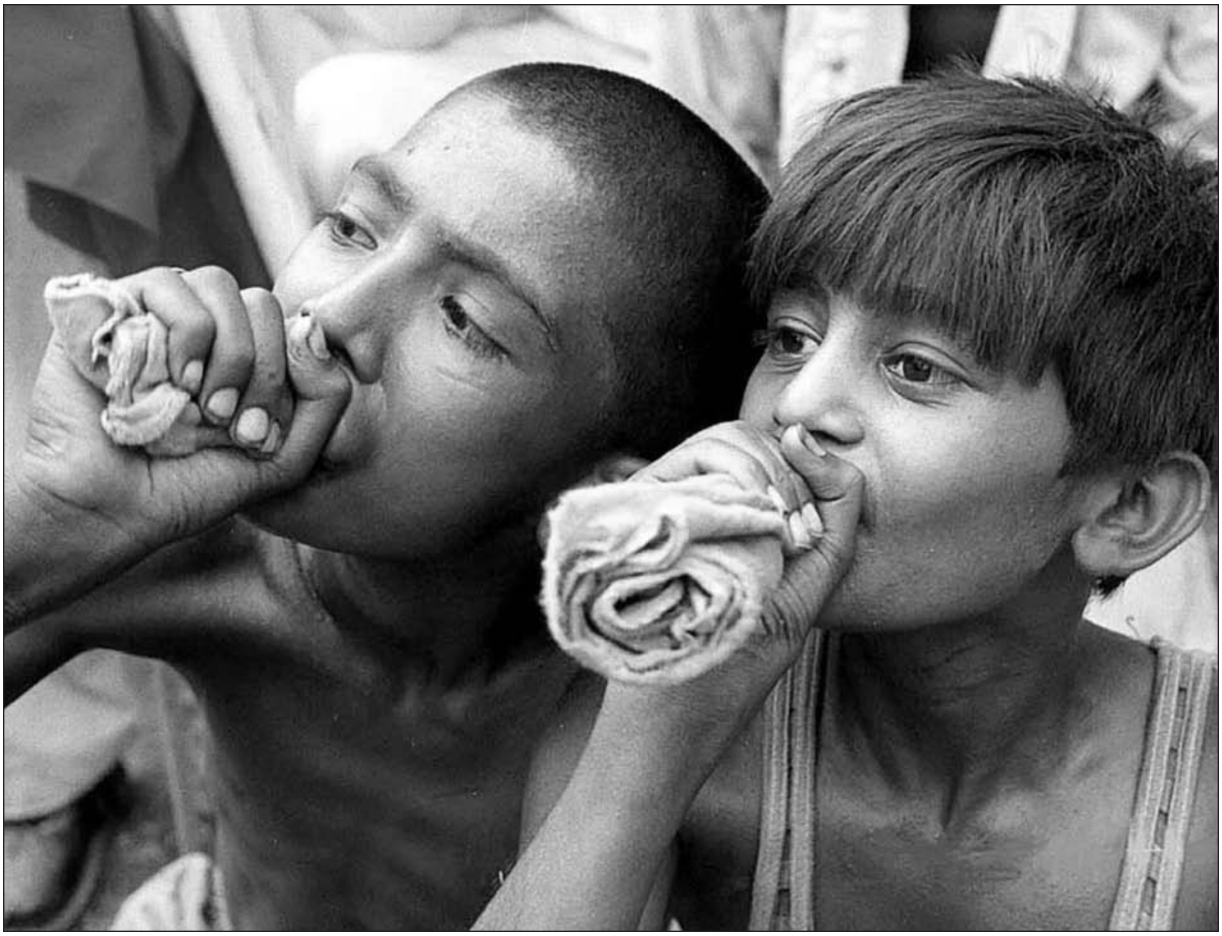
- Organic nitrites are volatiles that include cyclohexyl, butyl, and amyl nitrites, commonly known as "poppers." Amyl nitrite is used in certain diagnostic medical procedures. Volatile nitrites are often sold in small brown bottles labeled as "video head cleaner," "room odorizer," "leather cleaner," or "liquid aroma."

Forms of Use and Abuse

In the United States, it is estimated that inhalant use is the most common form of drug abuse among ten-, eleven-, and twelve-year-olds, and use may begin as early as third grade (about eight years of age). Most users quit the practice by the time they are twenty years old. Some observers have speculated that inhalant use may lead to the use of harder drugs, but this so-called gateway function of inhalants has not been established empirically.

The substances involved in inhalant abuse are poisonous and pose significant hazards to young people. The danger depends on both the amount that is inhaled and the chemical composition of the substance inhaled. Because the amount inhaled is not well controlled, the danger from inhaling too much substance is significant.

The substances that can be inhaled are almost limitless—anything that is in a liquid, aerosol, or gas form can be used. Commonly abused products include gasoline, kerosene, nail polish remover, glue, felt-tipped markers, lighter fluid, spray paint, and hair spray. Gases that may be inhaled include propane, butane, and nitrous oxide. Inhaling benzene, a component of gasoline, increases the user's risk of leukemia and lowers immune function. Inhaling propane, found in lighter fluid, can produce serious cardiac effects. Freon, an aerosol propellant, can cause respiratory obstruction and liver



Two young Pakistani boys inhale the fumes of an ether-based solvent from cloths. The abuse of inhalants is a growing problem around the world, particularly in poor countries. *(AP/Wide World Photos)*

damage. Toluene, found in gasoline and paint thinners, can cause damage to the brain, liver, and kidneys. Nitrous oxide, sometimes referred to as laughing gas, can cause blackouts and cardiac effects.

Because inhalants replace oxygen in the lungs, asphyxiation, suffocation, convulsions, choking, and coma may result. Death may also result from cardiac arrest if the user experiences a sudden surge in adrenaline while under the influence of inhalants; this phenomenon is known as sudden sniffing death syndrome.

How Investigations Are Conducted

Isolated instances of inhalant abuse are not likely to come to the attention of law enforcement. It is usually only after a community begins to perceive the existence of an inhalant problem—perhaps after one or more users have died—that organized efforts are undertaken to arrest individuals and address the issue. Because most law-enforcement agencies place priority on higher-level drug problems, such as trafficking and use of heroin, cocaine, and so-called club drugs, inhalant use is more likely to be approached as a public health problem. Many American communities address the issue of inhalant abuse through education at the middle and high school levels. When law enforcement becomes involved, it is often to break up groups that use inhalants or to address widespread usage in a high school or community.

Law-enforcement agencies must approach the investigation of inhalant use in ways that are very different from those used to address other types of drug use. They cannot apprehend upper-level dealers who are bringing large amounts of inhalants into their jurisdictions because there are no such dealers—these substances are readily available in every household, business, church, and school. Law-enforcement authorities cannot even look for evidence of illegal substances, because most inhaled substances are completely legal.

The kinds of evidence available in a case of inhalant abuse may include inhaling paraphernalia, inhaled substances, blood tests, and the suspect's observable behavior. The suspect's observable behavior—which may be similar to that of an individual who has used alcohol—is frequently enough for an officer to have reasonable suspicion that a substance has been used. The individual can be arrested and taken into custody. At the police station, the suspect's blood is taken for testing and confirmation of inhalant use. The paraphernalia used for inhaling (which may include bags, aerosol cans, bottles, and rags) may contain traces of the inhaled substances, thus indicating that these items have been used for this illegal activity.

Ayn Embar-Seddon and Allan D. Pass

Further Reading

Julien, Robert M. *A Primer of Drug Action: A Comprehensive Guide to the Actions, Uses, and Side Effects of Psychoactive Drugs*. 10th ed. New York: Worth, 2005. Describes how drugs are absorbed and processed by the body as well as their effects on the body and mind.

Koellhoffer, Tara. *Inhalants and Solvents*. New York : Chelsea House, 2008. Provides basic information on inhalant drug use.

Kuhn, Cynthia, Scott Swartzwelder, and Wilkie Wilson. *Buzzed: The Straight Facts About the Most Used and Abused Drugs from Alcohol to Ecstasy*. 2d ed. New York: W. W. Norton, 2003. Easy-to-read guide provides basic information on commonly used drugs. Devotes a full section to inhalants.

Weatherly, Myra. *Inhalants*. Berkeley Heights, N.J.: Enslow, 1996. Describes the various substances that users inhale for a quick high and the toxic effects of such substances. Also discusses the social aspects of inhalant abuse.

Weil, Andrew, and Winifred Rosen. *From Chocolate to Morphine: Everything You Need to Know About Mind-Altering Drugs*. Rev. ed. Boston: Houghton Mifflin, 2004. Discusses the broad range of substances that affect the mind. Includes a chapter on solvents and inhalants.

See also: Club drugs; Drug abuse and dependence; Drug paraphernalia; Illicit substances; Psychotropic drugs.

Innocence Project

Date: Founded in 1992

Identification: Organization based at the Benjamin N. Cardozo School of Law at Yeshiva University that assists wrongfully convicted prisoners in using DNA evidence to prove their innocence.

Significance: The Innocence Project has helped to exonerate more than two hundred wrongfully convicted persons in the United States, fifteen of whom were serving time on death row. The wrongful convictions that this organization has helped to overturn have been attributed to a number of different factors, including eyewitness misidentification, reliance on unreliable or limited science, false confessions, fraud or misconduct on the part of forensic scientists, misconduct on the part of prosecutors or police, false testimony from informants, and incompetent legal representation.

The Innocence Project asserts that the wrongful convictions uncovered by the organization's work indicate that the American criminal justice system is in need of reform. Toward that end, the Innocence Project is involved in developing policy to strengthen the criminal justice system by addressing such issues as prisoner access to postconviction DNA (deoxyribonucleic acid) analysis, evidence preservation, eyewitness identification reform, crime lab oversight, compensation for those who have been exonerated, and the creation of a national criminal justice reform commission.

Eyewitness Misidentification

Approximately 75 percent of the wrongful convictions that have been overturned by the Innocence Project were based at least in part on eyewitness misidentification. In one case, a witness identified a suspect in a poorly lit parking lot in the middle of the night while the witness was sitting inside a police car positioned hundreds of feet away from the alleged perpetrator. In another case, a witness was shown an assortment of photos from which the witness identified a person as the perpetrator of the crime, but it was later revealed that the police had placed a mark on one of the photos in the assortment to indicate to the witness which suspect the police believed was the perpetrator. Other cases have been uncovered in which witnesses changed their descriptions of perpetrators after the witnesses were given information about particular suspects.

False Confessions and False Witness Testimony

In more than 25 percent of the cases of wrongful conviction overturned by the Innocence Project, the innocent defendants made incriminating statements or pleaded guilty to crimes they did not commit. It is difficult to understand why anyone would confess to a crime he or she did not commit, but research has shown that some false confessions may be attributable to the fact that some people, particularly those with mental disabilities and disorders, may be persuaded or manipulated relatively easily into agreeing with authority figures. Individuals who have

Larry Fuller (center) leaves a Dallas courthouse in October, 2006, after his exoneration based on DNA evidence. Convicted of aggravated rape in 1981, Fuller spent twenty-five years in prison before the Innocence Project won his release. Flanking Fuller are Innocence Project lawyers Vanessa Potkin and Barry Scheck. *(AP/Wide World Photos)* been subjected to lengthy interrogations will sometimes confess to crimes they did not commit as a means to put an end to their discomfort; often they do so believing that they will be able to prove their innocence later. In addition, police interrogators sometimes tell suspects that the only way they can avoid the death penalty is to confess to the crimes of which they are being accused.

Some people are wrongfully convicted because of false testimony given by others. In more than 15 percent of the Innocence Project cases that have been overturned through new DNA evidence, so-called jailhouse informants testified against the defendants. Such informants may have many different reasons to fabricate testimony. The Innocence Project has overturned convictions of people who were convicted based on the testimony of individuals who were paid by the prosecution to testify, inmates who testified in exchange for release from prison, and informants who testified in exchange for immunity from criminal prosecution.

False Convictions

False convictions have long been a concern of responsible members of the criminal justice community. In the eighteenth century, British theorist and philosopher Jeremy Bentham, whose ideas influenced the U.S. Constitution and the American criminal justice system, called false convictions "mis-seated punishment." Modern research concerning the causes and frequency of false convictions did not begin until the early twentieth century, when Yale law professor Edwin Borchard published case studies of sixty-five false convictions that occurred in the United States between 1812 and 1930. Borchard's pioneering work was followed, from the 1950's through the early 1980's, by a small number of other publications identifying additional cases.

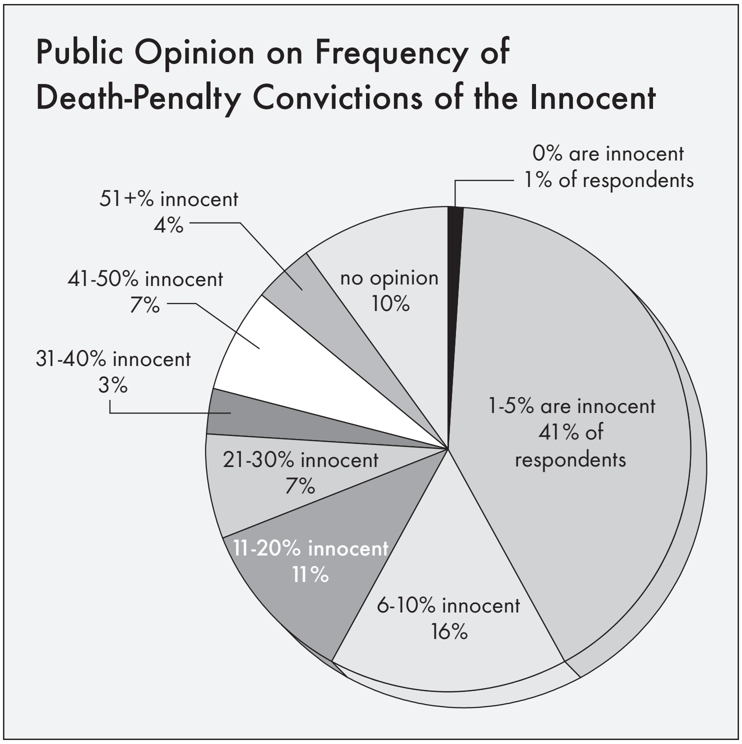
During the mid-1980's, the topic of false convictions began receiving increased attention from both researchers and the popular media, primarily as a result of the unprecedented availability of DNA testing. With growing frequency since that time, prisoners who have claimed they were convicted in error have sought to have old evidence that was used to convict them—particularly specimens such as blood, hair, tissue, and semen—reexamined using the latest techniques of DNA analysis. Between 1989—when the first DNA-based exoneration occurred—and 2008, more than two hundred convicted individuals were cleared in the United States based on the results of DNA testing.

Robert J. Ramsey

Misinterpretation or Misrepresentation of Forensic Evidence

In some cases, convictions overturned by the Innocence Project were based on various forms of scientific and technical evidence (such as blood typing, hair comparison, bite marks, and ballistics) that lack the scientific certainty of DNA evidence. In one case, a scientific expert witness told the jury that biological evidence matched a defendant's blood type but did not mention that this same biological evidence also matched the blood type of 41 percent of the general public. In another case, a bite mark was incorrectly matched to a defendant, with the result that he was found guilty and sentenced to death. Another person was wrongfully convicted when the jury was told that hair evidence matched the hair of the defendant and that the hair evidence could belong to only one in ten thousand people, even though this assertion was statistically impossible to prove.

The Innocence Project has also exonerated people who were wrongfully convicted because forensic scientists falsely testified, exaggerated their statistics, or engaged in laboratory fraud. It was uncovered that a former director of the West Virginia state crime lab fabricated results, lied in court about results, and willfully omitted evidence from his reports. This expert testified for the prosecution at trials in twelve states over the course of his career—more than a dozen cases in West Virginia alone. In Chicago, a lab technician's false testimony regarding evidence sample matches resulted in the conviction of at least eight defendants. DNA evidence was used to exonerate these defendants years after they were convicted.



Source: Gallup Poll taken in June, 2000. Respondents were asked their opinions regarding how often innocent people had been sentenced to death during the previous twenty years.

In another case, the director of the Houston Police Department's crime lab testified that hair found in a sexual assault victim's underwear could have belonged to the defendant and that blood evidence showed that biological fluids found on the victim came from the defendant. The man was convicted, but later DNA testing showed that the hair sample could not have been his and that the blood evidence could have belonged to an alternative suspect. The case was overturned after the man had spent seventeen years in prison for a crime he did not commit.

Incompetent Counsel

Many critics have asserted that the criminal justice system in the United States is economically biased against the poor, and this bias is exacerbated when indigent suspects are assigned incompetent or overburdened legal representation. In some of the worst cases taken on by the Innocence Project, convictions have been overturned because lawyers slept in the courtroom during trial, were disbarred shortly after finishing death penalty cases, failed to investigate their defendants' alibis, failed to call or consult experts on forensic issues, or failed to show up for hearings.

In one case in which a man was accused of the brutal rape of an eight-year-old girl, the defense attorney performed no investigation, filed no pretrial motions, gave no opening statement, provided no expert to refute the testimony of the state's hair microscopy expert (which was later found to be fraudulent), did not prepare closing arguments, and filed no appeal. The defendant was convicted and spent fifteen years in prison before the Innocence Project was able to use DNA evidence to prove that he did not commit the crime.

Daniel Pontzer

Further Reading

Junkin, Tim. *Bloodsworth: The True Story of the First Death Row Inmate Exonerated by DNA*. Chapel Hill, N.C.: Algonquin Books, 2004. Relates the experiences of a man who was wrongfully convicted, in part because of eyewitness misidentification, and his subsequent release from prison.

Kobilinsky, Lawrence F., Thomas F. Liotti, and Jamel Oeser-Sweat. *DNA: Forensic and Legal Applications*. Hoboken, N.J.: Wiley-Interscience, 2005. Presents a general overview of the uses of DNA analysis in the American criminal justice system.

Lazer, David, ed. *DNA and the Criminal Justice System: The Technology of Justice*. Cambridge, Mass.: MIT Press, 2004. Thought-provoking collection of essays explores the ethical and procedural issues related to DNA evidence.

Rudin, Norah, and Keith Inman. *An Introduction to Forensic DNA Analysis*. 2d ed. Boca

Raton, Fla.: CRC Press, 2002. Provides a good introduction to the use of biological evidence in forensics as well as the history and application of DNA fingerprinting in forensic investigations.

Scheck, Barry, Peter Neufeld, and Jim Dwyer. *Actual Innocence: Five Days to Execution, and Other Dispatches from the Wrongly Convicted*. New York: Random House, 2000. Describes some of the most prominent and successful cases taken on by the Innocence Project. Also offers commentary on the shortcomings of the American system of criminal justice.

See also: Competency evaluation and assessment instruments; DNA analysis; DNA database controversies; DNA profiling; Ethics; Ethics of DNA analysis; Eyewitness testimony; Interrogation; Postconviction DNA analysis; Wrongful convictions.

Insanity defense

Definition: Legal defense tactic used in the hope of reducing the culpability of criminal defendants.

Significance: When defendants invoke the insanity defense tactic (also known as the "not guilty by reason of insanity" plea), or when they plead guilty but mentally ill, the burden is on their defense teams to establish that when they committed their crimes they were incapable of distinguishing between right and wrong, they were unable to resist their impulses, or their criminal actions were products of mental defects or diseases.

The history of the insanity defense goes back to at least early fourteenth century England, where the "good and evil" test involving a child under the age of seven was developed in 1313. In 1724, the standard changed to the "wild beast" test. During that year, the case of *Rex v. Arnold* involved a defendant who had tried to kill a British nobleman; the defense argued that he was behaving like a wild beast, not like a thinking human being. The wild beast test was then used under English law until the early nineteenth century, when English courts developed the "right and wrong" test. Under that rule, juries had to determine if defendants understood that what they had done was wrong and whether they understood the consequences of their actions.

The principle used in modern insanity defense tactics was first recognized in England in 1843 in the case of Daniel M'Naghten. A delusional man, M'Naghten shot and killed the secretary to British prime minister Robert Peel, thinking he was killing Peel, because he believed that the government was plotting against him. He was tried for murder but acquitted on the grounds of insanity. The principle established in the M'Naghten case was later adopted by most of the states in the United States, where it has become known as the M'Naghten rule.

An insanity defense plea is considered a form of an "excuse defense" because defendants using it admit to having committed the criminal acts for which they are accused while simultaneously claiming they were not responsible for those acts at the time they committed them. In most regions of the United States, defendants using the insanity defense plead "not guilty by reason of insanity," but a modern trend permits some defendants to plead "guilty but mentally ill." The two pleas mean essentially the same thing, however, and both result in defendants' spending time in mental facilities until they are judged no longer to be threats to society.

Defendants found not guilty by reason of insanity often spend more time in mental institutions than they would spend in ordinary prisons if they were simply found guilty of their crimes. However, in its *Foucha v. Louisiana* (1992) decision, the U.S. Supreme Court ruled that inmates found not guilty by reason of insanity may not remain institutionalized indefinitely. In *Clark v. Arizona* (2006), the Supreme Court ruled that states have the right to alter or abolish their insanity defenses. As a consequence of that ruling, not all states offer the insanity defense as an option for defendants. For example, Montana, Idaho, Nevada, Kansas, and Utah

Mark Twain on the Insanity Defense

Throughout his long writing career, Mark Twain often railed against what he regarded as flaws in the American legal system. In 1870, while he was an editor of the Buffalo Express, *he published a sketch in that newspaper titled "A New Crime," in which he objected to the frequency with which confessed murderers were winning acquittals through the insanity defense. This extract shows the gist of his objections.*

This country, during the last thirty or forty years, has produced some of the most remarkable cases of insanity of which there is any mention in history. . . .

Is not this insanity plea becoming rather common? Is it not so common that the reader confidently expects to see it offered in every criminal case that comes before the courts? And is it not so cheap, and so common, and often so trivial, that the reader smiles in derision when the newspaper mentions it? And is it not curious to note how very often it wins acquittal for the prisoner? Of late years it does not seem possible for a man to so conduct himself, before killing another man, as not to be manifestly insane. If he talks about the stars, he is insane. If he appears nervous and uneasy an hour before the killing, he is insane. If he weeps over a great grief, his friends shake their heads, and fear that he is "not right." If, an hour after the murder, he seems ill at ease, preoccupied and excited, he is unquestionably insane.

Really, what we want now, is not laws against crime, but a law against *insanity*. There is where the true evil lies.

have formally abolished it. Montana and Utah, however, permit judgments of guilty but mentally ill.

Types of Insanity Defenses

To be acquitted of crimes on the basis of legal insanity, defendants must generally demonstrate that they were suffering from certain psychoses at the time they committed their crimes. Legally acceptable psychoses include schizophrenia, schizoaffective disorder, and bipolar disorder. Defendants suffering from antisocial personality disorders must also establish that they suffered from another of the Axis I disorders listed in the American Psychiatric Association's *Diagnostic and Statistical Manual of Mental Disorders*. However, it is difficult for forensic psychologists to attribute specific criminal behavior to an Axis I disorder. Merely having a mental disorder does not make an individual eligible for the insanity defense.

Each American state that allows insanity defenses recognizes one of four basic types of defenses: the M'Naghten rule, the Durham rule, the substantial capacity test, or the irresistible impulse test. The M'Naghten rule requires judges and jurors to determine whether defendants understood at the time they committed their criminal acts that those acts were wrong. This standard was used by nearly all jurisdictions in the United States through the mid-twentieth century.

In 1954, the Durham rule came into being through a U.S. Court of Appeals decision in the case of *Durham v. United States*. This rule holds that defendants are not responsible for their behavior if their crimes were the outcome of mental diseases or defects. The Durham rule expanded the insanity defense to include scientific findings regarding mental illness and developed a "product test." In other words, an accused person is not deemed criminally responsible for unlawful acts if the actions were the "product" of the mental disease or a mental defect. The ruling in *Durham v. United States* left open to debate the questions about how a lack of responsibility should be defined and what burden of proof is necessary.

In 1972, another case in a federal appeals court, *United States v. Brawner*, led to the replacement of the Durham rule in federal courts by the new substantial capacity test (also known as the ALI standard). This test holds that defendants should not be held criminally responsible for their acts if mental disease or defects rob them of the capacity to understand that what they have done was wrong, or if they cannot conform their actions to the law. This broader understanding assumed that mental impairment might rob people not only of the ability to judge the legality of their acts but also of their ability to judge the morality of their actions.

A fourth method of determining whether a person can be considered legally insane is the irresistible impulse test. Under this test, defendants may be found not guilty by reason of insanity even when they know that what they have done was wrong, if they can prove that they were unable to control their behavior because of mental diseases or defects. As in all insanity defense cases, the burden of proof lies with the defendants.

Insanity Defense Reforms

In 1981, John Hinckley shot President Ronald Reagan in Washington, D.C., in a failed assassination attempt. When he was later acquitted of attempted murder through his use of the insanity defense, public outrage led to changes in the law. At the same time, professional organizations fought to keep the insanity defense, so a compromise was reached. In 1984, the U.S. Congress passed the Insanity Defense Reform Act (IDRA), which essentially required federal courts to revert to the old M'Naghten rule. The law also explicitly shifted the burden of proof for establishing insanity from prosecution to the defense and limited the use of expert testimony in trial.

Afterward, two-thirds of the states followed the federal government's lead by altering their own laws. Twelve states adopted the "guilty but mentally ill" test, sixteen shifted the burden of proof, twenty-five made it more difficult for defendants found not guilty by reason of insanity to be released from institutions, and seven made it more difficult to apply the plea of not guilty by reason of insanity by narrowing the substantive test. Moreover, defendants were subsequently required to show clear and convincing evidence that they were legally insane at the moments they committed their crimes; this change represented a change from their having merely to present a preponderance of evidence in their favor.

In the history of the United States, no type of defense has created as much controversy as the insanity defense. Contrary to popular belief, however, the insanity defense is actually used only rarely and mostly in cases not involving deaths of victims. Moreover, it is rarely successful when it is raised and is generally applied in cases in which both the defense and prosecution agree that there has been a significant lack of responsibility on the part of the defendants. It is rare for defendants to fake insanity and even rarer for them to win acquittals by doing so.

Temporary Insanity

Temporary insanity is a defense that is related to the insanity defense. It differs in having

Burden of Proof

The concept of burden of proof encompasses two types of burdens: the burden of production and the burden of persuasion. In criminal cases, the prosecution bears the burden of production; it must offer sufficient evidence to support a claim. If it does not proceed with its initial presentation of evidence supporting an action, the case will not move forward, and the judge has authority to terminate the proceedings. The prosecution meets this burden in various ways: presenting physical evidence, introducing exhibits, and presenting witnesses to testify about events related to the case. The burden of production generally remains with the prosecution and does not shift in criminal cases. However, when defendants raise defenses that require proof, such as insanity, the burden of production shifts.

The burden of persuasion requires presentation of evidence that will convince juries that certain parties should prevail. Juries, not judges, make those determinations. Juries must measure the facts that they find from the evidence according to three standards of proof. First is the preponderance, or weight, of the evidence, in which plaintiffs must tip the scales, indicating that there is more credible or convincing evidence on one side than on the other (used in civil cases only). The second is clear and convincing evidence that attains a higher standard of proof than preponderance of the evidence. The third and highest standard is proof beyond a reasonable doubt, which is required in all criminal cases.

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defendants claim they were legally insane at the time they committed their crimes but are currently legally sane. A successful use of this defense generally allows a defendant to be released with no requirement for psychiatric treatment. This defense was first used in New York in 1859 by Congressman Daniel Sickles after he killed his wife's lover. However, since the 1950's, it has rarely been successful.

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Further Reading

Fersch, Ellsworth L. *Thinking About the Insanity Defense: Answers to Frequently Asked Questions with Case Examples*. Lincoln, Nebr.: iUniverse, 2005. Covers everything from the history of the insanity defense to controversies surrounding it. Highlights all relevant information with sixteen case examples.

Perlin, Michael L. *The Jurisprudence of the Insanity Defense*. Durham, N.C.: Carolina Academic Press, 1993. Critiques public concerns about possible abuses of the insanity plea.

Robinson, Daniel. *Wild Beasts and Idle Humors: The Insanity Defense from Antiquity to the Present*. Cambridge, Mass.: Harvard University Press, 1998. Focuses on the social contexts that have surrounded changes to the insanity defense over time.

Rogers, Richard, and Daniel W. Shuman. *Conducting Insanity Evaluations*. 2d ed. New York: Guilford Press, 2000. Examines the substantive issues in criminal law regarding the insanity defense, bringing together clinical and legal issues.

Simon, Rita James. *The Jury and the Defense of Insanity*. 1967. Reprint. New Brunswick, N.J.: Transaction, 1998. Delves into the motivations and competencies of jurors with respect to how they understand expert testimony and judges' instructions regarding the insanity defense.

Steadman, Henry J., et al. *Before and After Hinckley: Evaluating Insanity Defense Reform*. New York: Guilford Press, 1993. Identifies changes in the insanity defense from 1978 to 1990 and examines the impacts of these changes on acquittals, pleas, and confinement. Includes discussion of the abolition of the insanity defense and the impact of the "guilty but mentally ill" plea.

Weiner, Irving B., and Allen K. Hess, eds. *Handbook of Forensic Psychology*. 3d ed. Hoboken, N.J.: John Wiley & Sons, 2006. Discusses the application of forensic psychology to criminal and civil cases. Provides information on expert witnesses and professional issues.

See also: ALI standard; Competency evaluation and assessment instruments; Expert witnesses; Forensic psychiatry; Forensic psychology; Guilty but mentally ill plea; Irresistible impulse rule; Legal competency; *Mens rea*; Minnesota Multiphasic Personality Inventory.

Insects. *See* Forensic entomology

Integrated Automated Fingerprint Identification System

Date: Became operational in July, 1999

Identification: Automated national system, maintained by the Federal Bureau of Investigation, for collecting, analyzing, and comparing digital copies of human fingerprints.

Significance: Containing digitized fingerprint records of more than fifty-five million subjects, the electronic database of the Integrated Automated Fingerprint Identification System has made revolutionary contributions to increasing the efficiency of law-enforcement investigations throughout the United States by collecting, storing, and sharing forensic information that can be rapidly searched on computers.

Digital image of a latent fingerprint as viewd on a computer screen. *(AP/Wide World Photos)*

More commonly known as IAFIS, the Integrated Automated Fingerprint Identification System is operated by the Criminal Justice Information Service (CJIS) Division of the Federal Bureau of Investigation (FBI). The system is a technologically advanced automated fingerprint database that allows law-enforcement agencies throughout the United States to share information. The system is built on the largest biometric global database of fingerprints and related criminal history information in the world and uses advanced computer technology to enable extremely fast fingerprint matches. Before the development of this technology, manual fingerprint searches could take technicians weeks, months, and sometimes even years to process and thereby greatly slowed down investigators' attempts to identify offenders during criminal investigations.

IAFIS offers several basic services, not all of which have direct criminal justice applications. For example, the service's Civil Ten-Print Fingerprint Submission program is used by many civilian companies and institutions for background checks for employment, issuing licenses, and other functions not necessarily related to criminal justice concerns. By contrast, the service's Criminal Ten-Print Fingerprint Submission program collects copies of complete ten-digit sets of fingerprints of persons arrested by all levels of law enforcement throughout the country. The automated system converts the prints to an electronic format that can be searched online. The Subject Search and Criminal Histories Services and the Interstate Identification Index segments of IAFIS store federal and other government agency fingerprint images of arrested suspects. The Latent Fingerprint Services supports electronic unidentified latent fingerprints and unsolved files.

IAFIS offers uninterrupted, around-the-clock service to crime investigators at all levels of government. When state and local agencies submit requests for electronic fingerprint data to the service, they generally receive responses within two hours. This time-saving technology has revolutionized the field of fingerprint identification by supporting law enforcement's historical efforts to classify and search forensic evidence as quickly as possible. Rapid matching of fingerprint evidence helps criminal investigators resolve their cases while other evidence remains fresh, thereby increasing arrest and conviction rates.

Criminals never leave prints as complete and perfectly rolled at crime scenes as those that police stations collect on cards when they process arrestees. Indeed, experienced fingerprint technicians often feel fortunate to collect only a few latent or partial prints at crime scenes. Another contribution to law enforcement made by IAFIS technology has been the greater ease with which it can match incomplete and imperfect prints.

Among the standing goals of IAFIS is increasing its connections, or interoperability, with other agencies and with law-enforcement bodies throughout the world. The FBI also actively seeks to broaden the range of its biometric identification capabilities, particularly with the IDENT system used by the U.S. Department of Homeland Security to process immigration data requests. By 2008, IAFIS had begun development on its Next Generation Identification (NGI) system to connect with the IDENT system to increase the efficiency of identifying criminals, suspected terrorists, and undocumented aliens attempting to enter the United States. The Next Generation system will be designed to incorporate such biometric identification features as facial recognition, iris scans, palm authentication, and possibly applications using DNA data. These upgrades continue to improve the volume, accuracy, and speed of IAFIS responses while meeting the increasing interoperability requirements of the twenty-first century.

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Further Reading

Komarinski, Peter. *Automated Fingerprint Identification System*. St. Louis: Elsevier/Academic Press, 2005.

Lee, Henry C., and R. E. Gaensslen, eds. *Advances in Fingerprint Technology*. 2d ed. Boca Raton, Fla.: CRC Press, 2001.

Ogle, Robert R., Jr. *Crime Scene Investigation and Reconstruction*. 2d ed. Upper Saddle River, N.J.: Prentice Hall, 2007.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007.

See also: Ballistic fingerprints; Biometric identification systems; CODIS; DNA fingerprinting; Ear prints; Facial recognition technology; Federal Bureau of Investigation Forensic Science Research and Training Center; Federal Bureau of Investigation Laboratory; Fingerprints; Integrated Ballistics Identification System; Interpol; National Crime Information Center; Prints; Superglue fuming.

Integrated Ballistics Identification System

Date: Adopted by the U.S. government in 1993

Identification: Automated computer system operated under a branch of the federal Bureau of Alcohol, Tobacco, Firearms and Explosives that compares firearms evidence collected at crime scenes with the ever-growing body of ballistics information stored within its own database.

Significance: The two primary functions of the Integrated Ballistics Identification System are data acquisition and signature analysis. By consolidating and sharing ballistics information collected throughout the United States in a single database, the system makes important contributions to federal, state, and local law enforcement by providing data and expertise that few agencies could afford on their own. The data and services it provides help forensic investigators identify the specific weapons and ammunition used in the commission of crimes.

The Integrated Ballistics Identification System, or IBIS, operates under the Firearms Program Division of the National Integrated Ballistic Information Network (NIBIN), a branch of the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) that helps coordinate and link independent criminal investigations across widespread jurisdictions. The IBIS technology was originally developed by a Canadian corporation, which sold it to the U.S government in 1993.

IBIS is based on the principle that bullets fired from any specific weapon carry "signatures" that are unique to that weapon, much as human fingers leave unique prints. Computer matches of bullets fired from known weapons and those recovered from crime scenes make it possible to identify the specific weapons used in the commission of crimes by matching both class and individual characteristics. Firearms recovered from crime scenes or taken from suspects are test fired and digital images of the bullets are created that can be compared with bullets collected from crime scenes. The signature data analysis station scans the digitally cap-

An IBIS Success Story

During October of 2002, motorists around Washington, D.C., and northern Virginia were terrorized by a mysterious series of random sniper attacks. With the possible exception of the shooting of a Federal Bureau of Investigation employee, no motivation for the shootings was apparent, and the victims appeared to be unrelated. Moreover, the snipers fired from concealed positions within the trunk of their moving vehicle, inaccurate descriptions of which slowed the police investigation. The only solid clues investigators collected were bullet fragments recovered from the sniping incidents. The snipers eventually attempted to extort a ransom in return for stopping their attacks. Meanwhile, however, the National Integrated Ballistic Information Network analyzed bullets and casings from the crime scenes and, using IBIS, matched the evidence to previously recorded digital images in the database. This information ultimately led to the arrest and conviction of two suspects.

A Maryland State Police colonel demonstrates the use of the Integrated Ballistics Identification System. The computer monitor displays the markings on a bullet that the system is comparing with bullets in the IBIS database. *(AP/Wide World Photos)* tured images of bullets and shell casings, and each image is assigned its own distinctive mathematical signature. Ballistics technicians then search the IBIS database for possible matches.

IBIS data analysis technicians focus their efforts on retrieving missing pieces of firearms by analyzing and comparing side-by-side digitized images. Examinations of bullet and shell casing evidence often yield the digitized bullet profile signatures and individual characteristics that are unique to the weapons that fired them. Successful "hits" are defined as linkages in at least two investigations. When they are found, firearms examiners manually compare the bullet or cartridge case evidence using comparison microscopes for final determinations.

The information provided by IBIS to federal, state, and local law-enforcement agencies has made a significant contribution in deterring violent crimes. The value of IBIS continues to increase as its database and partnerships with law-enforcement agencies across the United States grow.

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Further Reading

DiMaio, Vincent J. M. *Gunshot Wounds: Practical Aspects of Firearms, Ballistics, and Forensic Techniques*. Boca Raton, Fla.: CRC Press, 1998.

Heard, Brian J. *Handbook of Firearms and Ballistics: Examining and Interpreting Forensic Evidence*. New York: John Wiley & Sons, 1997.

Warlow, Tom. *Firearms, the Law, and Forensic Ballistics*. 2d ed. Boca Raton, Fla.: CRC Press, 2005.

See also: Ballistic fingerprints; Ballistics; Bureau of Alcohol, Tobacco, Firearms and Explosives; Firearms analysis; Gunshot residue; Integrated Automated Fingerprint Identification System; National Crime Information Center.

International Association for Identification

Date: Formed in October, 1915

Identification: Organization of professionals dedicated to advancing forensic science techniques used for identification purposes.

Significance: The International Association for Identification is the oldest established organization of forensic specialists involved in education, certification, and the creation of guidelines used by law-enforcement agencies around the world.

Started in California as the International Association for Criminal Identification in 1915, the International Association for Identification (IAI) has grown to be one of the largest professional forensic organizations in the world, with more than six thousand members in all fifty U.S. states and sixty countries. The IAI provides certification and recertification programs in areas specific to forensic investigations, including fingerprint collection and analysis, blood pattern examination, crime scene investigation, footwear and tire-track examination, forensic photography, and forensic art. Requirements for certification in any given area typically include both classroom training and practical field and lab experience. For example, to be eligible for blood spatter certification, an applicant must have at least a week of formal training and at least three years of practical on-the-job experience.

The IAI is involved in the development and advancement of new forensic identification techniques and sponsors groups of experts who work closely with law-enforcement agencies, including the Federal Bureau of Investigation (FBI). Guidelines established by the IAI cover areas such as detection, collection, evaluation, identification, reporting, and storage of forensic evidence. Working groups have also been formed around relatively new developments in forensics, such as imaging technologies and digital evidence. More traditional ar-

Among the functions of the International Association for Identification is providing educational opportunities for forensic professionals, such as this dig at a mock grave site at Mount Charleston in Nevada, which was offered as part of the organization's annual conference in 2002. *(AP/Wide World Photos)*

eas, such as latent prints and blood spatter, continue to be studied as well, as the investigation techniques related to these areas change and advance. As new methods of identification are developed, the IAI becomes involved in creating guidelines and in providing specific training in the techniques related to each type of forensic evidence.

Among the functions of the IAI is the training of forensic scientists, and the organization provides a number of educational opportunities designed to meet the needs of the forensic community. It holds an annual conference that combines educational workshops, technical presentations, and certification training into a weeklong event. In addition, local chapters of the IAI sponsor courses related to specific certification areas throughout the year. The IAI also publishes the bimonthly *Journal of Forensic Identification*, which features informative articles written by forensic authorities from around the world.

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Further Reading

McCartney, Carole. *Forensic Identification and Criminal Justice: Forensic Science, Justice, and Risk*. Portland, Oreg.: Willan, 2006.

Polski, Joseph P. "The Science Behind Forensic Science." *Science* 304, no. 5669 (2004): 389.

Thompson, Tim, and Sue Black, eds. *Forensic Human Identification: An Introduction*. Boca Raton, Fla.: CRC Press, 2007.

See also: American Academy of Forensic Sciences; Argentine disappeared children; Blood

spatter analysis; Crime scene investigation; European Network of Forensic Science Institutes; Fingerprints; Forensic photography; Training and licensing of forensic professionals.

International Association of Forensic Nurses

Date: Founded in 1992

Identification: Professional organization that supports and promotes the science of forensic nursing and advocates for forensic nurses worldwide.

Significance: The International Association of Forensic Nurses is the only international professional organization for registered nurses that works to develop and support the science of forensic nursing and to publicize the work of forensic nurses nationally and internationally.

The International Association of Forensic Nurses (IAFN) was established in 1992 when a group of sexual assault nurses held their first national convention in Minneapolis, Minnesota. By 2008, the organization had grown to twenty-six state chapters in the United States and a membership of more than two thousand, including nurses and other professionals in more than sixteen nations around the world. Members include students, forensic scientists, emergency medical technicians, and physicians as well as nurses.

The IAFN is devoted to promoting the practice of forensic nursing and disseminating information about the field of forensic nursing science. Forensic nursing encompasses activities in many areas in which the nursing profession and the legal system intersect, particularly the areas of child and elder abuse, domestic violence, and emergency trauma. For example, forensic nurses may investigate and collect evidence in incidents involving trauma and questionable deaths; treat perpetrators and victims of violence, abuse, and traumatic accidents; conduct physical and mental health examinations; provide consultation services to health, medical, and legal agencies; and serve as expert witnesses regarding adequacy of health care and services. Forensic nurses practice in diverse roles, including as members of disaster response teams, as sexual assault nurse examiners (SANEs), as legal nurse consultants and attorneys, as medicolegal death investigators, as nurse educators, and as researchers.

The IAFN has established standards of ethical conduct for forensic nurses and works to improve forensic nursing practice, to promote and encourage the exchange of ideas among members and others in the profession, and to develop knowledge in the field of forensic nursing by offering educational opportunities for nurses and professionals in related disciplines. Toward these ends, the association holds an annual international conference at which issues of forensic nursing practice are discussed. The organization is also involved in an effort to integrate prevention strategies to stop interpersonal violence around the world.

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Further Reading

Hammer, Rita M., Barbara Moynihan, and Elaine M. Pagliaro, eds. *Forensic Nursing: A Handbook for Practice*. Sudbury, Mass.: Jones & Bartlett, 2006.

Lynch, Virginia A. *Forensic Nursing*. St. Louis: C. V. Mosby, 2006.

Nelson, Valerie. "Shattering the Myths About Forensic Nursing." *NurseWeek*, July 13, 1998.

Pyrek, Kelly M. *Forensic Nursing*. Boca Raton, Fla.: CRC Press, 2006.

Stevens, Serita. *Forensic Nurse: The New Role of the Nurse in Law Enforcement*. New York: Thomas Dunne Books, 2004.

See also: American Academy of Forensic Sciences; Forensic nursing; Forensic pathology; Forensic toxicology; International Association of Forensic Sciences; Living forensics; Rape kit; Thanatology.

International Association of Forensic Sciences

Date: Inaugurated in 1957

Identification: Professional organization created to enable forensic professionals from diverse geographic locations and forensic specialties to share their research and insights.

Significance: Through its triennial conferences, the International Association of Forensic Sciences enhances scientific forensic work by enabling collaboration among colleagues from many countries. The sharing of information that takes place at these professional meetings has served to improve forensic practices worldwide.

Dr. Charles Philip Larson (1910-1984), a pathologist whose forensic experiences included post-World War II examinations of concentration camp victims, recognized that international forensic professionals pursuing various specialties needed to be able to discuss their work with peers regardless of where they were based professionally. In 1957, Larson served as president of the International Meeting of Forensic Medicine in Brussels and Ghent, Belgium. The organization that would become the International Association of Forensic Sciences (IAFS) emerged from that meeting, where forensic scientists agreed to gather every three years. They refined their ideas over time, agreeing on the IAFS name at a meeting in Copenhagen, Denmark, in 1966 and approving a constitution three years later during a conference in Toronto, Ontario.

Unlike other forensic organizations, the IAFS does not enroll members or maintain a central office. Instead, former IAFS presidents form a council that designates new presidents, who plan conferences in their countries. Several hundred people attended early IAFS meetings, with attendance varying according to geopolitical situations and expanding as increasing numbers of forensic professionals became aware of IAFS's benefits. Approximately thirteen hundred scientists from fifty-five countries participated in the 2005 IAFS conference, which was held in Hong Kong.

The triennial meetings usually feature unifying themes, such as terrorism or fraudulent documents, that are of interest to forensic scientists globally. Papers, seminars, and workshops held during the conferences explore numerous forensic fields, and attendees tour forensic laboratories near the meeting sites. The locations of some conferences influence the discussions rather directly, such as when forensic experts at the 1996 IAFS conference in Tokyo, Japan, described their work regarding the 1995 sarin gas attacks on the Tokyo subway system.

Forensic professionals have used IAFS conferences to create additional global forensic opportunities. Groups such as the World Police Medical Officers, the International Association of Forensic Toxicologists, and the International Organization for Forensic Odonto-Stomatology have held meetings during IAFS conferences, and information regarding the International Reference Organization in Forensic Medicine (INFORM) has been presented at IAFS meetings. The International Forensic Summit provided 2005 IAFS conference attendees with a day of sessions focused on how forensic scientists can work together globally. IAFS leaders arranged for publication of the conference proceedings, and abstracts were also printed in issues of *Forensic Science*, the *Journal of Clinical Forensic Medicine*, and *Forensic Science International*.

The association created the H. Ward Smith Memorial Award, named for an early IAFS president, to honor global achievements in forensic scientific work. At the 1990 meeting, which was held in Adelaide, South Australia, the IAFS introduced the Adelaide Medal, which recognizes people whose accomplishments have had impacts on the forensic sciences worldwide. In addition to the awards presented by the IAFS, international forensic awards are sometimes presented by other related organizations while many of the world's leading forensic scientists are gathered at the IAFS meetings; one such award is the Douglas M. Lucas Medal, presented by the American Academy of Forensic Sciences. The recipients of these awards often present lectures at IAFS meetings.

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Further Reading

International Association of Forensic Sciences. *Proceedings of the Twelfth Meeting of the International Association of Forensic Sciences: Adelaide, 24-29 October 1990*. Harrogate, North Yorkshire, England: Forensic Science Society, 1991.

Obafunwa, John. "Fourteenth Meeting of the International Association of Forensic Sciences, Tokyo, Japan, 26-30 August 1996." *Journal of Clinical Forensic Medicine* 4 (March, 1997): 45-46.

See also: American Academy of Forensic Sciences; American Society of Crime Laboratory Directors; European Network of Forensic Science Institutes; Federal Bureau of Investigation Forensic Science Research and Training Center; International Association for Identification; International Association of Forensic Nurses; International Association of Forensic Toxicologists; Interpol; National Crime Information Center.

International Association of Forensic Toxicologists

Date: Founded on April 21, 1963

Identification: Worldwide professional organization that promotes cooperation and coordination among stakeholders in the field of forensic toxicology.

Significance: As environmental concerns have increased around the world, the legal community's need for qualified forensic toxicologists has risen also. The International Association of Forensic Toxicologists provides an arena for the advancement of ideas, knowledge, analytical techniques, research, education, and training in forensic toxicology.

Forensic toxicology was not developed into an academic discipline in the United States until the late twentieth century. The creation of three certification boards helped to professionalize the field: the American Board of Clinical Chemistry, the American Board of Forensic Toxicology, and the American Board of Toxicology. The International Association of Forensic Toxicologists (TIAFT) has continued the work of promoting the advancement of forensic toxicology as a discipline by bringing together members from more than eighty-eight nations. TIAFT members come from many different professional backgrounds, including policing, athletic medicine, law, pharmacology, and toxicology.

TIAFT's activities are governed by a constitution that was adopted soon after the organization was created in 1963 and was last amended in 2001. The official language of the association is English, and four levels of membership are offered: full, student, sponsor, or honorary. The association elects an executive board every third year; the positions of president and president-elect are limited to single terms. The association collects annual dues, appoints regional representatives, maintains a Web site, and publishes a quarterly bulletin for its members.

One of TIAFT's specific goals is to engage professionals from varied backgrounds who have an interest in the area of forensic toxicology or related areas of analytical toxicology. The association also promotes and encourages research in forensic toxicology and the interpretation of results from these analyses for its members. Discussions and exchanges among members concerning their professional experiences in the field as well as in education and training in forensic toxicology are also encouraged. The association holds at least one scientific meeting every year.

As forensic toxicology grows as a science, the need for professionals versed in the identification of poisonous substances is also on the rise in relation to legal endeavors. Whether they are isolating poisons involved in crimes or diseases, analyzing evidence in sports doping cases, or identifying the illegal or prescribed drugs involved in cases of abuse or overdose, forensic toxicologists who provide accurate, impartial, and understandable analyses are in high demand. The need for forensic toxicologists is further compounded by rising concerns about toxic substances in homes and workplaces and the growing global concern with environmental pollution and contamination involving human-made toxins. TIAFT recognizes the importance of toxicology and aims to advance the field by providing a forum for its growth and development.

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Further Reading

Hayes, A. Wallace, ed. *Principles and Methods of Toxicology*. 5th ed. Philadelphia: Taylor & Francis, 2007.

Klaassen, Curtis D., ed. *Casarett and Doull's Toxicology: The Basic Science of Poisons*. 7th ed. New York: McGraw-Hill, 2007.

Trestrail, John Harris, III. *Criminal Poisoning: Investigational Guide for Law Enforcement, Toxicologists, Forensic Scientists, and Attorneys*. 2d ed. Totowa, N.J. : Humana Press, 2007.

See also: Air and water purity; American Academy of Forensic Sciences; Arsenic; Controlled Substances Act of 1970; Food poisoning; Forensic toxicology; International Association of Forensic Sciences; Opioids; Toxicological analysis.

Internet tracking and tracing

Definitions: Internet tracking is the collection of information about the Web sites and chat rooms visited by Internet users, as well as e-mails and instant messages sent and received. Internet tracing consists of following selected Internet activity between senders and receivers.

Significance: To determine whether particular persons have used the Internet to commit crimes, and later to prove in legal settings that such crimes were committed, law-enforcement authorities have to track suspects' Internet activities. This forensic work often requires tracing how suspects use the Internet.

Law-enforcement authorities can use Internet tracking and tracing to identify and prosecute persons who are responsible for irresponsible or malicious Internet activity. Internet tracking and tracing are used, for example, in the identification, capture, and conviction of those who mount denial-of-service (DoS) attacks against online companies. In such attacks, the perpetrators attempt to stop particular Internet sites from functioning. In a DoS case that took place in February, 2000, a number of Web sites—including those of Yahoo, CNN, and eBay—were overrun, and essentially disabled, by requests that were orchestrated by a young boy in Montreal, Canada, who used the alias "Mafiaboy."

Agents for the Federal Bureau of Investigation (FBI) and the Royal Canadian Mounted Police (RCMP) began to suspect that Mafiaboy was behind the DoS attacks after they tracked activity in an Internet chat room. After they established that Mafiaboy was a suspect, they used standard software to trace his URL (uniform resource locater)—that is, his online address—and obtain his IP (Internet protocol) address. With this information, they obtained permission to tap the suspect's telephone and recorded his descriptions of the DoS attacks in subsequent phone conversations. Mafiaboy ultimately pleaded guilty to fifty-six charges related to his DoS attacks. Although estimates differ, it is generally agreed that his attacks caused more than one million dollars' worth of damage to the companies he victimized.

Tracking and Tracing Tools

The activities of Internet tracking and tracing are often done by humans. For example, undercover agents might pose as children in online chat rooms to catch child predators. Humans also inspect Internet log files heuristically to detect the misuse of browsers to search the Internet for illegal items such as drugs and weapons.

Many of the forensic tools used for Internet tracking and tracing are computer programs that are designed to search chat rooms, Web sites, and e-mail automatically. For example, MySpace partnered with Sentinel Tech Holding Corporation to build a sexual predator database and search program that could automatically discover sexual predators using MySpace. The effort was so successful that several state attorneys general demanded and received predator information from MySpace to assist in the prosecutions of sexual predators in their states.

"Honey pots" are network resources that law-enforcement authorities use to fool potential online attackers into thinking they can easily perpetrate attacks; the authorities then let the attacks occur and collect important information about the attackers from these activities. Most honey pots are Web sites, but a number of wireless access-point honey pots have been developed to defend against those attacking wireless networks. Honey pots have been very successful tools for the early identification of computer hackers and crackers.

Tracking Individual Users

Employers and concerned parents of Internet-using children sometimes use Internet tracking to detect and then prevent or control undesirable Internet behavior. This type of tracking is generally done at individual computers with software programs that record every keystroke made by users. Individual Internet tracking software packages record such information as instant messages, chat, and e-mails sent and received; peer-to-peer file searching and swapping; Internet search strings typed; Internet sites visited; and Web-oriented programs used. By installing an individual tracking package on each computer, a company can encourage all employees to make proper use of the Internet, catch those employees who abuse the Internet, and document the company's efforts to secure its computer systems.

Home and corporate products aimed at defending against malware (malicious software, including viruses and worms) often have databases of dangerous sites that function to stop users from visiting those sites. These software packages also keep records of users' attempts to access forbidden sites, such as pornography sites; this could be valuable information for parents, employers, or law-enforcement agencies if they need to prove that particular users have been misusing their Internet access.

Tracking at Routers and Firewalls

Some of the most important Internet tracking done by organizations takes place at border routers and firewalls, where it is routine to inspect all incoming Internet traffic. If a firewall serves as a bastion host, for example, it will check all requests of the corporate Web server for known attackers. Also, all e-mails arriving at an organization's e-mail post office are usually checked for viruses, with attachments opened and scanned as well. In addition to tracking incoming traffic, it is common for computer systems to track outgoing traffic as well. Some famous cases in which the American public has been made aware of this type of tracking have occurred at the White House. During the Clinton administration, the White House e-mail archives were important because they allowed the tracking of communications between President Bill Clinton and intern Monica Lewinsky. During the presidency of George W. Bush, the log files of official and unofficial White House e-mail traffic appeared to be significant in the investigation of the firings of several federal attorneys.

Internet tracing to determine all routers used in the sending of Web requests or e-mails is also an important activity carried out by both individuals and organizations, including law-enforcement agencies. Numerous computer programs have been designed to carry out automatic traces to find the home addresses of online attackers or e-mail senders. For example, several Internet security packages intended for home use can provide the home IP addresses of suspected Web server attacks with a simple mouse click on the URL.

The U.S. government tracks Web activity and e-mail use as part of ongoing efforts to defend against potential terrorist threats. For example, for a period the FBI used a system known as Carnivore to monitor e-mails sent and received as a tool for identifying, deterring, and prosecuting terrorists. Public uproar over the use of such a system caused the government to drop the project, but the FBI is reported to have replaced Carnivore with commercial products that collect much of the same desired information.

George M. Whitson III

Further Reading

Almulhem, Ahmad, and Issa Traore. *Experience with Engineering a Network Forensics System*. New York: Springer, 2005. Emphasizes the capture, recording, and analysis of network packets and events for investigative purposes.

Berghel, Hal. "The Discipline of Internet Forensics." *Communications of the ACM* 46 (August, 2003): 15-20. Surveys the new field of Internet forensics, which was created in response to the activities of computer crackers and hackers.

Mandia, Kevin, Chris Prosise, and Matt Pepe. *Incident Response and Computer Forensics*. 2d ed. Emeryville, Calif.: McGraw-Hill/Osborne, 2003. Covers incident response as well as attacks and includes several chapters on Internet incident responses.

Marcella, Albert J., and Robert S. Greenfield, eds. *Cyber Forensics: A Field Manual for Collecting, Examining, and Preserving Evidence of Computer Crimes*. Boca Raton, Fla.: CRC Press, 2002. Collection of case studies offers a basic introduction to the practical aspects of computer forensics. Includes several chapters on Internet forensics.

Shinder, Debra Littlejohn. *Scene of the Cybercrime: Computer Forensics Handbook*. Rockland, Mass.: Syngress, 2002. Bridges the gap between the computer professionals who provide the technology for cybercrime investigations and the law-enforcement professionals who investigate the crimes.

Vacca, John R. *Computer Forensics: Computer Crime Scene Investigation*. 2d ed. Hingham, Mass.: Charles River Media, 2005. Provides a good introduction to computer forensics. Devotes several chapters to Internet forensics.

See also: Computer crimes; Computer forensics; Computer Fraud and Abuse Act of 1984; Computer hacking; Computer viruses and worms; Cryptology and number theory; Cyberstalking; Identity theft; Steganography; Telephone tap detector.

Interpol

Date: Established in 1923

Identification: The largest international police organization in the world, more formally known as the International Criminal Police Organization.

Significance: Interpol's forensic experts have cemented an international partnership with law-enforcement agencies throughout the world.

Founded in Austria in 1923 as the International Criminal Police Commission, Interpol was headquartered in Vienna until 1942, when it moved to Berlin. After World II, the organization's headquarters shifted to Belgium, from which it later moved to its present location, Lyon, France. Financed by contributions from 186 member nations, Interpol is concerned primarily with public safety; specifically, Interpol focuses on communication among nations with regard to terrorism; trafficking in drugs, weapons, or human beings; money laundering; child pornography; and white-collar and computer crime. Interpol's staff, which includes citizens of approximately eighty nations, includes various law-enforcement specialists who receive and dispense information in four official languages: Arabic, English, French, and Spanish. Interpol's Command and Co-ordination Centre operates twenty-four hours a day and functions as a first point of contact for any member nation involved in a crisis situation.

Forensic Services

Interpol serves as a clearinghouse for law-enforcment forensic managers, offering them the most recent information available for their countries. One of the primary services Interpol offers its member nations is fingerprint information from its international database. When member-country agencies submit fingerprints to Interpol headquarters for identification, they must do so according to specific guidelines. In addition to sending the fingerprints to be identified (palm prints and facial prints may also be submitted), they must provide Interpol with precise information concerning the suspects, including full descriptions and information on the offenses with which the persons are being charged.

Recognizing the value of DNA (deoxyribonucleic acid) profiling as an investigative tool, Interpol adopted a resolution in 1998 to secure international cooperation on the use of DNA in criminal investigations. The Interpol DNA Unit was established to pursue DNA profile comparisons across international borders. DNA profiles contain no information per se about individuals' physical or psychological characteristics or health histories. Rather, such profiles consist of lists of numbers based on the patterns of individuals' DNA; because each person's DNA profile is unique, such profiles can be used to identify individuals. DNA samples obtained from hair, blood, or other body fluids collected from crime scenes are used to create DNA profiles, which can be compared with other genetic profiles within Interpol's DNA database.

Interpol promotes the increased use of DNA profiling through four main areas of interest: the Monitoring Expert Group, a panel of forensic experts who work to strengthen accreditation standards; the DNA Gateway, which facilitates the transfer of profile data between two or more countries; conferences that are held every two years to oversee developments in DNA technology; and regional support for solutions for the criminal identification process.

The support of Interpol's forensic experts is invaluable to member countries during the aftermath of major disasters, such as airplane crashes, earthquakes, and terrorist attacks. Comparisons of fingerprints, dental records,

An Interpol fingerprint specialist examines prints taken from bodies of tsunami victims in Phuket, Thailand, in January, 2005. Throughout the following year, Interpol deployed rotating teams of forensic scientists to Phuket to help identify nearly three thousand victims of the tsunamis that struck Southeast Asia in late 2004. *(AP/Wide World Photos)* and DNA with the records stored in Interpol databases can accelerate the processes of victim identification and recovery as well as the identification of possible attackers. Following the Southeast Asian tsunami of December, 2004, Interpol deployed rotating teams of officials in Phuket, Thailand, throughout 2005, who helped to identify nearly 3,000 of the 3,750 victims of that catastrophe. In the case of victim identification related to terrorism, Interpol's organized responses may help alert countries that have citizens among the victims.

The Structure of Interpol

- **General Assembly:** Interpol's supreme governing body, made up of delegates appointed by member countries, meets once a year and is responsible for making all important decisions concerning the organization's resources and finances, policies, working methods, activities, and programs.
- **Executive Committee:** The General Assembly elects this thirteen-member committee, which comprises the president of Interpol, three vice presidents, and nine delegates covering four regions.
- **General Secretariat:** Employing officials from more than eighty countries, the Secretariat, located in Lyon, France, is guided by the secretary-general of Interpol. The Secretariat also maintains six subregional bureaus (in Argentina, El Salvador, Ivory Coast, Kenya, Thailand, and Zimbabwe) as well as a liaison office at the United Nations in New York City.
- **National Central Bureaus:** Every member country establishes an Interpol National Central Bureau (NCB) within its own borders and staffs the bureau with national law-enforcement personnel. A country's NCB serves as its point of contact with the General Secretariat and with regional offices and other member countries seeking help with investigations.
- **Advisers:** These are scientific experts who serve purely advisory roles. Interpol advisers are appointed by the Executive Committee, and their appointments are confirmed by the General Assembly.

Public Image

Interpol's forensic specialists participate in conferences around the world, sharing vital information about identification, video analysis, and the implementation of law-enforcement support programs. Despite the romanticized depiction of Interpol officers in popular culture, including novels, films, and television programs, the Interpol constitution forbids the organization from providing any services to or receiving any services from individuals. Because Interpol's primary goal is to enable communication among law-enforcement agencies across the globe, the organization's efforts are focused on the maintenance of an integrated community network for member nations.

Mary Hurd

Further Reading

Anderson, Malcolm. *Policing the World: Interpol and the Politics of International Police Co-operation*. New York: Oxford University Press, 1989. Focuses on the need for cooperation among law-enforcement agencies around the world in ongoing attempts to address global crimes.

Bales, Kevin. *Disposable People: New Slavery in the Global Economy*. 2d ed. Berkeley: University of California Press, 2004. Combines case studies with information about the global economy in describing the extent of the problem of human trafficking.

Bannon, David Race. *Race Against Evil: The Secret Missions of the Interpol Agent Who Tracked the World's Most Sinister Criminals—A Real-Life Drama*. Far Hills, N.J.: New Horizon Books, 2006. Recounts the author's recruitment and training as a tracker, interrogator, and "eliminator" of child pornographers previously believed to be beyond the law. Interesting but unbelievable account illustrates the popular culture's view of Interpol.

Farr, Kathryn. *Sex Trafficking: The Global Market in Women and Children*. New York: Worth, 2004. Considers the impacts of the trafficking of one million people forced into the sex industry on a global scale.

Hall, Angus, ed. *The Crime Busters: FBI, Scotland Yard, Interpol*. 1976. Reprint. New York: Time Warner, 2002. Discusses the work of the agencies covered and presents information on their methods of criminal detection. Includes illustrations.

See also: Asian tsunami victim identification; CODIS; DNA analysis; DNA profiling; DNA sequencing; European Network of Forensic Science Institutes; Integrated Automated Fingerprint Identification System; International Association of Forensic Sciences; Interpol, U.S. National Central Bureau of; National Crime Information Center.

Interpol, U.S. National Central Bureau of

Date: Became operational in 1969

Identification: U.S. agency that operates under the guidelines of the Department of Justice and Homeland Security to facilitate cooperation between American law-enforcement representatives and Interpol (the International Criminal Police Organization).

Significance: The establishment of the U.S. National Central Bureau of Interpol served to foster international cooperation among police agencies within the contracting global community. The agency functions primarily to transmit information, to coordinate international investigations, and to respond to requests by law-enforcement agencies, organizations, and institutes affiliated with Interpol.

The U.S. National Central Bureau (USNCB) of Interpol is the link for both American and foreign police for all Interpol matters. It serves all American police organizations at the local, state, and federal levels and provides them with assistance in dealing with their counterparts in Interpol member countries concerning criminal and humanitarian matters. The USNCB also facilitates access for U.S. authorities to Interpol databases and in turn allows Interpol access to records in the U.S. Treasury Enforcement Computer System, the Federal Bureau of Investigation's National Crime Information Center, files of U.S. Immigration and Customs Enforcement, and records of the Drug Enforcement Administration. Because of control issues related to the sharing of information among countries, however, classified information is not provided to Interpol members. The USNCB posts all Interpol notices on behalf of U.S. authorities as well as alerts all U.S. authorities of Interpol notices by other countries.

The USNCB organizational structure includes a director, a deputy director, a general counsel, an executive officer, and six assistant directors, who are in charge of USNCB's six divisions: the Economic Crimes Division, the Drug Investigative Division, the Alien/Fugitive Investigative Division, the Terrorism and Violent Crimes Division, the State and Local Police Liaison Division, and the Interpol Operations and Command Center. The USNCB staff is composed of agents, analysts, computer and forensic specialists, translators, and administrative and legal personnel.

Because of the high numbers of foreign nationals living in or visiting the United States, American state and local law-enforcement authorities have experienced an increased need for assistance from international police agencies. To meet these demands, many U.S. cities have set up liaison offices to coordinate requests through the USNCB pertaining to international investigations that affect their jurisdictions. The USNCB also has bureaus in U.S. territories such as Puerto Rico, the U.S. Virgin Islands, and American Samoa.

Aside from providing invaluable information for investigations and securing global communication services for American and international law-enforcement agencies, the USNCB provides emergency operational support services for more than twenty thousand participating state and local law-enforcement agencies. Since its establishment, the USNCB has seen considerable growth, and its value as an investigative entity is likely to increase as crimes and criminals continue to cross international borders.

Shamir Ratansi

Further Reading

Anderson, Malcolm. *Policing the World: Interpol and the Politics of International Police Co-operation*. New York: Oxford University Press, 1989.

Fooner, Michael. *Interpol: Issues in World Crime and International Criminal Justice*. New York: Plenum, 1989.

Hall, Angus, ed. *The Crime Busters: FBI, Scotland Yard, Interpol*. 1976. Reprint. New York: Time Warner, 2002. Discusses the work of the agencies covered and presents information on their methods of criminal detection. Includes illustrations.

See also: Biological terrorism; Bombings; Chemical warfare; Federal Bureau of Investigation; Forgery; Interpol.

Interrogation

Definition: Questioning of suspects by law-enforcement personnel to determine their possible involvement in criminal activity under investigation.

Significance: The methods and circumstances of law-enforcement interrogation of suspects raise questions about practical effectiveness (what works in eliciting truthful responses), and they are also subject to requirements of ethical and legal propriety, the precise nature, scope, and justification of which are topics of ongoing social debate.

Criminal investigation involves the interviewing of witnesses and victims as well as more focused interrogation of (potential or actual) suspects. The verb "interrogate" suggests forceful questioning that has an adversarial (if not accusatory) character, and this raises issues of both effectiveness (What methods are likely to be effective?) and ethics (What methods are acceptable?).

Over time, older "third degree" methods of interrogation have given way to social pressures to sustain the integrity of individuals, even suspects, who may, after all, be innocent. The U.S. Supreme Court's 1966 ruling in *Miranda v. Arizona*—reinforcing the importance of the right to remain silent, the right not to be questioned except in the presence of legal counsel, and the right to be informed about these rights—is the best known of many decisions. The Court, however, has also declined to rule all police use of deception out of bounds (for example, in the case of *Frazier v. Cupp*, 1969).

Given legal limitations on police questioning—and in the absence of any really compelling purely physical technique (lie detector, "truth" serum, brain scans)—it has proved necessary for law enforcement to develop alternative approaches to interrogation, although some traditional techniques (such as "good cop/bad cop") remain popular.

The Reid Technique

One of the most widely influential models for questioning suspects is the Reid Technique, which was developed by John E. Reid and Associates, an organization that provides training in the technique. The Reid Technique involves an elaborate "nine steps" of interrogation. The heart of the technique consists in unwavering confidence in the suspect's guilt and the creative elaboration of alternative explanations (known as "theme development") that sympathetically provide the suspect with an opportunity to shift the blame for the criminal occurrence to other people or to circumstances. On one hand, the suspect's denial of involvement is limited, discouraged, or dismissed (on the principle that truly innocent suspects will not move past denial, no matter what, and that guilty suspects will find it more difficult to confess if they have frequently denied responsibility). On the other hand, the suspect is presented with a "choice" in which either option is an admission of guilt, but one appears more morally acceptable than the other. ("Did this just happen, or was it premeditated?" "Is this the first time this

A Chicago police lieutenant demonstrates the control panels from which video feeds from interview rooms can be monitored at the department's Area 1 headquarters. Since July 18, 2005, Illinois police departments have been required by law to videotape all interrogations in homicide cases. *(AP/Wide World Photos)*

has happened, or have you done this sort of thing frequently before?")

The Reid Technique originally grew out of work with the polygraph, but it has developed into a more general kind of behavioral assessment. Its proponents see it as carefully constructed not to be coercive in its elicitation of confessions, but rather to exploit the natural human psychology of self-justification. Critics view such techniques as insensitive to the complex decision situation faced by even innocent accused persons.

False Confessions

Modern forensic science recognizes the need to guard against false confessions, which have been proposed by social scientists as a leading cause of wrongful conviction. Richard A. Leo and his colleagues, for example, suggested in 2006 that of more than 170 established, DNA (deoxyribonucleic acid)-evidence-supported exonerations of wrongfully convicted persons, between one-fifth and one-fourth of the initial convictions had "resulted in whole or in part from police-induced false confessions."

Joseph P. Buckley, president of John E. Reid and Associates, has argued that the cases discussed by Leo and others "do not provide any scientific basis for the claim that police interrogation techniques that conform to the guidelines established by the courts result in false confessions." However, he does concede that they may have demonstrated that "illegal interrogation procedures can cause innocent people to confess." Leo and his colleagues believe that "properly trained" law-enforcement personnel understand the need for objective verification of confessions but recognize that many injustices may result from inadequate training or improper motivation of interrogators or from poor quality control. They argue that videotape recording of the entire process of interrogation would enable courts to detect the subtle influence of cognitive and emotional bias on the ability of suspects to make reasonable (and uncoerced) choices.

Harsh Interrogation

Especially since the destruction of the World Trade Center as the result of terrorist attacks on September 11, 2001, and the emergence of the "war on terrorism," questions about torture, once largely regarded as settled by the Geneva Convention and other international agreements, have reappeared in discussions about "harsh" or "enhanced" interrogation techniques. The discussion has not always distinguished which government agency (the Central Intelligence Agency, military intelligence, police) is treating which kind of suspect (terrorist, prisoner of war, enemy combatant).

With improbable but dire ("ticking bomb") examples, apologists have defended extreme measures in interrogation as "necessary." Critics have claimed that such measures produce unreliable information as well as violate fundamental moral principles. The long-term relevance of such measures to ordinary forensic practice (especially at the international level) remains to be seen.

Edward Johnson

Further Reading

Dershowitz, Alan M. *Is There a Right to Remain Silent? Coercive Interrogation and the Fifth Amendment After 9/11*. New York: Oxford University Press, 2008. Well-known Harvard Law School constitutional expert, a leading voice in the reassessment of torture, discusses the U.S. Supreme Court's treatment of preventive interrogation techniques.

Guiora, Amos N. *Constitutional Limits on Coercive Interrogation*. New York: Oxford University Press, 2008. Law professor with a background in the Israel Defense Forces discusses the tensions between national security and civil rights and argues for a "hybrid" category of detainees distinct from both prisoners of war and traditional criminals.

Inbau, Fred E., John E. Reid, Joseph P. Buckley, and Brian C. Jayne. *Criminal Interrogation and Confessions*. 4th ed. Boston: Jones & Bartlett, 2004. Standard work, sometimes referred to as the bible of interrogation, explains the widely utilized Reid Technique.

Leo, Richard A. *Police Interrogation and American Justice*. Cambridge, Mass.: Harvard University Press, 2008. A longtime critic of the role of interrogation in the production of false confessions offers a treatise on what he thinks is wrong with American police and judicial practices.

McCoy, Alfred W. *A Question of Torture: CIA Interrogation, from the Cold War to the War on Terror*. New York: Henry Holt, 2006. Presents a critical history of interrogation techniques used by the Central Intelligence Agency.

White, Welsh S. *Miranda's Waning Protections: Police Interrogation Practices After Dickerson*. Ann Arbor: University of Michigan Press, 2001. Discusses the movement away from the protections of the *Miranda* case.

See also: Brain-wave scanners; Cognitive interview techniques; Criminal personality profiling; False memories; Forensic psychology; Hostage negotiations; Innocence Project; *Miranda v. Arizona*; Polygraph analysis; Pseudoscience in forensic practice; Training and licensing of forensic professionals; Truth serum; Wrongful convictions.

Iris recognition systems

Definition: Computer-assisted systems that identify individuals based on comparisons of patterns in the irises of the eyes.

Significance: Because no two people—even identical twins—have identical iris patterns, iris recognition systems are especially useful in counterterrorism security. In contrast to passports and identity cards, which can be forged or stolen, these systems allow absolute authentication of individuals wishing to enter a country or high-security area.

Biometrics is the science of measuring physical characteristics and using them for identification. Fingerprinting is a form of biometrics, and iris identification is based on the same concept as fingerprinting. The iris is the colored part of the eye surrounding the pupil. No two irises are the same; even the right and left eyes of the same individual are different. Barring injury to the eye, the iris pattern remains stable for years.

For each person who will need to be recognized by an iris identification system, a digitized picture is taken of one eye, and a complex algorithm processes the information in the picture. The result is a very small computer reference file known as an IrisCode. When authentication of an individual's identity is needed, that person's eye is photographed and the result is rapidly processed and compared with the full IrisCode reference file.

In addition to being highly accurate, iris recognition systems have several positive features. For example, an iris scan can be performed at a distance of anywhere from about 4 inches (10 centimeters) to several yards (meters); the equipment does not need to touch the person being photographed. In addition, such systems will work even if those scanned are wearing clear glasses or contact lenses. In all but the most extreme lighting conditions, iris recognition systems can also compensate for changes in pupil size caused by changes in the intensity of illumination.

Such systems also have some disadvantages, however. Although they are not fooled by contact lenses, they can be fooled by photographs—that is, someone could trick a system by having it scan a photograph of the eye of a person whose IrisCode is stored in the system's database. This makes such systems much less useful for controlling access to limited-access areas that are not also monitored by human guards. It is theo-

At an elementary school in Freehold, New Jersey, the parent of a student has her iris scanned (left), and the data are entered into a computer. On future visits to the school, the woman will be able to unlock the door to the entrance by staring into an iris scanner that will match her iris to the image stored in the database. *(AP/Wide World Photos)* retically possible to build into an eye recognition system a sensor that detects movement of the natural eye and will reject a static photograph, but such systems are not yet available. The other great drawback to this technology is the cost of the equipment needed to implement it.

Iris recognition systems have had trials at airports in Europe, Canada, and the United States. They are likely to find increasing uses, not only in border control but also in commercial settings, such as for access to automated teller machines (ATMs). Their use in the United States, however, has raised questions and some objections among civil rights and privacy advocates.

Martiscia Davidson

Further Reading

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005.

Wechsler, Harry. *Reliable Face Recognition Methods: System Design, Implementation and Evaluation*. New York: Springer, 2007.

Woodward, John D., Jr., Christopher Horn, Julius Gatune, and Aryn Thomas. *Biometrics: A Look at Facial Recognition*. Santa Monica, Calif.: RAND, 2003.

See also: Airport security; Biometric eye scanners; Biometric identification systems; Facial recognition technology; Imaging; Integrated Automated Fingerprint Identification System; National Institute of Justice.

Irresistible impulse rule

Definition: Test of legal insanity that focuses on whether mental disease impairs defendants' ability to exercise control over their conduct.

Significance: The courts' acceptance of the irresistible impulse rule widened the scope of the insanity defense in the United States to include those who, owing to mental disease, cannot restrain themselves.

During the nineteenth century, a number of American jurisdictions began adopting what became known as the irresistible impulse rule, recognizing that some defendants are, because of some mental abnormality, deprived of their power of choice or their ability to refrain from wrongful conduct. One type of case cited by jurists and psychiatrists at that time was that of a mother suffering from melancholia (extreme depression) who kills her children and attempts to kill herself. She may know what she is doing, but she cannot resist the "morbid impulse" stemming from her mental state. Such a person does not seem to be deserving of criminal punishment, given that she did not perform her actions with wrongful intention.

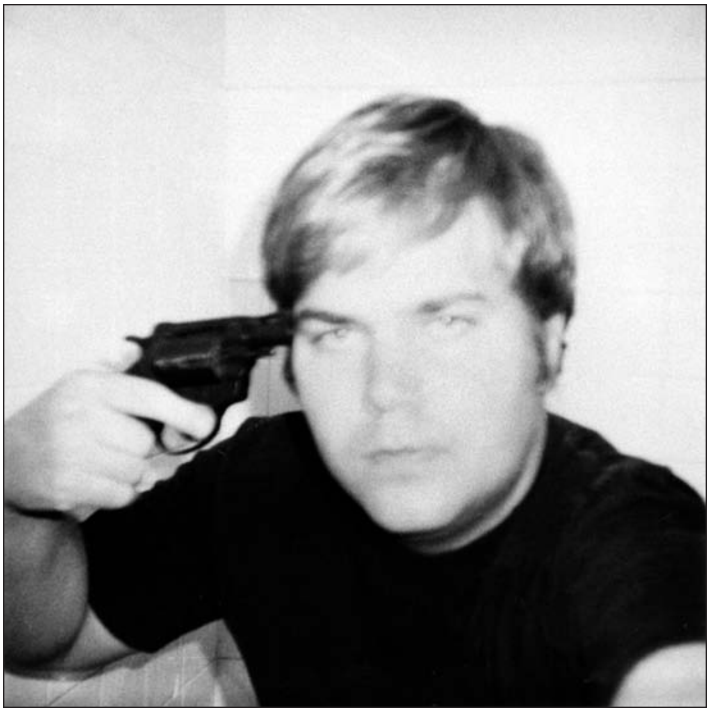
The M'Naghten rule was the first formal test of legal insanity, adopted in England in 1843 and soon after in almost all U.S. states. It focused on cases of insanity that impaired the cognitive capacities of the accused, especially their knowing what they were doing or that what they were doing was wrong. The irresistible impulse rule, in contrast, is directed at cases in which the defendants' insanity impairs their volitional capacities, so that their power to exert control over themselves is eliminated. Jurists and psychiatrists had criticized the M'Naghten test as too simple and narrow, and had urged that the law take into account the complex nature of the human mind. They argued that some forms of insanity deprive persons not of their ability to know but rather of their power to choose, and the law should recognized this.

By the early twentieth century, about one-half of the U.S. states had adopted the irresistible impulse rule as a supplement to the M'Naghten test. Unlike for the latter, no single "classic" formulation exists for the irresistible impulse rule. In a 2007 case in Virginia, the court stated that "the irresistible impulse defense is available where the accused's mind has become so impaired by disease that he is totally deprived of the mental power to control or restrain his act."

The irresistible impulse test never took hold in Great Britain, where judicial skepticism centered on two issues. The first is that all humans, sane and insane, are subject to strong impulses. If they are too weak to resist on their own, the law, with its threat of punishment, provides them with an additional incentive. A second concern raised was that of the practical difficulty for juries and forensic psychiatrists of distinguishing between irresistible impulses and impulses that are not resisted.

The acquittal of John Hinckley in 1982 for the attempted assassination of President Ronald Reagan prompted changes in federal law in the United States that revealed skepticism about volitional impairment. The federal Insanity Defense Reform Act of 1984 eliminated the volitional impairment component from the insanity defense. Almost all U.S. states followed suit with laws of their own, with only six states retaining some type of irresistible impulse or volitional impairment test.

Mario Morelli



John Hinckley, Jr., holds a gun to his head in this Polaroid photograph he took of himself some time before he attempted to assassinate President Ronald Reagan on March 30, 1981. When Hinckley was tried for murder the following year, his defense team won him an acquittal by drawing on evidence that included this photo to cast doubt on his ability to control his own impulses. *(AP/Wide World Photos)*

Further Reading

Maeder, Thomas. *Crime and Madness*. New York: Harper & Row, 1985.

Meyer, Robert G., and Christopher M. Weaver. *Law and Mental Health: A Case-Based Approach*. New York: Guilford Press, 2006.

Rogers, Richard, and Daniel W. Shuman. *Fundamentals of Forensic Practice: Mental Health and Criminal Law*. New York: Springer, 2005.

See also: ALI standard; Forensic psychiatry; Guilty but mentally ill plea; Insanity defense; Minnesota Multiphasic Personality Inventory.

Isotopic analysis

Definition: Identification of forms of the same chemical element that have the same number of protons but a different number of neutrons in the nucleus.

Significance: Organic and inorganic materials vary in chemical properties that can be detected in evidence from crime scenes. Forensic applications of isotopic analysis usually focus on identifying the chemical composition of physical evidence samples.

Isotopes of the same element have different atomic weights and travel at slightly different rates in chemical reactions. Isotopes exist in two forms: stable isotopes and radioisotopes. Stable isotopes do not change over time and reflect isotopic variation that exists in nature. Stable isotope values are reported as the ratio of the rarer, heavy isotope to the lighter, more abundant isotope. For example, carbon has two stable isotopes, ^{13}C and ^{12}C, found in the atmosphere in abundances of 99 percent and 1 percent, respectively. Isotope ratios of both organic and inorganic materials can be precisely measured using a mass spectrometer and compared against standards of known isotopic composition. The International Atomic Energy Agency regulates these standards to maintain quality control between laboratories.

Unlike stable isotopes, radioisotopes are unstable forms that radioactively decay over time. These are rarely used in forensic science, although recent applications in forensic anthropology have been successful in determining whether a person was born before or after testing of the atomic bomb through the study of radioactive decay of carbon in human skeletal remains. This can be used to determine the antiquity of human remains and whether the remains are forensically significant.

The reason that stable isotopes vary in nature is based on the principle of isotopic fractionation—the differential incorporation of the heavy and light isotope during chemical reactions. Isotope ratios are usually measured against a known standard and are converted into a "permil" (parts per thousand) value. Several important stable isotopes are used in the forensic sciences, including carbon, nitrogen, oxygen, strontium, and lead.

Stable isotope analysis is typically used to trace the composition and origin of physical evidence. A forensic scientist can analyze an unknown substance using a mass spectrometer to determine its isotopic composition for different elements. If a sample has a unique chemical composition, isotope values can be used to determine its probable geological or biological origin. For example, soil evidence recovered from a suspect's shoes or vehicle may be traced to soil samples found at a crime scene. Food companies may consult with forensic scientists to evaluate the isotopic composition of imported foods as a means of quality control. Forensic anthropologists may use stable isotope analysis of human bones and teeth to trace the probable geographic birthplace of an unidentified individual. Isotopic analysis is a growing field of study in the forensic sciences.

Eric J. Bartelink

Further Reading

Bell, Suzanne. *Forensic Chemistry*. Upper Saddle River, N.J.: Pearson Prentice Hall, 2006.

Fry, Brian. *Stable Isotope Ecology*. New York: Springer, 2006.

Yinon, Jehuda, ed. *Forensic Applications of Mass Spectrometry*. Boca Raton, Fla: CRC Press, 1995.

See also: Analytical instrumentation; Dosimetry; Forensic geoscience; Geographic profiling; Laser ablation-inductively coupled plasma-mass spectrometry; Mass spectrometry; Nuclear detection devices; Nuclear spectroscopy.

J

Jefferson paternity dispute

Date: Began in 1802

The Event: Investigations into long-standing allegations that Thomas Jefferson fathered one or more children by one of his slaves, Sally Hemings, involved both social science and forensic science.

Significance: Forensic evidence in combination with other forms of evidence can play an important role in resolving paternity disputes even if the parties are deceased and the disputes are decades, if not hundreds of years, old.

As long ago as the early years of his U.S. presidency (1801-1809), Thomas Jefferson was accused of having a sexual relationship with one of his slaves, Sally Hemings, who bore six or more children although she was unmarried. James Callender, a disreputable journalist once employed by Jefferson who turned against him and worked for his political opponents, made these charges in newspaper articles he wrote for the Federalist press in 1802. Initially, some believed the charges because it was reported that Jefferson had made a promise to his wife, Martha, on her deathbed in 1782 that he would never remarry; it was alleged that his dying wife had suggested that Jefferson take a slave as a mistress, as her father had done. Sally Hemings was the child of Martha's father and one of his light-skinned slaves, and it was said that Sally bore a strong resemblance to her half sister, Martha. Thomas Jefferson's immediate family denied the charges that Hemings's children were fathered by Jefferson and attempted to account for the fact that the two youngest Hemings boys looked exactly like Jefferson by opining that the father might have been one of two of Jefferson's nephews, Peter or Samuel Carr.

Given that Callender had a clear political motive for smearing Jefferson, it was fairly easy for Jefferson to avoid answering the charges in print, although contemporary sources indicate that Jefferson denied the charges implicitly. The press representing Jefferson's party—the Democratic Republicans—denied the charges and successfully portrayed the attack as a smear. After Jefferson's death, most mainstream historians paid no attention to the charges, although they surfaced again in 1873 when one of Sally's sons, Madison, asserted that he was the illegitimate son of Thomas Jefferson in his memoir, part of which was published as a newspaper article.

For more than one hundred years, the story was largely ignored until Annette Gordon-Reed published the results of her exhaustive research on the subject. Gordon-Reed's work showed that it was highly probable that Jefferson and Hemings were involved in a long-term monogamous relationship. The compelling evidence included the fact that Hemings conceived her children only when Jefferson was at his home, Monticello, where Hemings lived, and Hemings never conceived any children when Jefferson was absent—as was frequently the case when he was in Washington.

Gordon-Reed's findings also lent support to the 1873 claim of Madison Hemings that the Jefferson-Hemings relationship began when Sally Hemings was a teenager, while she was staying with Jefferson in Paris. France prohibited slavery at the time, and Hemings threatened to refuse to return to the United States with Jefferson unless he promised that he would emancipate her and any of her children by him upon his death. Jefferson's estate was so financially depleted by the time he died that it could ill afford to emancipate any of his slaves, but five slaves were freed, all members of the Hemings family.

Mitochondrial DNA Analysis

Gordon-Reed published her findings without knowing that plans had been made to conduct mitochondrial DNA (mtDNA) comparisons with samples from individuals claiming to be descended from Jefferson and Hemings. Because no surname-bearing descendants of Thomas Jefferson were alive to act as a positive control, the researchers used mtDNA from the five living male descendants of his paternal uncle, Field Jefferson, who cooperated in the effort. The mtDNA samples of these five men were compared with a sample from a male descendant of one of Sally Heming's sons, Thomas Eston Hemings. (Sally Hemings's oldest known son, Beverly, had no male heirs; her son Madison had heirs, none of whom have yet been tested.)

The mtDNA match was perfect except for a minute, inconsequential difference. It is safe to say that forensic evidence has established at the least that a male Jefferson, most likely Thomas Jefferson, fathered one of Sally Hemings's sons. Technically, the father could have been Thomas's brother, Randolph, but there is no evidence that he was even likely to have been present when Sally Hemings conceived Thomas Eston Hemings, and there is evidence that Thomas Jefferson was. The mtDNA evidence also refutes the Jefferson family's initial attempts to shift the focus to Jefferson's nephews, as the mtDNA for their male descendants does not match that of Thomas Eston Hemings's male descendant.

Technically, the forensic evidence does not establish that Thomas Jefferson was the father of Thomas Eston Hemings, but the overwhelming circumstantial evidence coupled with the impressive mtDNA analysis has persuaded most unbiased observers to conclude that Thomas Jefferson fathered at least one, if not more, of Sally Hemings's children.

Richard L. Wilson

Descendants of Thomas Jefferson and of his slave Sally Hemings pose for a group photo at Jefferson's plantation, Monticello, in May, 1999. The results of mitochondrial DNA analysis have been widely accepted as proof that Jefferson fathered at least one of Hemings's children. *(AP/Wide World Photos)*

Further Reading

Beran, Michael Knox. *Jefferson's Demons: Portrait of a Restless Mind*. New York: Free Press, 2003. Biographical work makes it clear that although most scholars accept that both DNA and other circumstantial evidence indicate that Jefferson fathered one or more children by Sally Hemings, this view is not unanimous.

Burstein, Andrew. *Jefferson's Secrets: Death and Desire at Monticello*. New York: Basic Books, 2005. Offers some fascinating additional circumstantial evidence to support the Jefferson-Hemings connection.

Gordon-Reed, Annette. *Thomas Jefferson and Sally Hemings: An American Controversy*. Charlottesville: University of Virginia Press, 1997. This exhaustive study of the circumstantial evidence convinced many historians of the strong likelihood that Jefferson and Hemings had a long-term monogamous relationship even before the mtDNA forensic evidence became available.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005. Comprehensive work provides an excellent summary of mitochondrial DNA analysis for the general reader along with a wealth of additional material.

Scheffler, Immo E. *Mitochondria*. 2d ed. Hoboken, N.J.: John Wiley & Sons, 2008. Offers an extensive technical discussion of mitochondrial DNA analysis.

See also: Class versus individual evidence; Direct versus circumstantial evidence; DNA analysis; DNA database controversies; DNA extraction from hair, bodily fluids, and tissues; DNA profiling; DNA sequencing; Mitochondrial DNA analysis and typing; Paternity evidence; Paternity testing.

Journalism

Definition: Collection and dissemination of factual information regarding crimes and other events through mass-communication avenues, including newspapers, magazines, television, radio, and Web sites.

Significance: Members of the public gain most of their information about forensic evidence and the forensic techniques used to solve crimes through the mass news media as well as through fictional depictions. In addition, practitioners of forensic journalism sometimes use techniques similar to those used by forensic scientists to uncover evidence of crimes that may lead to investigation by law-enforcement officials.

For many members of the American public, the journalistic media are the main sources of factual information on the legal system, including the forensic sciences. Unlike fictionalized accounts, which often glamorize forensic endeavors and exaggerate the capabilities of forensic experts and technologies, good journalism has the power to educate the public on the role the forensic sciences play in the legal system.

The press in all its forms—whether reporting in newspapers or magazines, on television or radio, or through Internet news outlets—serves an important purpose within the American legal system. The so-called Fourth Estate keeps the public informed and provides oversight of government entities, including the legal system. The news media often serve as the front line in identifying issues and events that may require legal intervention. Through a process commonly known as investigative reporting or criminal justice reporting, journalists frequently use techniques similar to those employed by forensic specialists to dig for the truth. In fact, reporters who engage in investigative journalism are increasingly becoming known as forensic journalists, and many university journalism schools have initiated classes devoted to instruction in specific forensic techniques that can be used in investigative reporting.

Depictions of Forensics

Until the 1990's, mainstream journalism frequently shied away from detailed depictions of the forensic sciences. Deeming such information gruesome or exploitative, most media outlets reported on the results of forensic investigations rather than on the actual techniques employed in such investigations. The public, however, has held a fascination for the forensic sciences dating back to well before Sir Arthur Conan Doyle's fictional character Sherlock Holmes employed such techniques so compellingly. Beyond fictional accounts, the forensic sciences were often relegated to the pages of tabloid newspapers and magazines, which frequently emphasized the most gruesome aspects of the field and ignored the sometimes tedious science behind forensic endeavors.

During the 1990's, however, a single case catapulted forensic science to the forefront of many journalistic endeavors in the United States. The 1994 slaying of Nicole Brown Simpson and Ronald Goldman, and the subsequent murder trial of Nicole's ex-husband, former football star O. J. Simpson, spurred intense media scrutiny that captured the attention of the nation. In fact, the O. J. Simpson trial remains the most publicized in American history, thanks to the extensive, often minute-by-minute, coverage provided by both broadcast and print media.

Although many media outlets were castigated for sensationalizing the trial, the public appeared to have an insatiable appetite for even the tiniest shreds of information, and the forensic sciences employed by both the prosecution and the defense were almost as much stars as the defendant himself. The public reveled in the minutiae of DNA (deoxyribonucleic acid) evidence, footprint and fingerprint analyses, analyses of hair and fiber samples, and computer recreations of the murders, and the media gave the public what it wanted. By providing complete coverage of the trial, including detailed presentations of forensic evidence, the media, in a sense, placed viewers and readers in the jurors' box. In the end, possible contamination of evidence by forensic investigators was a key element of Simpson's acquittal.

If the O. J. Simpson case brought forensic science—and its fallibility—to the forefront of journalistic interest, a second case in 1996 solidified this interest. The mystery of JonBenét Ramsey began the morning after Christmas Day, 1996, when the six-year-old was found strangled in the basement of her family's sprawling home in Boulder, Colorado. After an initial outpouring of sympathy for JonBenét's parents, John and Patsy Ramsey, the wealthy businessman and his socialite wife soon fell under suspicion. Despite an abundance of forensic evidence, including an extensively reviewed autopsy, blood and fiber samples, possible semen, footprint casts, and a handwritten ransom note, the case remains unsolved.

Although a trial never occurred, the media provided extensive coverage of the analysis of the forensic evidence, noting, for example, that handwriting experts could not rule out Patsy Ramsey as a possible author of the ransom note. In addition to devoting newspaper and magazine articles and television reports specifically to the forensic analysis of the evidence, the media also severely criticized the Boulder Police Department for not securing the crime scene properly and for poor collection of the evidence.

Other high-profile cases followed. The 2002 abduction and grisly murder of Laci Peterson and her unborn child and the 2005 conviction of serial killer Dennis Rader, known as the BTK (bind, torture, and kill) killer, helped thrust the forensic sciences into the limelight. The terrorist attacks on New York City and the Pentagon on September 11, 2001, also resulted in significant reporting on forensic techniques as experts tried to identify victims and analyze structural failures that led to the destruction of the World Trade Center's twin towers.

Although such coverage often provides a window into the world of the forensic sciences, constraints on time or column space frequently lead to attenuated depictions of the actual processes involved in investigating legal issues, leaving the public with less-than-accurate perceptions of this field. Critics charge that the news media tend to misrepresent the forensic sciences as being used more ubiquitously and as more effective and reliable than can realistically be expected. Also, they assert that journalists often represent forensic support as more easily accessible than it actually is. Among the most frequent criticisms is that both journalistic and fictional depictions of the forensic sciences paint a far more glamorous and fast-paced picture of the field than is true in real life.

Impacts of Depictions

Although much of the interest in forensic science in the early years of the twenty-first century has been attributed to the glut of television crime investigation dramas, the genesis of these shows can actually be traced back to journalistic depictions of forensics associated with high-profile cases of the 1990's. When the entertainment industry recognized the public's fascination with the details of the O. J. Simpson case, for example, it was an easy call to turn that interest into profitable fiction. The industry, however, first tested the waters with more documentary-style real-life crime dramas, such as Court TV's *Forensic Files*, which straddled the line between journalism and entertainment. After it became apparent that such programming could pique consumers' interest, a variety of fictionalized dramas featuring forensics, including *Cold Case* and the three series in the *CSI* franchise, soon followed.

The impacts of fictionalized and journalistic depictions of the forensic sciences were both positive and negative. On one hand, they publicized a previously obscure field, spurring interest and provoking a surge in enrollment in university forensic courses. On the other hand, they frequently presented a skewed or inadequate picture of the field that, according to some critics, significantly affected the ability of the legal community to prosecute criminals. Many criminologists came to decry the "*CSI* effect," asserting that because of the fictional depiction of forensic science in program such as *CSI: Crime Scene Investigation*, juries expect and even demand increasing amounts of testimony on expensive, time-consuming, and often unnecessary forensic analyses in order to opt for conviction of suspects.

Journalism as Forensics

Journalism has always had a forensic element to it. Often known as investigative journalism or investigative reporting, forensic journalism has played an increasing role in ferreting out legal breaches, and the reporters who practice this form of journalism frequently employ many of the same techniques used by forensic professionals.

Forensic journalism came to the public's attention most dramatically in the 1970's. Carl Bernstein and Bob Woodward were young reporters for *The Washington Post* investigating a break-in at the headquarters of the Democratic National Committee in the Watergate Hotel, Washington, D.C. Five men in business suits and surgical gloves had been arrested with illegal bugging devices. The reporters' investigation eventually led to the White House and, some experts claim, the resignation of President Richard M. Nixon in 1974. Bernstein and Woodward's book *All the President's Men* (1974), and the film based on the book, recounted the reporters' investigative efforts, from utilizing confidential informants to identifying accounting discrepancies related to improper use of campaign funds. Since that time, the work of investigative journalists has led to literally thousands of legal cases, involving everything from local scandals to national and international events.

In the twenty-first century, forensic reporters have been at the forefront of several scandals involving athletes who had allegedly taken performance-enhancing drugs. In Canada, *Toronto Star* reporter Harold Levy was honored in 2006 for a series of investigative stories that led to a review of child autopsies in forty-four cases of homicide and suspicious death. As a result of Levy's investigations, a forensic pathologist was sanctioned for sloppy work that may have allowed perpetrators to go free and an innocent man who had been accused of killing his niece was released.

Forensic journalists are likely to seek the assistance of forensic accountants, computer experts, and laboratories in identifying possible leads. The rise of the Internet has been a boon to many investigative reporters, allowing them to cut their research time significantly. In fact, a new field known as computer-assisted reporting, or CAR, is growing rapidly.

Forensic journalism investigations often require months or even years of research to produce what are commonly known as exposés, which may be disseminated to the public in print, audio, or video form. Journalists may work in conjunction with law-enforcement officials or go outside official channels. Unlike the glamorous depictions of investigative or forensic journalists in fictional movies and television programs, real-life reporters often work grueling hours with little credit. In 2006, the Public Broadcasting Service (PBS) launched a documentary series on investigative journalism called *Exposé: America's Investigative Reports*. The series highlights the work of journalists who might otherwise remain in the shadows.

Unlike law-enforcement officials who are conducting investigations, forensic journalists have no authority to compel witnesses to testify or to compel sources to produce evidence of crimes. Instead, they must rely on others, as well as their own ingenuity, to discover the truth. Often, a key element of their ability to discover the veracity of claims is their lack of connection to law-enforcement officials. Journalists have traditionally kept their sources of information and evidence secret, although that practice has often been challenged in court and some journalists have gone to jail rather than reveal their sources.

Beyond disclosure of sources, investigative journalism raises other pointed questions regarding ethics. Because journalists have few tools to compel witnesses to speak or to demand production of evidence, some have resorted to debatable tactics to discover the facts of the cases they are investigating. Tactics such as the use of hidden cameras, false identities, and other deceptions raise important issues regarding the privacy of innocent or even guilty parties and the legality of such techniques. These issues have often led to litigation—a common concern for reporters and news media executives alike.

Many experts have asserted that in the early twenty-first century investigative reporting is being undertaken with decreasing frequency because of limited financial resources and a media system controlled by major conglomerates, which may squelch the kind of time- and labor-intensive research such reporting requires. Further, such large organizations may be especially sensitive to the legal issues and potential costs of litigation associated with investigative reporting. Many journalism experts have expressed the fear that such reporting will eventually be relegated exclusively to tabloid newspapers and television shows that may sensationalize stories rather than report objectively.

Training in Forensic Journalism

Many colleges and universities in the United States offer courses specifically in forensic or investigative journalism techniques. Such training provides practitioners with a working knowledge of the skills they need to conduct in-depth research into events and issues. A wide array of expertise is often required to produce comprehensive, well-documented articles or broadcast reports. Practitioners frequently must work not only with other reporters and editors, but also with legal specialists, accountants, statistical analysts, librarians, and news researchers. Forensic journalists must also be keenly aware of libel laws, public information access rules such as the Freedom of Information Act, and other pertinent directives. Competent journalism schools help students learn to navigate business, government, and legal systems to uncover information that may otherwise go unnoticed by the public.

Some journalism schools have themselves been involved in cracking real cases, setting wrongfully convicted prisoners free by discovering and publicizing new evidence or by reexamining old evidence using forensic techniques that were unavailable at the time the cases were tried. Among the most spectacular of these interventions was the case of Illinois death row inmate Anthony Porter. Porter, with an IQ of just 51, had been convicted in the brutal 1982 murder of a young couple. With the help of a private investigator, a journalism class at Northwestern University in Evanston, Illinois, began to reinvestigate the case. The students examined court records, tracked down witnesses, and reconstructed the crime. Their work implicated another man in the murders, and Porter was exonerated just two days before he was scheduled to be executed. What made this case even more compelling was that eventually another twelve people on death row in Illinois were found to be innocent. As a result, the state's governor commuted the executions of all death row inmates.

Although not considered a forensic science, the field of journalism contributes to and profoundly affects the practice of forensics and has the power to develop an initial foundation for official forensic investigation of potential wrongdoing. With proper training and experience, forensic reporters serve as an important part of the legal process by spotlighting possible violations of the law and by educating the public on the processes involved in official investigations of criminal activities.

Cheryl Pawlowski

Further Reading

Aucoin, James L. *The Evolution of American Investigative Journalism*. Columbia: University of Missouri Press, 2005. Provides a history of the medium from the colonial era to modern times. Also examines how the practice of investigative journalism helped shape the 1960's and 1970's in the United States.

Bernstein, Carl, and Bob Woodward. *All the President's Men*. 1974. Reprint. New York: Simon & Schuster, 1999. The two *Washington Post* reporters who broke the story of the Nixon-era Watergate scandal present a memoir—in political thriller format—of their experiences while they were investigating the story.

De Burgh, Hugo, ed. *Investigative Journalism: Context and Practice*. New York: Routledge, 2000. Collection of essays explores the history, theory, and practice of investigative journalism and examines key events such as Watergate. Also discusses how the practice of investigative journalism relates to the legal system.

Gibbs, Cheryl, and Tom Warhover. *Getting the Whole Story: Reporting and Writing the News*. New York: Guilford Press, 2002. Examines the practice of and philosophical issues surrounding investigative journalism. Provides an introduction to the general field of reporting as well as more in-depth discussion of critical investigative reporting techniques.

Houston, Brant, Len Bruzzese, and Steve Weinberg, eds. *The Investigative Reporter's Handbook: A Guide to Documents, Databases and Techniques*. 4th ed. Boston: Bedford/St. Martin's Press, 2002. Comprehensive reference source for students and teachers of journalism as well as practicing journalists.

Lee, Henry C., with Thomas W. O'Neil. *Cracking More Cases: The Forensic Science of Solving Crimes*. Amherst, N.Y.: Prometheus Books, 2004. A renowned forensic criminologist analyzes five murder cases on which he worked and explains the scientific skills and techniques used to identify pertinent information. Provides chronologies of the events and detailed descriptions of the crimes.

Schiller, Lawrence. *Perfect Murder, Perfect Town*. New York: HarperCollins, 1999. Investigative journalist examines all the available evidence to explore the mysterious death of JonBenét Ramsey and the exhaustive investigation by the Boulder, Colorado, Police Department.

Shapiro, Bruce, ed. *Shaking the Foundations: Two Hundred Years of Investigative Journalism in America*. New York: Thunder's Mouth Press. 2003. Anthology of investigative journalism includes stories from the days of slavery and child labor to Watergate and the crusades of Ralph Nader, as well as biographical sketches of noted practitioners.

See also: Celebrity cases; Computer forensics; *CSI: Crime Scene Investigation*; *Forensic Files*; Hitler diaries hoax; Literature and forensic science; Misconceptions fostered by media; Silkwood/Kerr-McGee case; Simpson murder trial.

K

Kennedy assassination

Date: November 22, 1963

The Event: The law-enforcement investigation that followed the assassination of President John F. Kennedy reached conclusions that have continued to be disputed.

Significance: Forensic scientists played important roles in the investigation of this high-profile crime, particularly in the autopsy and in the determination of the trajectories of the bullets fired.

On November 22, 1963, a presidential motorcade set out from Dallas's Love Field. Inside the lead limousine, an open vehicle, were Texas governor John Connally, and his wife, Nellie, seated on jump seats. Directly behind them was President John F. Kennedy, seated to the right of his wife, Jacqueline. The motorcade headed toward the Texas Trade Mart, where the president was scheduled to speak at 12:30 P.M. As Kennedy's car approached Dealey Plaza, cheering crowds strained to see the president and those accompanying him. The motorcade, traveling at eleven miles per hour, was about five minutes from its destination. It turned down Elm Street. To the left was Dealey Plaza, and across Elm Street to the right was the Texas School Book Depository, a seven-story brick building. People inside the building lined the windows to view the spectacle below. Crowds filled the grassy knoll beside the Depository.

Three shots—according to most witnesses—were suddenly heard. The president clutched his throat, and his head jerked backward. Jacqueline Kennedy jumped onto the trunk of the limousine, apparently to retrieve a large portion of the president's skull that had been blown off. The motorcade sped to nearby Parkland Hospital, where valiant attempts were made to revive Kennedy, whose brain was shattered. He was officially declared dead at 1:00 P.M.

The first priority of the law-enforcement authorities was to determine who shot the president. Witnesses reported seeing someone in a window on the sixth floor of the School Book Depository and seeing that person fire a weapon. One witness, Howard Brennan, provided detailed information about the person standing at the sixth-floor window.

Jurisdictional concerns muddied the investigative process. Although Congress later enacted legislation making presidential assassinations federal offenses, no such law existed in 1963, so the Federal Bureau of Investigation (FBI) could arrest a suspect in the case only on the charge of assault, which carried a five-year maximum penalty. Murder cases fell under the purview of local law-enforcement agencies, in this case, the Dallas Police Department.

A suspect, Lee Harvey Oswald, a twenty-four-year-old former Marine who had lived in Russia and who worked in the School Book Depository, was seen on the sixth floor of the building at the time of the assassination. Three spent bullet casings were found near the window at which he was seen, and a 6.5-millimeter Italian Mannlicher-Carcano rifle, later identified as the murder weapon, was found nearby.

One forensic scientist determined that Oswald's palm prints were on boxes on the sixth floor and were also on the barrel of the murder weapon. The large brown bag in which Oswald carried the rifle into the Depository and part of the rifle itself had small cloth fragments on them that matched the clothes Oswald was wearing when he was arrested.

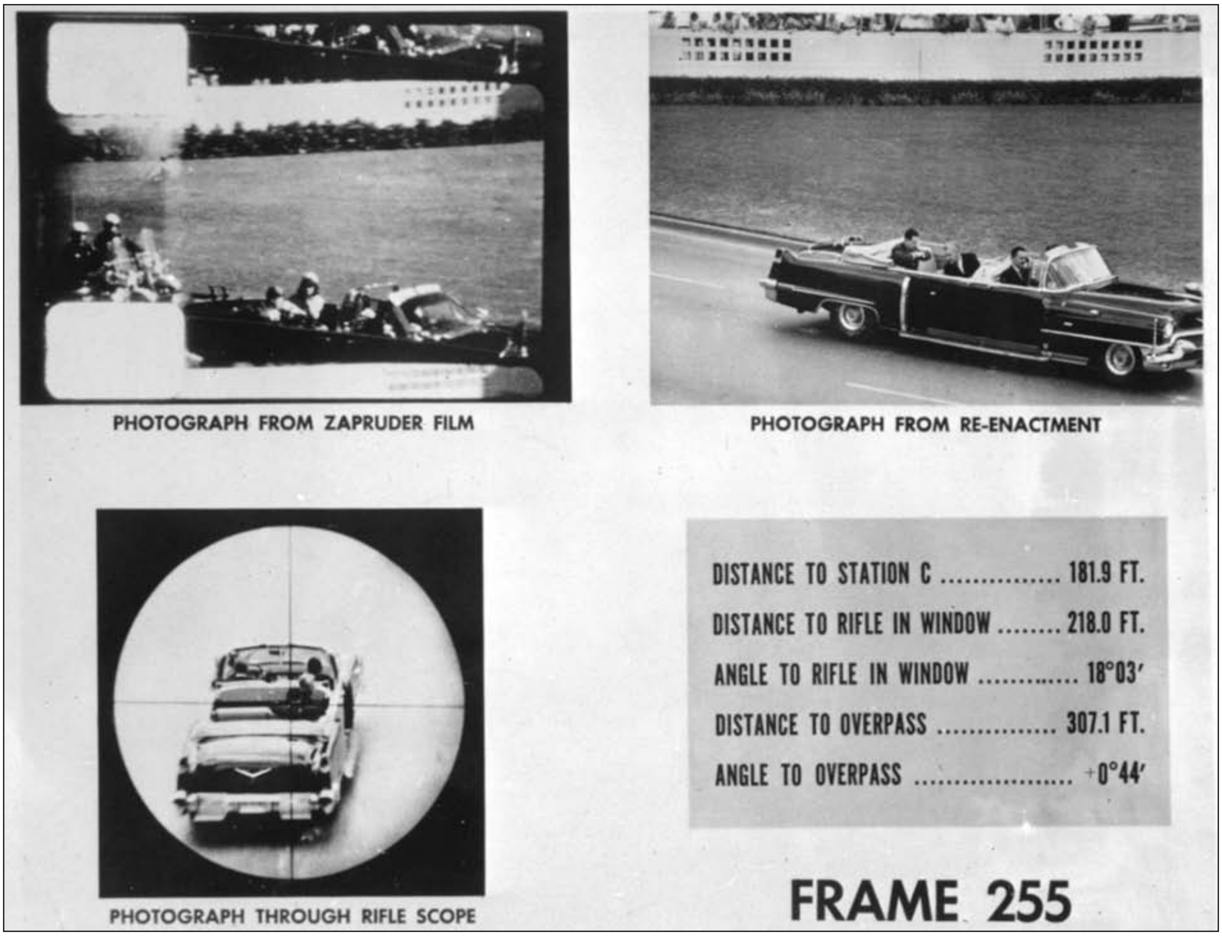
Oswald was held and questioned extensively from November 22 until November 24. He never admitted killing the president or killing police officer J. D. Tippit, who had recognized Oswald from descriptions broadcast immediately after the assassination. When Tippit tried to apprehend him, it was alleged, Oswald killed Tippit with a revolver traceable to him.

Following questioning on November 24, Oswald was being returned to jail. As he was escorted through a crowd of reporters and police officers toward the vehicle that was to transport him, Jack Ruby, a petty mobster with connections to organized crime, lunged from the crowd and shot Oswald once in the abdomen. Oswald, told that he was dying, was urged to confess, but he refused. He was rushed to Parkland Hospital, where he was pronounced dead shortly after 1:00 P.M.

Application of Forensic Science

Investigators determined that Oswald had purchased the Mannlicher-Carcano rifle that killed Kennedy on March 12, 1963, from a Los Angeles mail-order company; six weeks earlier, he had bought from the same company the .38 caliber Smith & Wesson revolver that was used to kill Tippit. Both purchases were made in the name of A. Hidell, and both were shipped to a post office box rented in Oswald's name. Handwriting analyses confirmed that the orders submitted in the name of A. Hidell were in Oswald's handwriting.

Questions soon arose concerning whether Oswald acted alone in killing the president or whether he (and possibly Jack Ruby) was part of a conspiracy, perhaps related to organized crime or even to the Central Intelligence Agency (CIA). Forensic psychologists examined possi-



These pictures and the accompanying measurements make up Exhibit 901 in the Warren Commission's report on the assassination of President John F. Kennedy. At top left is a frame from an 8mm film made by amateur photographer Abraham Zapruder in which Kennedy is seen clutching his chest as a bullet strikes. At top right is a photo taken during a reeenactment of the assassination, and at bottom left is a photograph showing how the presidential limousine would have been lined up in the sight of a rifle aimed from an upper floor of the Texas School Book Depository building. *(AP/Wide World Photos)* ble motivations for Kennedy's assassination, focusing on political considerations related to such dissident factions as the Mafia, enclaves of Cuban refugees, and others who might wish Kennedy dead.

President Lyndon B. Johnson established a seven-member commission to investigate the assassination. The commission, headed by Earl Warren, chief justice of the United States, studied the forensic evidence on the trajectories of the bullets fired in the assassination and declared that they had entered Kennedy's body from the back. In its formal report, the Warren Commission conjectured that one of the bullets had ripped through Kennedy and then entered Connally's body, passing through his back, chest, right wrist, and right thigh, and that a third bullet had gone astray, striking no one in the motorcade.

The Warren Commission dismissed some forensic evidence that suggested that at least one bullet had entered Kennedy's body from the front. Witnesses who had been on the grassy knoll near the School Book Depository claimed that one shot came not from the sixth-floor window of the building but from the grassy knoll. They insisted that they had heard a shot and smelled gun smoke. The Warren Commission declared this testimony invalid and dismissed it. Had this testimony been accepted, a conspiracy theory would have replaced the lone-assassin theory the commission espoused.

When Oswald died, the case against him was strictly circumstantial although seemingly airtight. Still, so many loose ends remained and so many forensic errors were later detected that the conspiracy theory persisted. In 1979, a committee of the House of Representatives that investigated the assassination concluded that Oswald probably had not acted alone but was part of a conspiracy. In 1998, however, a congressional review board invalidated the 1979 finding and concluded that Oswald had acted alone.

R. Baird Shuman

Further Reading

Fuhrman, Mark. *A Simple Act of Murder: November 22, 1963*. New York: William Morrow, 2006. Revives many conspiracy theories that have circulated since the assassination of John F. Kennedy.

Holland, Max, ed. *The Kennedy Assassination Tapes*. New York: Alfred A. Knopf, 2004. Reproduces many of Lyndon B. Johnson's recorded conversations with eminent people following the Kennedy assassination. The dialogues shed light on Johnson's relationships with members of the Kennedy family, particularly Jacqueline, and demonstrate his animus toward Robert F. Kennedy.

Kurtz, Michael L. *The JFK Assassination Debates: Lone Gunman Versus Conspiracy*. Lawrence: University of Kansas Press, 2006. Wide-ranging consideration of the Kennedy assassination presents cases for both the lone gunman theory and the conspiracy theory. Includes an excellent chapter on the organized crime connection.

Lane, Mark. *Rush to Judgment: A Critique of the Warren Commission's Inquiry into the Murders of John F. Kennedy, Officer J. D. Tippit, and Lee Harvey Oswald*. New York: Holt, Rinehart and Winston, 1966. Casts considerable doubt on the validity of the Warren Commission Report. Notes the failure of authorities to secure the murder scene sufficiently immediately after the assassination and cites the suppression of forensic evidence, including the loss of certain key pieces, such as bullet, bone, and tissue fragments.

Netzley, Patricia D. *The Assassination of President John F. Kennedy*. New York: New Discovery Books, 1994. Readable account of the assassination and its aftermath aimed at young adult readers. Includes informative illustrations.

President's Commission on the Assassination of President John F. Kennedy. *The Warren Commission Report of the Assassination of President John F. Kennedy*. 1964. Reprint. New York: St. Martin's Press, 1992. The official report on the assassination by a government commission that has been severely criticized as distorting forensic evidence and reaching conclusions hastily and under pressure.

Semple, Robert B., ed. *Four Days in November: The Original Coverage of the John F. Ken-*

nedy Assassination by the Staff of The New York Times. New York: St. Martin's Press, 2003. An important documentary history of the aftermath of the Kennedy assassination in the four days, November 22 to November 25, 1963, immediately following the event.

See also: Assassination; Autopsies; Ballistics; Crime scene documentation; Crime scene investigation; Crime scene measurement; Crime scene reconstruction and staging; Criminal personality profiling; Federal Bureau of Investigation; Fingerprints; *Forensic Files*; Gunshot wounds; Lincoln exhumation; Secret Service, U.S.

Kennewick man

Date: Remains discovered on July 28, 1996

The Event: After ancient human remains were found on the bank of the Columbia River near Kennewick, Washington, forensic scientists became involved in efforts to learn more about the person now widely known as Kennewick man.

Significance: When forensic scientists examined the remains, they found that they were approximately 9,800 years old and that they were those of a Caucasoid male, but the remains were found in a section of the North American continent where no Caucasoid male had previously been believed to have lived until more than 9,000 years later. This discovery forced the reexamination of long-held beliefs about the history of the settlement of North America.

On July 28, 1996, two spectators attending a hydroplane race came upon a skull in Lake Wallula, a reservoir along the Columbia River near Kennewick, Washington. That skull and the related skeleton came to be known as Kennewick man. The discoverers of the remains called the police, and when it became obvious that the remains were at least one hundred years old, the authorities called in forensic anthropologist and archaeologist James C. Chatters, who collected 350 pieces of bone, almost a complete skeleton, in ten visits to the site.

The Forensic Examination

Based on his examination of the remains, Chatters concluded that they belonged to a fifty-year-old Caucasoid male who was about 68 inches tall. Around the ilium (a part of the pelvis), Chatters found that bone had partially grown over a small stone projectile, indicating that Kennewick man had been wounded, but not killed, by a primitive weapon. This led to speculation that the skeleton belonged to a Caucasoid settler of the nineteenth century who may have been wounded by Native Americans.

Chatters put the bone with the stone projectile through a computed tomography (CT) scan and found that the projectile was siliceous with igneous origins. This meant that the stone was formed in a silica-rich environment during a volcanic period. The projectile was leaf-shaped, long and broad, with serrated edges. It had the characteristics of a Cascade point, a Stone Age tool much older than the nineteenth century. This was strange because the skull of Kennewick man appeared to be Caucasoid; a facial reconstruction based on the skull produced an image of a middle-aged man who looked more European than Native American.

These anomalies indicated a need for further forensic testing, particularly radiocarbon dating. When this test was done, it revealed that the skeleton was approximately 9,800 years old. This was a stunning finding, as it had been widely believed that no Caucasoid person had inhabited the Pacific Northwest until almost 9,500 years later.

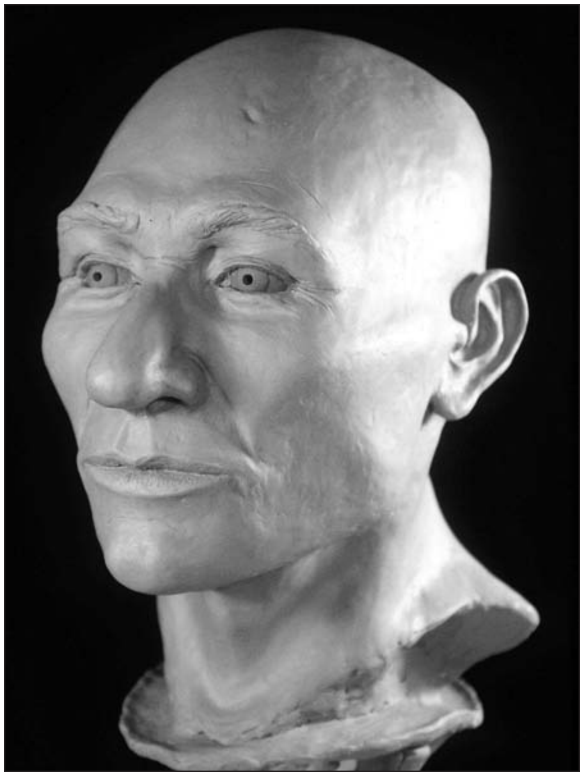
The Controversy

Given the age of the remains, the conventional wisdom was that they must be Native American, and several Native American tribes asserted their right to claim the remains and bury them in traditional fashion. Under the provisions of the Native American Graves Protection and Repatriation Act (NAGPRA) of 1990, five Native American tribes claimed the remains as theirs. Only the Umatilla went to court over the matter; they sought not only to bury the remains but also to prohibit any further forensic testing that might establish that the remains were not Native American. Initially, the federal courts sided with the Native Americans, but in February, 2004, the Ninth Circuit Court of Appeals ruled that a cultural link had not been established between the Umatilla and the skeleton, and the court allowed additional forensic testing to be done.

This forensic testing determined that Kennewick man was not European. Instead, based on comparisons of the Kennewick skeleton to eighteen modern populations, it was determined that the remains most closely resembled the Ainu, descendants of a once-thriving nomadic culture scattered across the Pacific. This culture has almost entirely disappeared, with the surviving Ainu living primarily on the Japanese island of Hokkaidō.

Kennewick man's physical features are undeniably Caucasoid; the remains do not resemble any Native American peoples. More important, the biological variety among Stone Age skulls has ruled out any possibility that Kennewick man is closely related to any modern Native American tribes. Apparently, a genetic shift took place about 8,000 years ago, and skulls older than that have been discovered to possess greater physical diversity than do those of modern Native Americans. In an attempt to determine the nature of Kennewick man more exactly, and to find out if the skeleton could possibly belong to the Umatilla tribe, scientists attempted to extract DNA (deoxyribonucleic acid) from the remains but were unsuccessful.

The discovery of Kennewick man, as well as a few other ancient skeletons, has encouraged debate among scientists regarding the exact origins and history of Native American peoples. Since at least the middle of the twentieth century, most scientists have contended that Mongoloid hunters—ancestors of the Native Americans—followed large herds of game across the Bering Strait land bridge some 12,000 years ago. Although some still believe that is what happened, many others have come to believe that numerous waves of migration to the Americas took place over time. Forensic examinations of ancient skeletal remains support the theory that Kennewick man was an individual representative of one of the multiple peoples who roamed the Americas during the prehistoric period.



Forensic sculpture of the head of Kennewick man, based on the skull found in 1996 near Kennewick, Washington, which was determined to be more than nine thousand years old. Sculptor Tom McClelland and anthropologist James C. Chatters collaborated on the facial reconstruction. *(AP/Wide World Photos)*

Richard L. Wilson

Further Reading

Benedict, Jeff. *No Bone Unturned: Inside the World of a Top Forensic Scientist and His Work on America's Most Notorious Crimes and Disasters*. New York: HarperCollins, 2003. Details the diversity of the forensic science done by Dr. Douglas Owsley, who contributed to the investigation into the origins of Kennewick man.

Chatters, James C. *Ancient Encounters: Kennewick Man and the First Americans.* New York: Simon & Schuster, 2001. Comprehensive account of Chatters's extensive examination of Kennewick man as well as several other Caucasoid skeletons that indicate Kennewick man is not an isolated case.

Jones, Peter N. *Respect for the Ancestors: American Indian Cultural Affiliation in the American West*. Boulder, Colo.: Bauu Press, 2005. Presents discussion of the Kennewick man controversy from the Native American perspective.

Neusius, Sarah W., and G. Timothy Gross. *Seeking Our Past: An Introduction to North American Archaeology*. New York: Oxford University Press, 2007. Comprehensive archaeology textbook includes discussion of the Kennewick man case.

Thomas, David Hurst. *Skull Wars: Kennewick Man, Archaeology, and the Battle for Native American Identity*. New York: Basic Books, 2000. Detailed history of prehistoric archaeology in the United States includes discussion of the disagreement between Native Americans and archaeologists regarding the handling of ancient remains.

See also: Ancient criminal cases and mysteries; Ancient science and forensics; DNA database controversies; DNA extraction from hair, bodily fluids, and tissues; Forensic anthropology; Forensic archaeology; Forensic sculpture; Peruvian Ice Maiden; University of Tennessee Anthropological Research Facility.

Kidd blood grouping system

Definition: System used for typing blood based on specific proteins, known as Kidd blood antigens, on the surface of red blood cells.

Significance: Because Kidd blood antigens are present on red blood cells in forms that vary from person to person, these differences can aid in the identification of blood left at crime scenes.

A drop of blood the size of a pinhead can contain five million red blood cells. Each red blood cell has up to one hundred different surface molecules that show some person-to-person variation. Such a cadre of molecules, otherwise known as antigens, provides the forensic scientist with a large resource for identifying the owner of a bloodstain at a crime scene.

After blood dries, the red blood cells explode, and this complicates blood type analysis because many blood-borne molecules are unstable when dried. For this reason, the forensic laboratories of the Federal Bureau of Investigation (FBI) typically test only for the ABO, rhesus (Rh), and Lewis blood group antigens in dried blood. However, some specific blood proteins are present in dried blood and can be used for blood type analysis.

Red blood cell surface proteins regulate the entry and egress of various molecules. One particular protein on the surface of red blood cells is called the Kidd or Jk antigen. This protein transports a nitrogen-based waste product called urea from the cell and is also found in the kidney. The Kidd antigen is encoded by the *Jk* (or *SCL14A1*/*HUT11*) gene, which is located on chromosome 18. The *Jk* gene comes in two main functional forms (alleles), Jk^a and Jk^b. The bodies of persons who lack a functional Kidd antigen protein (Jk^{a-b-}) are unable to concentrate urine properly. F. H. Allen and his colleagues first described the Kidd blood grouping system in 1951.

Because humans have two copies of each chromosome, they can possess two copies of Jk^a, two copies of Jk^b, or one copy of Jk^a and another copy of Jk^b. An individual with two copies of Jk^b who receives a blood transfusion from a donor who possesses two copies of Jk^a can form antibodies against the Jk^a form of the Kidd antigen, and this prevents the individual from tolerating a second blood transfusion from a donor who possesses a copy of Jk^a. Similarly, if a pregnant woman has antibodies against a particular Kidd antigen that is present on the red blood cells of her unborn baby, these maternal antibodies can destroy the fetal red blood cells and cause hemolytic disease of the newborn (HDN).

Because individuals can have one of four distinct combinations of Kidd antigens—Jk(a+ b–), Jk(a– b+), Jk(a+ b+), and Jk(a– b–)—Kidd antigens are useful for typing blood found at crime scenes, especially when this system is used in combination with other blood group systems (such as ABO, Duffy, or MN). Identification of the types of blood found at crime scenes may enable law-enforcement investigators to narrow their search for suspects.

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Further Reading

Nash, Jay Robert. *Forensic Serology*. New York: Chelsea House, 2006.
Nordby, Jon J. *Dead Reckoning: The Art of Forensic Detection*. Boca Raton, Fla.: CRC Press, 2000.
Platt, Richard. *Crime Scene: The Ultimate Guide to Forensic Science*. New York: Dorling Kindersley, 2003.

See also: Benzidine; Blood residue and bloodstains; Blood spatter analysis; Blood volume testing; Crime scene investigation; DNA extraction from hair, bodily fluids, and tissues; Luminol; Multisystem method; Orthotolidine; Presumptive tests for blood; Serology.

Kidnapping. *See* Child abduction and kidnapping

Knife wounds

Definition: Puncture or slash wounds caused by knives or other sharp instruments.

Significance: In cases of deaths involving knife wounds, forensic pathologists can determine useful information from the patterns and types of wounds, both about the weapons and about the persons who wielded them.

By examining the pattern of injuries and the type of wounds inflicted by a knife, a forensic pathologist can often determine what type of knife was used, what hand the assailant used to hold the knife, the order in which the wounds were

Types of Killing Knives

Knives have always been weapons of stealth, used by spies, assassins, and others who want to kill swiftly and quietly. Because of this, many types of knives have been invented that are easily hidden and quite ingenious. In addition to the widely available fixed-blade and folding-blade knives are knives that look like coins and stilettos that can be hidden in the tips of umbrellas or other common objects. Such knives are usually much too small to cause fatal wounds, but, in the right hands, even a small knife can be deadly.

One of the most famous knives ever invented was the Fairbairn-Sykes fighting knife, a deadly weapon perfected by the British just before the start of World War II. This knife, named for William Ewart Fairbairn and Eric Anthony Sykes, the two British officers who designed it, was issued to British commando units during World War II. It was made expressly for use in surprise or stealth situations. The Fairbairn-Sykes fighting knife was a dagger, with a double-edged, thin blade made for stabbing, thrusting, and cutting (in contrast to a stiletto, which is made solely for stabbing, has no sharp edges, and may have a triangular blade). It had a relatively long blade, about 6.5 to 7.5 inches, which was designed to penetrate clothing and slip between ribs or vertebrae, and an equally long handle to provide a precise grip and maximum control. It perfectly joined balance and weight, two crucial elements of the perfect knife.

Other types of knives specifically made for killing include the following:

- **Bayonet:** a knife designed to fit over the barrel of a gun
- **Combat knife:** any type of knife made for hand-to-hand fighting
- **Shiv** or **shank:** a knife fashioned from any material at hand, such as a sharpened toothbrush or tool handle
- **Switchblade:** a knife with a folding blade that springs out when a button is pressed

inflicted, and which of the wounds was the one that caused death.

A knife can cause different kinds of wounds, depending on the way an assailant wields it. For example, if the assailant jabs with the knife, it will cause a deep puncture wound. Alternatively, if the knife is used to slash, the wounds will be long but superficial. The pattern of the wounds can help determine where the assailant was standing in relationship to the victim, with which hand the assailant held the knife while assaulting the victim, whether the victim was above or below the assailant, and even the state of mind of the assailant (indicated by the type of wound, such as slashing or jabbing, the number of wounds inflicted, and the speed and ferocity of the attack). A blood spatter pattern found at a crime scene can also help investigators to determine whether wounds were inflicted by a knife.

From the depths and locations of knife wounds, a forensic pathologist can determine the order in which the wounds were caused and even determine which one actually caused death. If this is an important issue, the pathologist must examine the wounds carefully, as often knife wounds are inflicted very close to one another, or even on top of each other. By carefully examining the tissues, the pathologist can usually determine which damage was caused first, and so can determine which wound caused the death. Bleeding patterns and blood spatter patterns are also sometimes helpful in determining which wound caused death.

Because assailants who use knives must handle their weapons during their attacks, knives can be a good source of forensic evidence. A knife may retain the user's fingerprints, blood or other body fluids, or skin. It may even retain fibers from the assailant's clothing or household items that can link a suspect to the crime through DNA or other evidence. A knife may also retain a victim's blood, thus linking a knife not found at the scene of the crime with the crime committed. Knives may also give clues as to where they were manufactured or purchased, helping to identify assailants through purchase records.

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Further Reading

Byrd, Mike. *Crime Scene Evidence: A Guide to the Recovery and Collection of Physical Evidence*. Wildomar, Calif.: Staggs, 2001.

Fisher, Barry A. J. *Techniques of Crime Scene Investigation*. 7th ed. Boca Raton, Fla.: CRC Press, 2004.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005.

Payne-James, Jason, Anthony Busuttil, and William Smock, eds. *Forensic Medicine: Clinical and Pathological Aspects*. San Francisco: Greenwich Medical Media, 2003.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007.

See also: Autopsies; Blood spatter analysis; Celebrity cases; Defensive wounds; Forensic pathology; Hesitation wounds and suicide; Puncture wounds.

L

Laser ablation-inductively coupled plasma-mass spectrometry

Definition: Technique in which a laser is used to vaporize a small amount of a solid sample for subsequent elemental analysis in a mass spectrometer.

Significance: Laser ablation-inductively coupled plasma-mass spectrometry enables forensic scientists to determine trace elements in solid samples with almost no sample preparation. This technique plays an important role in the forensic analysis of samples of materials such as glass, bullets, and paper.

Analysis by laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) begins with the vaporization of a small portion of a solid sample by a pulsed laser. The vaporized sample is entrained in a flowing gas and carried into a plasma, where it is atomized and ionized. The ions produced in the plasma are drawn into the mass spectrometer, where they are filtered according to their mass-to-charge ratio. The form in which the resulting data are produced is referred to as a mass spectrum. It indicates the relative amounts of the different elements present in the vaporized portion of the sample. The detection limits for most elements by LA-ICP-MS are parts per billion or better. Because of the low detection limits, the technique has the ability to distinguish between samples that are nearly identical in elemental composition. The equipment required to perform the technique is relatively expensive and requires a skilled user.

In contrast to many other mass spectrometric techniques, LA-ICP-MS is purely an elemental technique. Any molecules present in the original sample are destroyed by the laser pulse or the plasma; only atoms remain. LA-ICP-MS is thus not a suitable technique for identification of organic compounds. In forensic applications the most common samples analyzed are glass, bullets, and paper.

In using LA-ICP-MS to establish a match between two samples, the forensic scientist must remember that samples are not always homogeneous in their composition. Because the laser vaporizes less than a microgram of a sample, samples that appear to be homogeneous can be shown to vary in composition from one location to the next. The scientist must compare the variation in composition within a single sample (intrasample variation) with the variation in composition among different samples (intersample variation) in order to establish a match or a difference.

David A. Rusak

Further Reading

Bell, Suzanne. *Forensic Chemistry*. Upper Saddle River, N.J.: Pearson Prentice Hall, 2006.

Ingle, James D., Jr., and Stanley R. Crouch. *Spectrochemical Analysis*. Englewood Cliffs, N.J.: Prentice Hall, 1988.

Skoog, Douglas A., F. James Holler, and Stanley R. Crouch. *Principles of Instrumental Analysis*. 6th ed. Belmont, Calif.: Thomson Brooks/Cole, 2007.

See also: Analytical instrumentation; Bullet-lead analysis; Energy-dispersive spectroscopy; Glass; Isotopic analysis; Lasers; Mass spectrometry; Paper; Spectroscopy.

Lasers

Definition: Sources of intense coherent, monochromatic electromagnetic radiation.

Significance: Because laser light beams can be sharply focused in a given direction, lasers are very helpful in the detection of hidden evidence at crime scenes or related locations and for use in spectroscopic analysis of evidence samples.

In forensic investigations, the presence of such evidentiary materials as fingerprints, skin, hair, body fluids, and bone fragments is more easily detected with laser light than with other optical devices. When suspected matter in an investigation is coated or injected with fluorescent dyes and then illuminated with the spectral brightness of laser light, atoms in the dyes absorb photons and become excited. Upon deexcitation, the material fluoresces, and photons of a lower frequency are emitted. The fluorescence produces a sharp image of hidden evidence that can be captured on film.

The technique of combining laser technology with mass spectrometry, known as laser ablation-inductively coupled plasma-mass spectrometry, is an accurate, rapid method for identifying evidential substances. An extremely fine laser beam is used to vaporize small amounts of the suspect material inside of a mass spectrometer. By analyzing the mass spectral fragmentation patterns of the components of this vapor, scientists can identify the constituent compounds. This method can be used to differentiate trace amounts of dirt, paint chips, clothing fibers, strands of hair, and pieces of glass. Forensic scientists can use this method to analyze rates of growth in a shaft of hair, which can indicate drug usage or exposure of the subject to materials used to manufacture chemical and biological weapons.

During forensic anthropology studies, when it is difficult to obtain fingerprints or dental records of a subject, facial reconstruction of the skull can provide important identification information, including information on the individual's age, sex, height, and general level of health. Lasers can be used to scan skulls and generate three-dimensional reconstructed images of cranial morphology and facial features. Laser scanners do not release radiation, are noninvasive, are fast and accurate, and do not contact the subject material.

Laser capture microdissection (LCM) is used in the forensic investigation of sexual assaults. This method isolates spermatozoa from microscope slides that contain sperm and vaginal cells taken from complex tissue samples. Laser beam energy directed onto a slide can extract sperm cells from the sample and exclude the majority of female DNA (deoxyribonucleic acid) that often contaminates sperm cell analysis in sexual assault cases. LCM may eventually replace preferential lysis as the standard forensic method for processing microscope slide samples.

Raman spectroscopy (RS) is a laser technique that enables forensic scientists to gather detailed information about the chemical composition of evidentiary material. When light from a high-intensity laser is reflected off a material, a small fraction of the reflected light is shifted to a slightly different frequency from the original laser light. The frequency shift identifies the molecular composition of the specimen. RS has proven very useful in identifying fiber, ink, dye, and resin evidence.

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Further Reading

Conn, Michael P., ed. *Laser Capture Microscopy and Microdissection*. Boston: Academic Press, 2002.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005.

Murray, Graeme I., and Stephanie Curran, eds. *Laser Capture Microdissection: Methods and Protocols*. Totowa, N.J.: Humana Press, 2005.

See also: Biometric identification systems; Confocal microscopy; Fax machine, copier, and printer analysis; Fibers and filaments; Hair analysis; Laser ablation-inductively coupled plasma-mass spectrometry; Mass spectrometry; Microscopes; Paint; Semen and sperm; Spectroscopy.

Lead

Definition: Heavy and malleable bluish-white metallic element that occurs naturally, at low levels, in the environment and has many industrial and domestic uses.

Significance: Because of lead's many industrial and domestic applications, human beings often come into contact with the metal, which has dangerous toxic properties. A high level of lead in the human bloodstream has been linked to significant cognitive deficits, poor impulse control, kidney damage, and behavioral problems. The fact that numerous studies have found higher-than-average levels of lead in the bloodstreams of violent prisoners makes the determination of the causes of lead poisoning an important matter in both civil and criminal law.

Because lead is a naturally occurring, easily mined, and easily worked metal that resists corrosion, it has been put to many uses by humans since ancient times. The early Romans, for example, used lead in their plumbing systems, some of which are still in use. During the eighteenth century, both arsenic and lead were used in wallpaper. Until the late 1970's, lead was commonly mixed into household paints because it helps bind paint to surfaces. Lead alloys are used in solder that joins metal surfaces. Lead used to connect pipes often finds its way into human water supplies. Lead was also formerly mixed into gasoline. Kohl, which has been used as a cosmetic eyeliner in many countries, often contains lead.

Lead continues to have many industrial applications and presents a great potential for accidental or intentional poisoning. Because people do not ingest lead to get high, the mineral does not have the same potential for abuse that many other chemicals and drugs have. Nevertheless, lead exposure is a significant public health concern. Lead-based paint was commonly applied to residential structures before the 1970's, and much of that paint has not been properly removed, so it still poses a health threat to residents of such structures, many of whom live in low-income neighborhoods. Moreover, even on structures where lead-based paint has been subsequently painted over, lead dust can pose a health threat.

Lead dust can also be found on old vinyl blinds. The threat is greatest to young children—including unborn fetuses—because their developing bodies and nervous systems are most susceptible to the toxic effects of lead. Even small amounts of lead dust can be very toxic. Children who are at risk for lead exposure should be screened through blood tests at one and two years of age. Special chelating drugs can be given to children with high levels of lead in their blood to remove the toxin from their bloodstreams.

Because lead is chemically slow to act, it has little potential as a weapon of terrorism or war. Moreover, even if significant amounts of lead were dispersed into public water supplies, the pollution would be detected quickly. Nevertheless, forensic techniques used to identify the presence of lead and the causes of, and responsibility for, lead poisoning have many civil and criminal applications. Lead can be identified through a variety of forensic analyses. In human bodies, blood tests are used to assess lead levels. Inexpensive kits are available that allow individuals to spot test for lead in their own homes. In laboratories, lead can be identified through chromatography and spectroscopy.

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Further Reading

Bullard, Robert, ed. *Unequal Protection: Environmental Justice and Communities of Color*. San Francisco: Sierra Club Books, 1994.

Casdorph, H. Richard, and Morton Walker. *Toxic Metal Syndrome: How Metal Poisonings Can Affect Your Brain*. Garden City Park, N.Y.: Avery, 1995.

See also: Air and water purity; Beethoven's death; Bullet-lead analysis; Chemical agents; Chromatography; Gunshot residue; Mercury; Nervous system; Paint; Poisons and antidotes; Spectroscopy.

Legal competency

Definition: Capacity to understand the nature and purposes of legal rights, obligations, and proceedings. The authority of a person to take specific actions as provided by law is dependent on legal competency.

Significance: People who are not legally competent cannot make decisions or take actions that concern legal rights. In the United States, the civil and criminal justice systems rely on forensic experts to make determinations of legal competency to ensure that accused persons who are not competent are not wrongly convicted.

Competency, as a legal doctrine, derives from seventeenth century English common law. The concept of legal competency is related to concerns for fairness and the need for due process in protecting people's liberties and rights. It is important that people making decisions or taking actions that may be binding on them, or on others whom they represent, are competent—that is, it is important that they understand the legal implications and effects of what they are doing. Decisions regarding a person's competency may be based on capacity requirements as set forth in state and federal laws. In the context of criminal law, the issue of competency usually concerns mental defects that impair a person's ability to understand.

Capacity

Legal competency requires capacity. Adults are deemed to be competent unless proven otherwise by actual facts, such as evidence that a person is suffering from a mental disorder that affects understanding. Adults remain legally competent until they are declared incompetent by a court of law. A court may, however, decide that a previously declared incompetent person has recovered and is again competent to make decisions affecting legal rights. When a person is declared legally incompetent, the court may also appoint a guardian or conservator to make decisions on the incompetent person's behalf.

Legal competency also involves presumptions set forth in statutes. For example, statutory law provides that those under the age of eighteen lack the necessary cognitive development, and thus the capacity, to act in certain matters, such as executing or witnessing legal documents. In addition, people who are intoxicated or affected by drugs usually lack capacity to enter into legal transactions or to take actions that involve legal rights. However, persons who once lacked capacity may affirm legal transactions if they are later deemed competent.

When Competency Is Necessary

In civil law legal, competency must exist when people execute legal documents such as contracts, wills, trusts, and powers of attorney to appoint others to act on their behalf. In addition, people must be competent to testify as witnesses in lawsuits, serve on juries, or participate as parties to civil matters. Competency is also necessary when people act on behalf of others, such as serving as guardians over children or incapacitated adults, as conservators over the property of others, as executors or administrators of estates, or as attorneys-in-fact who can make legal and medical decisions on behalf of other persons.

In the criminal justice context, competency is required at all stages of legal proceedings. The term "competency to stand trial," as defined by the U.S. Supreme Court in the case of *Dusky v. United States* (1960), consists of two conditions that defendants must satisfy. First, defendants not only must have the capacity to understand the proceedings but also must demonstrate that their decisions are voluntary and knowing because they understand the facts, the nature of the charges, and the criminal process in which they are involved. Second, defendants must be able to participate in the criminal process by developing strategies and defenses and by assisting their attorneys, if they have not waived their right to an attorney. This rational understanding and ability to function must be present throughout the criminal proceedings.

The criminal justice process involves three main stages: pretrial, trial, and posttrial. At the pretrial stage, arrestees must be competent and understand that they can waive their Miranda rights, which include the right to remain silent rather than confess and the right to an attorney. In addition, prior to arrest, people must be competent to give consent to allow a search for evidence. If consent is not voluntarily given, the search could be declared unconstitutional, in which case evidence found during the search would be excluded from the trial.

Competency is also necessary during arraignment, in which defendants must understand the charges against them, the constitutional rights they are forfeiting, and the consequences of their pleas. Defendants must make their pleas—usually guilty or not guilty—voluntarily and knowingly. Defendants who plead not guilty by reason of insanity must understand that involuntary commitment to a mental health facility is a possible outcome of an insanity acquittal. Finally, when a defendant accepts a plea bargain offered during the criminal trial process, the judge will ask the defendant questions to determine competency and ensure that the defendant is making decisions voluntarily and understands the legal consequences of such decisions.

At the trial stage, defendants must be able to participate meaningfully in the proceedings and assist their attorneys in mounting effective defenses in order to avoid wrongful convictions. Defendants may refuse assistance of counsel as long as they understand the implications of rejecting this constitutional right. Defendants must also be competent when waiving the right to a jury trial, in challenging prospective jurors, in deciding whether to testify, and when testifying as witnesses.

A significant issue with respect to competency to stand trial concerns the use of psychotropic drugs or other medications to enable defendants to reach a competent state of understanding. Laws throughout the United States do not agree; some jurisdictions allow the use of drugs for this purpose, whereas others require defendants to demonstrate the ability to understand without medication to avoid an infringement of their constitutional right of privacy. The result is that some defendants never become sufficiently competent to stand trial and may be involuntarily committed to mental health facilities, where, by law, they must undergo periodic reviews to determine whether their competency status has changed.

Posttrial issues of competency generally concern the right of a state or the federal government to carry out a death sentence if the prisoner is not competent. Convicted criminals sentenced to death must have the mental capacity to understand the nature and purpose of the death penalty and appreciate why they are being put to death. Persons who are sentenced to death but are found to be incompetent must be held until it is determined that they have the capacity to understand. Some jurisdictions allow the use of drugs to achieve a state of competency in a death-penalty prisoner in order to carry out the death sentence.

Forensic Experts and Competency Evaluations

Courts rely on forensic clinicians to perform evaluations when the competency of particular persons is at issue. Except for legal presumptions of competency, such as age, laws do not usually prescribe any particular evaluation techniques to be used in determining competency. Forensic experts thus usually focus on prior medical evidence and the present mental capacity and psychological status of the persons whose competency is of interest. Irrational behavior and conduct during criminal proceedings may also be considered. Statutory law provides for competency hearings to assess individuals' competency to stand trial.

Forensic professionals called upon to evaluate competency in criminal defendants must

The Process of Determining Competency

Determining legal competency in American courts typically involves three stages: initiating an inquiry, making a preliminary determination as to competency, and, if sufficient evidence exists to warrant it, holding a competency hearing. Generally, after an inquiry is initiated—usually by counsel, either prosecution or defense—a psychiatric examination is mandatory. If the examination indicates that the defendant may be incompetent, a competency hearing is mandatory. The hearing is adversarial in nature; the main witness is usually the psychiatrist who performed the psychiatric examination, but other witnesses may also be called. The trial judge usually rules on the defendant's competency, and the judge may consider the defendant's appearance and demeanor as well as the testimony of any witnesses.

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also consider whether the defendants are malingering—that is, faking mental illness or psychological symptoms to delay negative outcomes, such as a trial or imposition of the death penalty. Specific tests and tools have been developed for experts' use in assessing competency to stand trial and malingering, which can be difficult to detect. These modern techniques have proven reliable and have received acceptance by the scientific community.

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Further Reading

Bardwell, Mark C., and Bruce A. Arrigo. *Criminal Competency on Trial: The Case of Colin Ferguson*. Durham, N.C.: Carolina Academic Press, 2002. Looks at the legal and psychological issues associated with competency to stand trial and proposes policy changes in the use of the legal doctrine on competency to stand trial.

Grisso, Thomas. *Evaluating Competencies: Forensic Assessments and Instruments*. 2d ed. New York: Springer. 2002. Provides useful instruments for the evaluation of legal competency in criminal and civil cases.

Rogers, Richard, and Daniel W. Shuman. *Fundamentals of Criminal Practice: Mental Health and Criminal Law*. New York: Springer, 2005. Focuses on competency to stand trial but provides a good discussion of the interrelationship between criminal law and mental health practice when competency is at issue.

Tabak, Ronald J. "Executing People with Mental Disabilities: How We Can Mitigate an Aggravating Situation." *St. Louis University Public Law Review* 25 (2006): 283-301. Includes a good review of mental incompetence and how it affects carrying out a sentence of death.

Yant, Martin. *Presumed Guilty: When Innocent People Are Wrongly Convicted*. Amherst, N.Y.: Prometheus Books, 1991. Reviews several cases involving mentally incompetent defendants and their fates within the American criminal justice system. Argues that many of these defendants were wrongfully convicted because of the failure of the system to consider their incompetence.

See also: Competency evaluation and assessment instruments; Courts and forensic evidence; Eyewitness testimony; False memories; Federal Rules of Evidence; Forensic psychiatry; Forensic psychology; Guilty but mentally ill plea; Insanity defense; Interrogation; *Mens rea*; Minnesota Multiphasic Personality Inventory; Trial consultants.

Less-lethal weapons

Definition: Weapons designed to force compliance with the wielders' orders, but not to maim or to kill.

Significance: Law-enforcement agencies are increasingly providing their personnel with less-lethal weapons for use in situations that do not call for lethal force. Some of these kinds of weapons have become sources of controversy, as their uses have at times resulted in unintentional deaths.

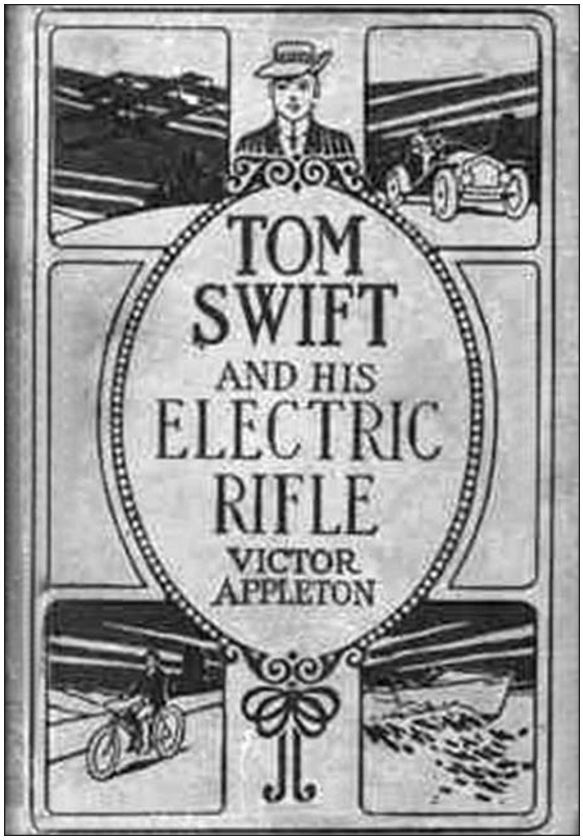
Formerly called "nonlethal" because they were not designed to kill, such weapons are better designated as "less lethal," given that, under some conditions, they can produce fatalities. Death is most likely to occur during the use of such a weapon when a subject has a preexisting condition, such as a weak heart, or when the weapon is misused, as when a subject is shocked numerous times. Less-lethal weapons may be grouped into several types: chemical, projectile, sound, light, microwave, and electroshock. Batons or nightsticks are also classified as less-lethal weapons.

Classic Less-Lethal Weapons

Tear gas is familiar to many Americans from television newscasts and fictional programs, where it is seen being used to flush people from buildings or to disperse crowds. Several different compounds are used in the products commonly referred to as tear gas, or lachrymatory (tear-causing) agents. These agents irritate the eyes, making them itch, water profusely, and perhaps swell shut. The agents also irritate the skin, cause the nose to run, and burn the mouth and throat. They may produce coughing spasms, making it difficult for those exposed to breathe.

One form of tear gas, CS gas (2-chlorobenzalmalononitrile), takes its name from the initials of the last names of its American discoverers, Ben Corson and Roger Staughton. A solid at room temperature, it can be delivered by an exploding canister, which turns it into an aerosol. CR gas (dibenzoxazepine), another tear gas, is approximately six to ten times stronger than CS gas and should not be used in confined spaces. The advantage of CR gas is that it can incapacitate someone very quickly. The United States does not allow the use of CR gas for riot control because the substance is suspected to cause cancer. Extracted from red peppers, pepper spray, also known as OC (oleoresin capsicum) spray, is an irritant as well as an inflammatory that causes the eyes to swell shut and to water profusely. It can also cause coughing spasms.

Rubber bullets were invented to address the needs of peacekeeping troops or law-enforcement officers to disperse crowds or subdue individuals from a distance without putting themselves in jeopardy. The British used fifty-six thousand rubber bullets in Northern Ireland from 1970 to 1975. These bullets, each 38 millimeters (about 1.5 inches) in diameter and 150 millimeters (about 6 inches) long, were fired from grenade launchers. They were powered only by the gases from the exploding primer, but even that proved to be too much force. The operators of the launchers were supposed to bounce the bullets off the ground and into the target persons, but seventeen people were killed, mostly by operators firing directly at people who were too close. The British phased out the rubber bullets, replacing them with new plastic bullets. Between 1973 and 1981, they fired forty-two thousand plastic bullets; fourteen fatalities were blamed on these bullets.



The hero of forty novels issued by girl detective Nancy Drew's publisher, Tom Swift is a boy genius with a knack for inventing high-tech gadgets. *Tom Swift and His Electric Rifle; Or, Daring Adventures on Elephant Island* (1911) was the tenth in a series of forty Tom Swift novels written by ghostwriters and attributed to Victor Appleton, a house name.

Tasers

Taser is a brand name, although the term is often used to refer to any electroshock weapon. The Taser was invented by Jack Cover in 1969, who named it "Thomas A. Swift's Electric Rifle" in honor of the fictional inventor and adventure hero Tom Swift. It was intended to subdue (not kill) target subjects from a safe distance, as opposed to the dangerous proximity required in the use of weapons such as police batons. A Taser uses compressed nitrogen gas or carbon dioxide gas to fire two darts connected to the body of the device by wires. The darts are most effective at striking a target no more than 5.5 meters (18 feet) away from the user. When the darts strike, the Taser sends electrical pulses of 50,000 volts to the target, causing intense pain by disrupting nerve signals and causing the person's muscles to contract uncontrollably.

In drive mode, the Taser itself is pushed against the target so that built-in electrodes can deliver the electrical pulses. In this mode, the weapon allows the user to administer shocks several times, until the subject is forced into compliance, and this has led to its abuse by some. Amnesty International has argued that the pain induced by Tasers is too cruel for law-enforcement agencies to inflict and that the use of Tasers should be sharply restricted, if not banned altogether. This organization has asserted that Taser use resulted in 291 fatalities in the United States and Canada from June, 2001, to September, 2007.

In 2007, the U.S. Bureau of Justice Statistics released the results of a study conducted for the Department of Justice by Wake Forest University School of Medicine concerning fatalities related to police arrests. The researchers examined arrests during the period 2003-2005 across the United States and found 2,002 fatalities that were possibly arrest-related; this was only 0.005 percent of the 40 million arrests made during that time. Of these fatalities, only 36 were found to be related to the use of Tasers or stun guns. Another study by the Bureau of Justice Statistics looked at nearly 1,000 arrests that involved the use of Tasers and found that 99.7 percent of the subjects suffered only minor scrapes and bruises. Three subjects required medical treatment, and two of those later died, but their autopsy reports did not link the deaths with the police use of Tasers.

Supporters of Taser use by police have complained that when no other immediate cause of death is evident in the case of an individual who dies in police custody, the cause of death is often given as "excited delirium," a nebulous diagnosis that is not yet accepted by the American Medical Association. Symptoms of excited delirium include violent behavior, incoherent speaking or shouting, imperviousness to pain, profuse sweating, and paranoia. The subject's heart

Law-enforcement officers react as they are hit with electric shocks from Tasers during a training exercise. *(AP/Wide World Photos)* and lungs suddenly stop functioning. Multiple shocks by Taser can cause breathing problems, and critics have also suggested that arresting officers may cause excited delirium by restraining a subject in such a position that the subject finds it difficult to breathe.

Studies have shown that when Tasers are properly used by police, the overall results can be beneficial. In a 2004 report, the Cincinnati Police Department stated that police officer injuries were down 56 percent and suspect injuries were down 35 percent in the period since the department began using Tasers.

Charles W. Rogers

Further Reading

Alexander, John B. *Future War: Non-lethal Weapons in Twenty-first-Century Warfare*. New York: St. Martin's Press, 1999. Presents justifications for the use of less-lethal weapons and describes cutting-edge weapons such as sticky foam guns and acoustic blasters.

_______. *Winning the War: Advanced Weapons, Strategies, and Concepts for the Post-9/11 World*. New York: St. Martin's Press, 2003. Describes how less-lethal weapons can be used in war and against terrorists.

Davies, Pete. *Taser: Why the Media Hates and Fears It*. Sun City, Ariz.: Adna Press, 2005. A committed supporter of electroshock weapons presents information on them and discusses negative responses to them.

Koplow, David A. *Non-lethal Weapons: The Law and Policy of Revolutionary Technologies for the Military and Law Enforcement*. New York: Cambridge University Press, 2006. A law professor describes less-lethal weapons and explains the laws governing their use. Includes examples from five real-life incidents.

Ross, Darrell, and Ted Chan, eds. *Sudden Deaths in Custody*. Totowa, N.J.: Humana Press, 2005. Collection includes chapters titled "Excited Delirium" and "Riot Control Agents, Tasers, and Other Less-Lethal Weapons"

See also: Bloody Sunday; Chemical agents; Chemical warfare; Electrical injuries and deaths; Nerve agents; Suffocation.

Lie detectors. *See* Polygraph analysis

Lincoln exhumation

Date: September 26, 1901

The Event: When a new tomb was constructed in 1900 to hold Abraham Lincoln's remains, Robert Lincoln, fearing that his father's tomb might be robbed, arranged for Lincoln's coffin to be exhumed before it was finally encased in an impregnable block of cement.

Significance: Witnesses who attended the reburial of Lincoln's coffin were permitted to look inside the coffin to identify the remains because it was considered important to verify that the body was indeed that of Abraham Lincoln before the new tomb was sealed.

During Abraham Lincoln's presidential administration, the United States was divided as it had not been since its founding, with the North and the South pitted against each other in war. Only days after the Civil War ended in April, 1865, John Wilkes Booth, an actor, shot Lincoln while the president was attending a play at Ford's Theatre in Washington, D.C.; Lincoln died the following day. There was little question about how Lincoln died, but conspiracy theories circulated about who was involved in his death. Punishment was meted out swiftly to those who had anything to do with the assassination. Less than two weeks after the shooting, Booth was captured and killed, and within three months, a military court sentenced four coconspirators in the crime to death by hanging.

Lincoln's body lay in state in Washington and several other cities before it was returned to Springfield, Illinois, to a receiving vault in Oak Ridge Cemetery on May 2, 1865. Shortly thereafter, it was transferred to a temporary vault, where it stayed until September, 1871, when it was placed in the unfinished Lincoln monument

A crowd gathers around the crate containing the exhumed coffin of Abraham Lincoln in 1901. The empty grave is seen on the right. *(Library of Congress)*

in the cemetery. At this point, the body was transferred to a metal casket. In October, 1874, prior to the dedication of the new Lincoln tomb, the body was transferred to another coffin, this one of red cedar lined with lead. The coffin was sealed before it was placed in a white sarcophagus.

On November 7, 1876, a band of grave robbers attempted to steal the Lincoln coffin so that they could hold the body for ransom. Their plot was foiled, but it resulted in a decision to transfer Lincoln's coffin to a protected place deep inside the tomb. The threat that someone might want to disturb his father's remains moved Lincoln's only surviving son, Robert, to call for the body's exhumation and to seek a means of protecting the body when it was reinterred.

Application of Forensic Science

Little sophisticated forensic science was involved in the final exhumation and reburial of Abraham Lincoln's casket. On September 26, 1901, in a ceremony cloaked in secrecy, the casket was removed from an underground vault in the temporary tomb that held Lincoln's and his wife's remains from 1889 until 1901. Twenty-three carefully selected witnesses were present for the final burial of the coffin.

Given the threats of grave robbing that had been uncovered earlier, there was considerable feeling that the coffin must be opened before it was reburied to confirm that the body it contained was indeed that of Lincoln. Although some of those present thought that opening the casket would violate family privacy, others argued convincingly that if the contents of the casket were not verified, rumors would persist that Lincoln's body was not there. It was eventually decided that a hole would be cut into the casket through which the witnesses could view the contents. An oblong piece was removed from the coffin directly above the head and shoulders of the body within; when the witnesses peered in, they saw a remarkably well-preserved body that was still recognizable as that of Abraham Lincoln.

The piece that had been removed was then replaced, and the casket was lowered into a huge cage in the ground, which was then covered with more than two tons of concrete. Protecting the coffin in this way was Robert Lincoln's idea; it was based on his knowledge of how industrialist George Pullman's remains had been entombed.

R. Baird Shuman

Further Reading

Goodrich, Thomas. *Lincoln, Booth, and the Great American Tragedy*. Bloomington: Indiana University Press, 2005. Presents a thorough account of the Lincoln assassination and its aftermath.

Kunhardt, Dorothy Meserve. "That Happened to Lincoln's Body?" *Life*, February 15, 1963. Richly illustrated article focuses on the exhumation of Lincoln's body in 1901.

Lewis, Lloyd. *The Assassination of Lincoln: History and Myth*. Lincoln: University of Nebraska Press, 1994. One of the best resources available on the exhumation of Lincoln's body.

Sanders, Gerald. *Abraham Lincoln Fact Book and Teacher's Guide*. New York: Eastern Acorn Press, 1982. Extremely informative volume for those interested in studying Lincoln. Includes discussion of the exhumation.

Steers, Edward, Jr. *Blood on the Moon: The Assassination of Abraham Lincoln*. Lexington: University Press of Kentucky, 2001. Excellent source of background material regarding the assassination.

Winik, Jay. *April 1865: The Month That Saved America*. New York: HarperCollins, 2001. Offers a useful account of the events that followed Lincoln's assassination.

See also: Anastasia remains identification; Assassination; Exhumation; Louis XVII remains identification; Taylor exhumation.

Lindbergh baby kidnapping

Date: March 1, 1932

The Event: When the infant son of the famous aviator Charles A. Lindbergh was kidnapped and later found dead, this shocking attack on the family of an American hero was called the crime of the century. An extensive investigation led to the arrest of an illegal immigrant, Bruno Hauptmann. After a highly publicized trial, Hauptmann was convicted on the basis of handwriting, wood, and other evidence.

Significance: The Lindbergh kidnapping case was an important and highly publicized demonstration of the value of forensic science to criminology. The case involved one of the most extensive uses of handwriting experts in the history of American criminal investigation. The analysis of the wood evidence in this and other cases by Arthur Koehler, federal wood expert, served as a precedent for the admission of botanical evidence in later trials. Because of this contribution, Koehler is considered the father of forensic botany.

On March 1, 1932, the infant son of Charles A. Lindbergh and Anne Morrow Lindbergh was abducted from his crib in the second-floor nursery of the Lindbergh home. A ransom note was found on the windowsill; it demanded a payment of fifty thousand dollars. The handwriting of the note suggested to some that the writer was German. In addition, a homemade ladder was found a short distance from the Lindbergh house. Over the next few weeks, the family received a series of handwritten communications, and eventually the ransom money was paid. The child, however, was not returned, and on May 12, 1932, an infant's decaying corpse was found a few miles from the Lindbergh estate. The corpse was identified as the missing infant by both Charles Lindbergh and Betty Gow, the baby's nurse, who also recognized clothing and thread found on the body.

For two years, the case was investigated with little success. The serial numbers of the bills used to pay the ransom had been recorded, and some of the money began to turn up, primarily in New York City, in both Manhattan and the Bronx. In September of 1934, Bruno Hauptmann was arrested after he paid for gasoline with a ransom bill. Hauptmann was German, had worked as a carpenter, lived in the Bronx, and had quit his job on the same weekend in 1932 when the ransom money was paid. Further investigation led to the discovery of almost fourteen thousand dollars of the ransom money hidden in his garage. Hauptmann denied involvement in the crime and claimed that the money had been given to him by a friend who had since died. His lawyers accused the police of framing Hauptmann in an effort to obtain a conviction in the high-profile case. Hauptmann was tried, found guilty, and executed for the crime, but subsequent revisionist literature has included accusations that the police manufactured evidence and that Lindbergh himself was involved in the crime.

At the heart of the case were two important streams of physical evidence: the handwritten ransom notes from the kidnapper and the homemade wooden ladder found at the scene of the crime.

Analysis of the Handwriting Evidence

After Hauptmann was arrested, police investigators procured previously existing samples (known as conceded samples) of his handwriting, including automobile registration forms and personal letters. In addition, the police dictated special passages to Hauptmann with sentences constructed from words that occurred in the ransom notes, and Hauptmann created new samples (known as request samples) of his handwriting. Eight prominent handwriting experts compared the conceded and request samples to the ransom notes; among these experts was Albert S. Osborn, considered by many to be the dean of handwriting analysis.

The experts analyzed two aspects of the writing in the samples and the ransom notes. They compared the shapings of the words and letters, and during Hauptmann's trial they used word and letter charts to identify and display a large number of corresponding characteristics in Hauptmann's writing and the ransom notes. In addition, the experts compared misspellings in the ransom notes with misspellings in Hauptmann's writing and found them to be similar. All eight experts testified in court to their conclusions that Hauptmann had written all of the notes. Four additional experts, kept in reserve by the prosecution, reached the same conclusions.

A Challenge to an Expert Witness

As this excerpt from the transcript of Bruno Hauptmann's trial shows, the testimony of the prosecution's wood expert, Arthur Koehler, was challenged by the defense. As prosecutor David T. Wilentz was questioning Koehler on the stand, Frederick Pope, one of Hauptmann's attorneys, raised an objection.

MR. POPE: Object to the question. We say that this witness is not qualified to express an opinion regarding wood.

THE COURT: Do you say that he is not qualified as an expert on wood?

MR. POPE: We say that there is no such animal known among men as an expert on wood; that it is not a science that has been recognized by the courts; that it is not in a class with handwriting experts or with ballistic experts. But this is no science, this is merely a man who has had a lot of experience in examining trees, who knows the barks on trees and a few things like that. We may say that the opinion of the jurors is just as good as his opinion, that they are just as qualified to judge whether there is any relationship between those two pieces of board as this man of experience as he terms himself.

THE COURT: I think the witness is qualified as an expert upon the subject matter.

MR. POPE: May we cross examine him on that subject and see what his qualifications are?

THE COURT: You surely may.

Handwriting expert Samuel Small compares ransom notes from the Lindbergh kidnapping case with the handwriting of Bruno Hauptmann, the main suspect. *(AP/Wide World Photos)*

The defense presented one handwriting expert at trial, John Trendley, who testified that Hauptmann did not write the notes. Analyses conducted much later by three handwriting experts hired for a review of the case to air in a 2005 episode of the Court TV television series *Forensic Files* generally supported the findings of the earlier prosecution experts.

Over the years, the handwriting evidence in the Lindbergh kidnapping case has been challenged in a number of ways. Hauptmann himself accused the police of directing him to misspell words during the dictation of the request writings. It was demonstrated during the trial, however, that misspellings comparable to those in the ransom notes occurred in Hauptmann's conceded writings as well as in the request writings.

Allegations have been made that the similarities between Hauptmann's handwriting and the ransom notes were common to most people who were taught to write in Germany during the early part of the twentieth century. The experts at the trial pointed out and discounted common German handwriting characteristics, however. They also identified individualized variations from the standard German style, such as a variant of the letter *x*, that were present in both Hauptmann's conceded writing and the ransom notes.

It has also been asserted that the similarities in shapings of words and letters between Hauptmann's request writings and the ransom notes were the result of police coercion; that is, the police forced Hauptmann to imitate the handwriting of the ransom notes. Experts who studied the notes found the request writings to be free and automatic, however, with no signs of such coercion. The use of the conceded writings also served to demonstrate that the corresponding characteristics in the shapes of the words and letters occurred in samples in which no police coercion was possible.

The Wood Evidence

In 1933, Arthur Koehler began a detailed examination of the ladder found at the scene of the Lindbergh kidnapping. Using oblique lighting, Koehler found an irregular pattern of planer marks, the patterns of cuts created when milling machines shape a board, on two of the ladder rails. These marks included defects caused by nicks in the planing machine blades. After a long, exhaustive search, Koehler was able to locate another board with the same defects and planing patterns at a lumberyard in the Bronx, the National Lumber and Millwork Company; he concluded that the board had come from the same planing run as the two ladder rails. After Hauptmann was arrested, it was found that he had worked at the same lumberyard.

Koehler identified an irregular series of ridges along the hand-planed edges of some of the boards and reasoned that these tool marks were left by a hand plane with nicks in its blade. After Hauptmann's arrest, Koehler was able to match these marks to a blade on one of Hauptmann's planes. In addition, an inspection of the attic of Hauptmann's home revealed a partial attic floorboard, suggesting that the remainder had been cut away. When one of the rails from the ladder, rail 16, was placed in the gap, nail holes in its side were found to align with nail holes in the joists in this area in angle, shape, and location. Upon examination of the botanical characteristics of rail 16 and the partial attic board, including the tree ring patterns on both sides and the edges, Koehler concluded that rail 16 had once been a part of the floorboard.

Over the years since these events, Koehler and the police have been accused of planting this evidence. Later examinations and studies, however, have supported Koehler's conclusions that rail 16 was once a part of the floorboard in question.

Errors in Investigative Procedure

Although the Lindbergh kidnapping case is notable for innovative uses of forensic science, the case was also riddled with lapses in proper investigative procedure. For example, investigators handled the ladder without gloves, hampering later attempts to use fingerprint identification to connect it with the suspect. One investigator apparently poked the remains of the baby with a stick, an act that led to confusion regarding cause of death. Koehler's courtroom diagram of Hauptmann's attic included minor errors in measurement. These mistakes, and others, left a legacy of suspicion, mistrust of police conduct, and complex conspiracy theories, underscoring the pitfalls that result from an absence of meticulous police procedure.

Implications of the Forensic Evidence

The forensic analysis of the physical evidence in the Lindbergh case was crucial to the solution of the crime. Although Hauptmann claimed that the ransom money had been given to him by a friend, the wood evidence demonstrated that Hauptmann was involved in the crime from the beginning. The handwriting evidence proved that Hauptmann was a willing and conscious participant. The analysis of this evidence and the public presentation of that analysis made the Lindbergh case a landmark in forensic science.

Kelvin Keraga

Further Reading

Fisher, Jim. *The Ghosts of Hopewell: Setting the Record Straight in the Lindbergh Case*. Carbondale: Southern Illinois University Press, 1999. Analysis of the evidence in the case is presented by a former FBI agent. Includes illustrations.

Graham, Shirley A. "Anatomy of the Lindbergh Kidnapping." *Journal of Forensic Sciences* 42 (May, 1997): 368-377. Presents a detailed analysis of Koehler's work on the case.

Haring, J. Vreeland. *The Hand of Hauptmann: The Handwriting Expert Tells the Story of the Lindbergh Case*. Plainfield, N.J.: Hamer, 1937. Obscure early work provides thorough analysis of the handwriting evidence in the case.

Journal of Forensic Sciences 28 (October, 1983). Entire issue is devoted to a series of articles about the Lindbergh kidnapping by forensic experts.

Koehler, Arthur. *Technique Used in Tracing the Lindbergh Kidnap Ladder*. Report R-1420, U.S. Department of Agriculture. Madison, Wis.: U.S. Forest Service, Forest Products Laboratory, 1937. Koehler's own description of his work.

See also: Child abduction and kidnapping; Crime scene investigation; Expert witnesses; Federal Bureau of Investigation Laboratory; Fingerprints; Forensic botany; *Forensic Files*; Handwriting analysis; Oblique lighting analysis.

Literature and forensic science

Significance: Forensic science has long been represented in fiction, both within the confines of genre fiction and in mainstream novels. The scope and style of this representation have created in the minds of the general public particular images of the field and those who work in it.

Most people who are interested in forensic science have no actual contact with the subject. They are not forensic scientists of any description, nor are they associated with the police or justice systems, the end users of forensic science. They are not doctors, pathologists, odontologists, entomologists, palynologists, or other professionals whose work may on occasion intersect with forensic science and the justice system. They are not victims of crime, criminals, or friends and family of victims or criminals, who could be exposed to forensic science in court settings.

Their interest in forensic science, thus, is most likely to have been stimulated by other than some professional context. It has become increasingly possible for interested persons to attend forensic science courses at universities and colleges, and many schools teach forensic science as a way of encouraging students to study science in a less specific way. Forensic science textbooks at both basic and advanced levels have become readily available, and, of course, the Internet has made quite complex material in forensic science easily accessible.

It seems likely, however, that for most people the initial stimulation of interest in forensic matters comes from entertainment, from fictional depictions of the subject and its practitioners in books, plays, films, and television programs, rather than more formal, educative processes. Forensic scientists believe that these media depictions have effects on public perceptions of forensic science. Much debate has taken place in the wider forensic community over the possible existence of the so-called *CSI* effect—that is, the notion that jurors expect to be presented with evidence based on high-quality forensic science in all legal cases, because that is what the television show of that name has encouraged them to expect.

The Detective

It is difficult to think back to a time when science as it is now perceived, as an organized body of knowledge that provides information about the world, was not part of the standard discourse. The first fictional detectives show this, in that deduction—rather than any forensic science analysis—provides the answers. The first emergence of the detective novel is seen in Charles Dickens's novel *Bleak House* (1852-1853), in which the police detective Mr. Bucket solves the mystery that permeates the novel (and a murder). The crime is only part of the novel, however, and Mr. Bucket not a main character. Wilkie Collins's novel *The Moonstone* (1868), in which the theft of a jewel is the story and the theft is solved by Sergeant Cuff, is considered to be the first true detective novel.

Earlier than these works, however, Edgar Allan Poe created C. Auguste Dupin, the first fictional detective, who was based on the French criminal-turned-policeman François-Eugène Vidocq. Dupin appears in a series of Poe's short stories, of which the most well known is "The Murders in the Rue Morgue" (1841). Dupin employs ratiocination—that is, the use of logical thought processes—to form conclusions. As a character, he is the ancestor of any arrogant and intelligent fictional detective, usually outside the police force, who solves cases that no one else can, much to the amazement of other characters in the work.

Clear descendants of Dupin are Arthur Conan Doyle's Sherlock Holmes and Hercule Poirot, perhaps Agatha Christie's most famous detective. In the novels, plays, and short stories that feature these detectives, the details of the crimes are solved by the reasoning of the central characters.

The detective novel continued to evolve, although fans of this genre point to a "golden age" during which such writers as Agatha Christie, Dorothy L. Sayers, Ngaio Marsh, and Rex Stout were writing. These traditions have been carried on by authors such as Elizabeth George, Colin Dexter, and Donna Leon. The detectives who appear in works by these authors may be private detectives or police detectives, but in all these works the forensic content is minimized, with more emphasis placed on deductive processes. When forensic skills are required, an expert is called in or the detective supplies his own skills. Poirot, for example, knows quite a bit about poisons, no doubt reflecting Christie's

The first significant police detective in crime fiction, Inspector Bucket, is seen searching a woman's boudoir for clues in this illustration from an early edition of Charles Dickens's *Bleak House* (1852-1853).

own interest in the topic, and Elizabeth George's Inspector Lynley can call on Scotland Yard skills.

An interesting British writer is P. D. James, who spent much of her working life as a public servant associated with the criminal justice system in England and with the government branch that oversees forensic science. James's descriptions of forensic science work and its contacts with her fictional investigations are notably accurate. The scientists help the investigations, they do not direct them. James's detective character Adam Dalgliesh has a career that spans several decades, and the forensic science in the Dalgliesh novels changes with time, reflecting changes in procedures and techniques in the real world, right up to the careful scene examination and hygiene precautions law-enforcement agencies put in place to deal with DNA (deoxyribonucleic acid) evidence. In *Death of an Expert Witness* (1977), the second Dalgliesh novel, a forensic science laboratory is at the center of events, and a forensic biologist is a murder victim.

Sherlock Holmes and His Influence

Sir Arthur Conan Doyle created Sherlock Holmes, who was active in the years around 1900 (the first Holmes story appeared in 1887). This great detective is a model for much of what came later in crime literature, not only in his professional activities but also in his personality and habits.

During the period when Doyle was writing his Sherlock Holmes stories, science was beginning to be applied in a systematic way to the investigation of crime. Although not all of the key enabling studies were carried out then (for example, Matthieu-Joseph-Bonaventure Orfila published the first toxicological work in 1813), it was a time of general scientific advances in the Western world, and these advances were inevitably reflected in crime fiction. For example, systematic studies of fingerprinting, firearms identification, ABO blood grouping, and questioned document examination were all carried out near the beginning of the twentieth century. Work by Edmond Locard and Hans Gross began to increase consideration of forensic science as a discipline, and, of course, Locard's exchange principle is still regarded as one of the key principles of forensic science.

A knowledge of science and the ability to apply it is what distinguishes Sherlock Holmes from his predecessors. He is described in the Holmes stories by Dr. John Watson, who is not stupid, but merely slower than Holmes (as are most other people). Holmes knows a great deal about chemistry, botany, and anatomy, among other topics, and over the course of numerous stories he shows himself to be able to identify newspaper print, carry out handwriting analysis, break codes, identify paper, identify blood by chemical tests, track people, identify soils, and, of course, look at scenes of events and reconstruct them. In modern terms, Holmes might be described as a combination of pathologist, toxicologist, criminalist, document examiner, forensic serologist, shoe-print expert, and crime scene examiner. In many of his cases he acts as a forensic scientist.

This set of skills is remarkable for any single person to have, even allowing for the much smaller amount of knowledge and range of skills Holmes's many roles would have contained in 1900 compared with the twenty-first century. (Even pathology, an established medical specialty linked to anatomical studies at that time, was less complex than its twenty-first century equivalent.) Why would Doyle make the choice to combine all these skills in a single character? Two main reasons likely lie behind his choice. First, one way in which a writer can keep a work of fiction focused and easy to follow is to restrict the cast of characters. This is particularly important in a short story, the form in which Holmes was most often presented. Incorporating all the expertise required by the plot in a single person was thus advantageous.

The other reason lies in the creation of the character. Doyle understood that readers are impressed by a person who knows so much and who contributes so much to the unraveling of the mystery or crime. Many authors since that time have continued to use this technique. Jeffery Deaver's Lincoln Rhyme is a wheelchair-using former crime scene investigator whose skills include knowledge of many areas of forensic science; this helps to keep Rhyme central to the plots of the books. The character Kay

Scarpetta, in a series of novels by Patricia Cornwell, moves over time from being a formidable forensic pathologist to being a specialist in other fields, such as crime scene investigation, as well. This allows Cornwell to keep the focus on Scarpetta, no matter what the criminal events in a given novel are.

A notable aspect of the work that Holmes, Rhyme, and Scarpetta perform is their ability to play major roles in investigations and be deeply involved in their cases. In real life, forensic scientists of all kinds do their own work—whether that work is the dissection of bodies, comparison of shoe prints, analysis of drugs, or something else—and then give the information they gather through their work to the investigator (usually a member of the local law-enforcement agency), who then interviews witnesses, interrogates suspects, and so on. By having their characters deeply involved in both the science and nonscience aspects of their cases, Doyle, Deaver, and Cornwell keep these characters at the center of their own stories.

Another lingering influence of Sherlock Holmes is related to the fact that he is a leading character whom readers feel they know very well. In part, this is because of the sheer volume of Doyle's work, but the main reason is the collection of quirks that Doyle has given Holmes. It can be difficult to create and sustain character in fiction that is purely plot-driven, but by enumerating a character's traits and habits, an author can help readers to recognize the individual. Thus Doyle created a Holmes who plays the violin, dabbles in drug abuse, and lights up his pipe when he needs to pause and think. This pattern has been repeated by later authors. Scarpetta drinks expensive malt whiskey, enjoys nice cars and clothes, and cooks authentic Italian food from scratch. It would be unfair to refer to Rhyme's physical condition as a character quirk, but readers remember him in part because his disability and his use of technology that helps circumvent the problems associated with his restricted mobility stick in readers' minds.

The Forensic Procedural Novel

The term "police procedural" has often been applied to the type of crime novel in which the methods and procedures of police work and the structures and personnel of police organizations are at the core of the work. Police procedurals are different from detective novels, whether the main characters are amateur or private detectives, such as Rex Stout's Nero Wolfe, or police detectives, such as James's Dalgliesh. Forensic science may be appear at some point in a police procedural, just as it may in a detective novel.

It has been suggested that the term "forensic procedural" could be applied to those novels in which forensic science, rather than being another technique or method by which the investigators establish the truth, becomes a main driver of the plot, with forensic scientists being either the primary investigators or very close to the primary investigators. The program *CSI: Crime Scene Investigation*, along with its spin-offs, provides the most extreme example of the forensic procedural in television. In this show, a group of multiskilled experts in bloodstain pattern analysis, entomology, ballistics, general crime scene examination, fingerprints, and almost any other forensic specialty necessary to the plot solve both large and small crimes. If the science were to be removed from *CSI*, nothing would be left. Such popular-media depictions reinforce public perceptions that forensic science and forensic scientists can do anything and find out anything.

Cornwell's Kay Scarpetta novels and those of Kathy Reichs featuring the forensic anthropologist Temperance Brennan are also examples of forensic procedurals. In both cases, the job and status of the main character allow her to function pivotally in the investigations in the books, even if actual professionals who fill those roles in real life can see ways in which real protocols are subverted or loosened for the purposes of the plots. It is interesting that after more than ten novels, Brennan is still a forensic anthropologist, whereas after the eleventh Scarpetta novel, Cornwell moved her main character out of her forensic pathology role and made her a forensic consultant, allowing the character to expand her repertoire of forensic skills.

Clearly, some forensic science roles fit into forensic procedurals more easily than others. For example, crime scene work can be, or can be

Holmes's Deductive Powers

Within the first few paragraphs of part 1, chapter 4, of the first Sherlock Holmes novel, A Study in Scarlet *(1887), Holmes draws deductions from wheel tracks, footprints, bloodstains, and cigar ashes. As he explains to his friend Dr. Watson, the book's narrator:*

"The very first thing which I observed on arriving there was that a cab had made two ruts with its wheels close to the curb. Now, up to last night, we have had no rain for a week, so that those wheels which left such a deep impression must have been there during the night. There were the marks of the horse's hoofs, too, the outline of one of which was far more clearly cut than that of the other three, showing that that was a new shoe. Since the cab was there after the rain began, and was not there at any time during the morning . . . it follows that it must have been there during the night, and, therefore, that it brought those two individuals to the house."

"That seems simple enough," said I; "but how about the other man's height?"

"Why, the height of a man, in nine cases out of ten, can be told from the length of his stride. It is a simple calculation enough, though there is no use my boring you with figures. I had this fellow's stride both on the clay outside and on the dust within. Then I had a way of checking my calculation. When a man writes on a wall, his instinct leads him to write about the level of his own eyes. Now that writing was just over six feet from the ground. It was child's play."

"And his age?" I asked.

"Well, if a man can stride four and a-half feet without the smallest effort, he can't be quite in the sere and yellow. That was the breadth of a puddle on the garden walk which he had evidently walked across. Patent-leather boots had gone round, and Square-toes had hopped over. . . . Is there anything else that puzzles you?"

"The finger nails and the Trichinopoly [a type of cigar]," I suggested.

"The writing on the wall was done with a man's forefinger dipped in blood. My glass allowed me to observe that the plaster was slightly scratched in doing it, which would not have been the case if the man's nail had been trimmed. I gathered up some scattered ash from the floor. It was dark in colour and flakey—such an ash as is only made by a Trichinopoly. I have made a special study of cigar ashes—in fact, I have written a monograph upon the subject. . . ."

made to be with a little adjustment, more key to a complete investigation and more involved in the investigation than, say, the work of a forensic entomologist. Generally, the more wide-ranging a specialty is, the more easily it can be made the center of a procedural novel. A specialty that involves dealing with the crime scene, the victim, the suspect, and many different sorts of evidence is ideal.

A forensic specialty that has proved amenable to the forensic procedural is forensic psychology, particularly as presented through the psychological profiler. Author Val McDermid created Tony Hill, James Patterson created Alex Cross (a policeman as well as a scientist), and Jonathan Kellerman created Alex Delaware. A major character in Cornwell's Kay Scarpetta novels is Benton Wesley, who is a criminal profiler for the Federal Bureau of Investigation (FBI). The psychologists in these novels are able to comment on many aspects of the investigations as they unfold because their expertise can be valuable as new clues are revealed that cast light on the original crime or crimes.

Interesting and in some ways atypical relationships exist in Kellerman's and McDermid's novels. It is somewhat traditional for the forensic experts in crime novels to exhibit arrogance toward colleagues, in particular toward any police who may be involved. This can be seen in Holmes's relationship with Dr. Watson, in Poirot's relationship with Colonel Hastings, and, to a lesser extent, in the various relationships that Scarpetta and Rhyme have with investigating police officers. These novelistic relationships mirror the relationship of the reader with the expert, in that the reader accepts the expert's brilliance and that the expert has the answers. Although they are very different relationships, those between Tony Hill and Detective Carol Jordan and between Alex Delaware and Detective Milo Sturgis are both those of fully equal partners in the investigations. It may be indicative of the modernization of the crime novel in emotional terms (it has always modernized itself with respect to technological and scientific advances) that these relationships are between a straight man and a straight woman and between a straight man and a gay man, respectively.

The Historical Forensic Scientist

In the information-rich and technologically driven modern age, the crime novel has kept pace with changes and improvements in the forensic sciences. Perhaps as a reaction against the increasingly technical content of many detective and mystery novels, another type of novel has arisen that is effectively a historical novel dealing with a crime. Perhaps the most widely known among the novels in this genre (because they were adapted for a popular television series) are those in the Brother Cadfael series, written by Ellis Peters (Edith Pargeter). Brother Cadfael is a monk in medieval England who uses standard detection skills and his knowledge of herbs and poisons to solve crimes.

Susanna Gregory's novels feature Matthew Bartholomew, a doctor at the University of Cambridge in the period of the Black Death. Bartholomew is a pathologist, and the character functions, like Brother Cadfael, as both overall investigator and forensic specialist. Other historical series, such as Lindsey Davis's series set in ancient Rome and featuring a character named Marcus Didius Falco, who is a sort of private investigator, have no specific forensic content, but the main characters use a knowledge of issues that in modern times are regarded as forensic. These sorts of books cannot help but be somewhat anachronistic, but good writers work very hard to keep the bounds of knowledge displayed by their forensic specialists tightly within the range of what people living in the works' historical periods could have known.

Common Threads

Clearly, the various categories of fictional works described here overlap, and some generalizations can be made. In these works, scientists are typically presented as persons who have the answers or who supply answers to investigators. Usually, something else can be done when a particular forensic technique fails to deliver a result. An equivocal result, or one that is clear-cut but does not advance the case, is less common than a clinching result or one that "proves" something.

Readers of such fiction need to keep in mind that the science serves the story; the story is not written or read to serve the science. Perhaps the most important thing that readers should remember is that all such works are primarily for the enjoyment of the readers—although some links to reality are important, as long as readers suspend their disbelief while they inhabit the worlds of these novels, the writers have succeeded.

Douglas Elliot

Further Reading

Frank, Lawrence. *Victorian Detective Fiction and the Nature of Evidence: The Scientific Investigations of Poe, Dickens, and Doyle*. New York: Palgrave Macmillan, 2003. Presents a critical look at the role of science in the novels of three important authors and also discusses the philosophy and technology of the world in which these nineteenth century writers lived.

Gerber, Samuel M., ed. *Chemistry and Crime: From Sherlock Holmes to Today's Courtroom*. Washington, D.C.: American Chemical Society, 1983. Focuses on the chemical processes and materials used in forensic science from historical, literary, and practical perspectives.

Hein, E. K. *The Forensic Mission: Investigate Forensic Science Through a Killer Mystery!* Hoboken, N.J.: John Wiley & Sons, 2007. Illustrates the principles and applications of forensic science through an annotated fictional narrative.

Rollyson, Carl, ed. *Critical Survey of Mystery and Detective Fiction*. Rev. ed. 5 vols. Pasadena, Calif.: Salem Press, 2008. Offers a comprehensive survey of the genre, with profiles of 393 individual writers and overview essays on thirty-eight topics, including forensic mysteries, police procedurals, and true-crime stories. Illustrated and thoroughly indexed, with bibliographic notes in every article.

Scaggs, John. *Crime Fiction*. New York: Routledge, 2005. Interesting work provides especially informative discussion of the differences between British and American crime fiction. Includes some consideration of the use of forensic science in such fiction.

Thomas, Ronald R. *Detective Fiction and the Rise of Forensic Science*. New York: Cambridge University Press, 1999. Provides a critical and epistemological look at technological innovation in the nineteenth and early twentieth centuries and their depiction and application in mystery fiction.

Wagner, E. J. *The Science of Sherlock Holmes: From Baskerville Hall to the Valley of Fear, the Real Forensics Behind the Great Detective's Greatest Cases*. Hoboken, N.J.: John Wiley & Sons, 2007. Offers a penetrating examination of the forensic elements in Arthur Conan Doyle's mysteries and discusses these elements' real-life foundations.

See also: *Cold Case*; *CSI: Crime Scene Investigation*; Journalism; Locard's exchange principle; Misconceptions fostered by media; Sherlock Holmes stories; *Silence of the Lambs, The*.

Lividity. *See* Livor mortis

Living forensics

Definition: Application of clinical medicine to survivors of traumatic injuries that require forensic investigation.

Significance: The practitioners of living forensics are important contributors to law-enforcement investigations concerning incidents in which traumatic injuries have been inflicted. By collecting and preserving evidence from the survivors of accidents and interpersonal violence, as well as from possible suspects in violent crimes, they can advance investigations and provide support for the prosecution of perpetrators.

In 1986, Dr. Harry McNamara, the chief medical examiner of Ulster County, New York, described the practice of living forensics as the application of clinical medicine to cases of trauma that require forensic investigation. The practitioners of living forensics are medical professionals and paraprofessionals who deal with the survivors of traumatic injuries (accidentally or intentionally inflicted) and with perpetrators of violence in relation to criminal investigations. These professionals work on cases involving living victims of alcohol and drug abuse, attempted suicide, domestic violence and other types of assault, food and drug poisoning, medical malpractice, mass disasters, motor vehicle accidents, rape, and workplace-related injuries. They also address such legal issues as competency to stand trial and paternity.

Training and Practice

To practice living forensics, health care professionals and paraprofessionals must receive additional education to enable them to identify signs and symptoms of abuse, violence, and neglect. They also must be trained in the proper collection, documentation, and preservation of evidence from living victims and from the possible perpetrators of crimes. Medical personnel who practice living forensics are found in many settings, including hospital emergency rooms and acute care centers, correctional facilities, environmental agencies, mental health agencies and clinics, nursing homes, senior centers, occupational health and rehabilitation centers, and schools.

Hospital emergency rooms are often sites of initial contact between medical personnel and trauma victims. Practitioners of living forensics are trained to recognize patterns of injuries and the types of objects that cause them, and they are aware that through their actions they can consciously preserve or inadvertently destroy evidence in cases of trauma or crime. Emergency room nurses, who are usually the first to see trauma victims who enter hospitals, can be instrumental in identifying trauma and collecting and preserving evidence from victims of trauma, illness, and crime. Their expertise in documenting and treating injuries can be integrated with forensic procedures to ensure that justice is served.

It is critical that every emergency room patient be screened for signs of abuse or violence at each visit. In 1997, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) began to require that hospital staff be trained in the identification of victims of abuse, violence, and neglect and in the collection and preservation of physical evidence from victims for potential legal proceedings.

Living Forensics Evidence

In many cases, the successful prosecution of the perpetrators of crimes involving interpersonal violence relies on evidence properly collected, documented, and preserved by members of living forensics teams. Among the types of ev-

Living Forensics and Violence

Professionals who practice living forensics are trained to recognize the signs of various kinds of violence. Any assault that causes or is intended to cause harm to persons is considered violence. Most violent offenders are young men, although the numbers of women who commit violent crimes are increasing.

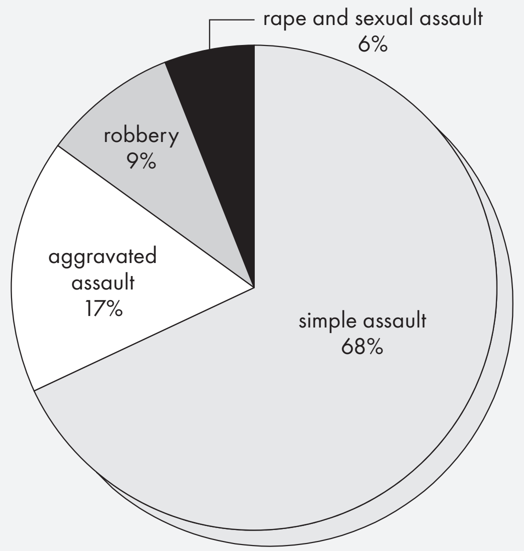
- **Child abuse:** Risk factors for being a victim of child abuse include premature birth, low birth weight, congenital anomalies, disabilities, chronic illness, high activity level, and poverty. Multiple hospital admissions or emergency room visits, "doctor shopping," domestic violence, and conflicting or inconsistent histories of injuries should all raise suspicions of abuse.
- **Elder abuse:** Risk factors for being a victim of elder abuse are social isolation, mental impairment, history of domestic violence, and living with a caregiver. In cases of elder abuse, the perpetrators are often the adult children of the abused. Laws regarding elder abuse vary by state, but most categorize such abuse as physical, emotional, sexual, or exploitative abuse, neglect, or abandonment.
- **Intimate partner violence:** Both men and women, whether homosexual or heterosexual, are potential victims of violence perpetrated by intimate partners; however, this form of violence is not as widely reported by male victims as it is by female victims. Adolescents may also be victims of violence perpetrated by boyfriends or girlfriends.
- **Rape and sexual assault:** Rape is reported by male and female victims of all ages, but close to 80 percent of victims are women. Many rapes are never reported. Risk factors for being a victim of sexual assault or rape include childhood abuse, drug and alcohol abuse, high-risk sexual behavior, history of sexual victimization at a young age, and poverty.
- **School violence:** When they take place in school settings, both assault and bullying can be classified as school violence. Victims of bullying may commit suicide, become bullies themselves, or commit acts of violence on others. School violence victims may have unexplained injuries, may suffer from nightmares, and may develop depressive and suicidal symptoms. They may be unwilling to discuss what happens at school, and some may become aggressive themselves, bullying siblings or other children.
- **Workplace violence:** Any violent acts that occur in business or industry workplaces may be classified as workplace violence. Such acts include violence directed at employers or employees, property damage, commercial damage committed by nonemployees, and terroristic damage committed by persons or groups for the purpose of disrupting workplaces or injuring specific targets. Both intimate partner violence and gang-related violence may also be considered workplace violence if the violent acts occur at workplaces.

idence that living forensics practitioners may collect from the bodies and clothing of the victims of trauma or from suspected perpetrators are gunshot residue, bullets, fingerprints, bitemark impressions, hairs, fibers, and bodily fluids from which DNA (deoxyribonucleic acid) can be extracted for analysis. The collection of DNA evidence is particularly important, as DNA analysis is often instrumental in linking victims, crime scenes, and perpetrators. DNA samples can be obtained from very small specimens, such as saliva on a cigarette butt or a strand of hair with its root intact. Practitioners of living forensics may use ultraviolet light sources to discover deposits of bodily fluids that are not visible to the naked eye.

The trace evidence collected by a living forensics team can link victims and suspects to each other and to crime scenes. For example, deposits of particular plant materials or fibers found on both a trauma victim and a suspected perpetrator may indicate that the two have had some contact. When a bullet is recovered from the body of a shooting victim, ballistics experts can often link the bullet to the gun from which it was fired by comparing the unique markings on the bullet with the markings on thousands of bullets that are stored in law-enforcement databases or with the markings on bullets test fired from any weapons suspected to have been involved in the case. When a gun is fired, gunshot residue is deposited on the hand and clothing of the person who fired it; thus documentation of the presence of gunshot residue is another important part of the work of practitioners of living forensics.

Sharon W. Stark

Types of Violent Acts by Intimate Partners



Source: U.S. Bureau of Justice Statistics, *Intimate Partner Violence*, 2003. Percentages are based on 691,710 incidents between intimate partners in the United States in 2001. Intimate partners include current and former spouses and current and former boyfriends and girlfriends.

Further Reading

Crosson-Tower, Cynthia. *Understanding Child Abuse and Neglect*. 7th ed. Boston: Pearson/Allyn & Bacon, 2008. Textbook covers all aspects of child maltreatment, from symptoms and signs to parental motivations. Includes discussion of the role of the social service system.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005. Well-respected text includes a chapter on forensic nursing that briefly discusses the concept of living forensics.

Payne-James, Jason, Anthony Busuttil, and William Smock, eds. *Forensic Medicine: Clinical and Pathological Aspects*. San Francisco: Greenwich Medical Media, 2003. Comprehensive reference source on clinical aspects of the forensic sciences is designed for professionals in forensic medicine. Chapters are all written by specialists in their fields.

Shkrum, Michael J., and David A. Ramsay. *Forensic Pathology of Trauma: Common Problems for the Pathologist*. Totowa, N.J.: Humana Press, 2007. General reference work covers technical aspects of how trauma affects human bodies.

Wilson, William C., Christopher M. Grande, and David B. Hoyt, eds. *Trauma: Critical Care*. Vol. 2. New York: Informa Healthcare,

2007. Covers such subjects as determination of types of blunt force trauma and wound analysis.

See also: Antemortem injuries; Criminalistics; DNA extraction from hair, bodily fluids, and tissues; Forensic nursing; Gang violence evidence; Gunshot residue; Medicine; Rape; Shaken baby syndrome; Strangulation; Trace and transfer evidence; Victimology.

Livor mortis

Definition: Discoloration that occurs in the skin of a corpse shortly after death as a result of the gravitational settling of pooled blood.

Significance: Although livor mortis analysis is one of three traditional methods of determining time of death, it may be the least reliable of the three because the supposedly regular rate of livor mortis development is dependent on many variables. More significant to medical investigators are coloration, which may furnish some indication of the cause of death, and its distribution, which is useful in determining whether a body has been moved.

At death the heart ceases to pump, and so circulation stops. Blood within the vessels remains liquid and, within thirty minutes to one hour, loses it ability to clot. As this blood pools, the heavier red blood cells tend to be drawn downward, into the lowest regions of the body. In this situation, any body points resting on firm surfaces will be subject to contact pressure. Because the vessels at these points are compressed, blood will not pool here. A person who dies in a supine position (lying on the back) will thus present a characteristic distribution of blood. While the back of the neck, small of the back, and thighs will generally show discoloration, contact points, usually the shoulder blades, the buttocks, the calves, and the heels, will be blanched or pale.

In the bodies of persons who were anemic or who suffered severe blood loss before death, this process, known as livor mortis (Latin for "the bluish color of death") or lividity, might be delayed or may not develop significantly. In cases of lingering cardiac failure, lividity might even begin before death. Livor mortis is sometimes initially mistaken for bruising.

A commonly cited postmortem chronology for the development of livor mortis is as follows: perceptible lividity within thirty minutes to four hours, when patches begin to appear; development of more patches, creating broader areas of discoloration, within the next three to four hours; and maximum discoloration at eight to twelve hours after death. At the third stage, the lividity is fixed; if a blotch is subjected to thumb pressure, it will not blanch or turn pale.

A medical examiner who finds a corpse lying facedown with lividity on the back side may thus justly conclude that the body was moved sometime after death. The presence of circular blanching around the waist would indicate the victim was wearing clothes or at least a constricting belt at the time of death. In assessing time of death, no competent investigator would regard these chronological parameters as absolute and use them in isolation. In fact, some researchers have pronounced the twelve-hour lividity rule to be no more than a vague generalization.

The coloration associated with lividity, often reddish to reddish purple, varies depending on the cause of death. In cases of carbon monoxide poisoning, for example, the color is often described as cherry red. Nitrate poisoning produces a deep brownish, almost chocolate, color, and death from hypothermia, low body temperature from exposure to cold, makes the skin pinkish.

David J. Ladouceur

Further Reading

DiMaio, Vincent J., and Dominick DiMaio. *Forensic Pathology*. 2d ed. Boca Raton, Fla.: CRC Press, 2001.

Innes, Brian. *Bodies of Evidence*. Pleasantville, N.Y.: Reader's Digest Association, 2000.

Nickell, Joe, and John F. Fischer. *Crime Science: Methods of Forensic Detection*. Lexington: University Press of Kentucky, 1999.

See also: Adipocere; Algor mortis; Carbon monoxide poisoning; Decomposition of bodies; Forensic pathology; Hypothermia; Rigor mortis; Taphonomy.

Locard's exchange principle

Definition: Dictum holding that whenever two objects come into contact, each leaves some trace or residue on the other that careful examination can detect and identify.

Significance: The principle that bears Edmond Locard's name is usually regarded as the basis for criminalistic investigation of objective evidence of contacts relating to crimes.

Inspired by Sir Arthur Conan Doyle's stories of the master detective Sherlock Holmes, as well as by the work of French biometrics researcher and law-enforcement officer Alphonse Bertillon and that of Austrian educator Hans Gross, who is credited with establishing the field of criminalistics, Edmond Locard (1877-1966) established the first modern scientific laboratory for the investigation of crime in Lyon, France, in 1910. Locard published numerous books on forensic techniques, including the six-volume magnum opus *Traité de criminalistique* (1931-1936; treatise on criminalistics). In essays with titles such as "Dust and Its Analysis" (*Police Journal*, 1928) and "The Analysis of Dust Traces" (*American Journal of Police Science*, 1930), Locard described his experimental work leading to the idea forensic scientists have come to refer to as Locard's exchange principle or Locard's theory.

This principle, which ties together the diverse investigations of the forensic sciences, has been called the basis of criminalistics. Variously formulated, it is expressed most succinctly as "Every contact leaves a trace." This applies broadly to interactions ranging from those that leave fingerprints to those that make the markings on a bullet, but it is of particular relevance to what is known as trace evidence. Locard called the microscopic particles that adhere to people's clothing and bodies "mute witnesses, sure and faithful, of all our movements and all our encounters."

Almost any kind of trace material can come to the attention of forensic scientists: hair, dirt, blood, fibers, and other substances. Some materials are more individualizable than others, but individuation may not be necessary to raise questions about how the presence of particular materials is to be explained. Because evidentiary use of enchanged materials depends on there being no acceptable alternative explanation for the materials being where they are, issues of chain of custody and prevention of contamination are extremely important.

The trace materials that forensic scientists analyze are ordinarily lightweight and small, even invisible to the naked eye—otherwise, the perpetrators who left them behind would have detected and removed them. Evidence often involves microscopic materials, and, as nanotechnology progresses, it is logical to expect the scale of evidentiary materials to grow smaller and smaller.

Law-enforcement investigators sometimes interpret Locard's principle in a general way when they refer to the idea that alterations, especially mutual alterations, result from two things engaging with each other. The principle is occasionally discussed in this sense, for example, in computing forensics, in connection with the changes that occur in computers when they communicate with one another.

Edward Johnson

Further Reading

Bisbing, Richard E. "Fractured Patterns: Microscopical Investigation of Real Physical Evidence." *Modern Microscopy Journal*, January 29, 2004.

Chisum, W. Jerry, and Brent E. Turvey. "Evidence Dynamics: Locard's Exchange Principle and Crime Reconstruction." *Journal of Behavioral Profiling* 1 (January, 2000).

Houck, Max M., ed. *Mute Witnesses: Trace Evidence Analysis*. San Diego, Calif.: Academic Press, 2001.

_______. *Trace Evidence Analysis: More Cases in Mute Witnesses*. Burlington, Mass.: Elsevier Academic Press, 2004.

See also: Chain of custody; Crime laboratories; Crime scene investigation; Crime scene protective gear; Cross-contamination of evidence; Direct versus circumstantial evidence; Disturbed evidence; Fibers and filaments; Hair analysis; Literature and forensic science; Sherlock Holmes stories; Trace and transfer evidence.

Lock picking

Definition: Method of opening locks without the use of the keys for which the locks are designed.

Significance: Lock picking is a simple and direct way for people to gain unlawful entry to an area without the use of easily detectable methods of force such as breaking windows or smashing in doors. Forensic crime scene experts require an understanding of the techniques involved in lock picking so that they can be familiar with the evidence such activities leave behind.

Locks are among the most popular security measures for everyday applications. They provide security for homes, office buildings, and vehicles. They are relatively inexpensive, most are technologically simple, and they can be engineered for a wide variety of applications. The design of the majority of modern locks is still based on the tumbler design originated by Robert Barron in 1778: A key inserted into the lock raises pins, also called tumblers, into their correct positions, which then allows the cylinder to turn. This technology is vulnerable, however, to a relatively simple procedure for turning the cylinder without using the key. This procedure, known as lock picking, can be done by almost anyone with the correct tools and some practice.

Methods

Basic lock picking requires only two tools: a pick and a torque wrench. The torque wrench is used to apply turning pressure to the cylinder while the pick is inserted into the cylinder to lift the pins into place. As each pin is lifted into place by the pick, the torque wrench keeps each pin in place by turning the cylinder a small amount. After all of the pins are in place, the torque wrench is able to turn the cylinder completely freely and thus unlock the lock. A basic lock-picking kit includes a variety of picks and torque wrenches for different sizes of locks and different types of pins. Similar tools can also be fashioned out of small slot-type screwdrivers, paper clips, dental picks, nail files, pocketknives, tweezers, and other readily available, similarly shaped objects.

Many lock-picking kits also include a tool known as a rake. This tool is used in a slightly different, less careful technique known as scrubbing or raking. In this technique, the torque wrench is used in basically the same way, but instead of the pick being used to push the pins into place individually, the rake is used to scrape back and forth within the cylinder while upward force is applied. The pins are thus pushed up together until each one reaches the shear line, the edge of the cylinder where they will allow the cylinder to turn. This technique can be faster, but it is more likely to damage the lock and generally has a lower success rate. The lock-picking gun, a handheld machine that performs a similar method using a vibrating tip, was invented in 1934. An experienced user with an electric lock-picking gun can usually gain access to locked areas within a matter of seconds.

Protecting Against Lock Picking

Many lock designers have introduced modifications to the tumbler design that are intended to prevent or at least slow down lock-picking efforts. One area of focus in lock design has been the pin. Originally, pins were cylindrical, uniform in size, and linearly positioned. More sophisticated locks now use differing sizes of pins, mushroom- or wafer-shaped pins, and nonlinear alignment of the pins. Barron's original design used only two pins, but most modern locks use five pins and some use even more. In tubular locks, the pins are placed in a circle around the key; these locks are thought to be much less susceptible to traditional lock-picking techniques.

Locks with such advanced features are generally more expensive than simpler locks and are not widely employed. Additionally, most of these locks have been conquered by ambitious lock-picking experts. Information about lock-picking techniques has been widely disseminated both in print and over the Internet, so although locks may be an excellent way to prevent casual entrance to a house, car, or office, most security experts do not consider locks to be effective measures against determined trespassers with enough time.

Basic lock picking requires only two tools: a pick and a torque wrench. The torque wrench is used to apply turning pressure to the cylinder while the pick is inserted into the cylinder to lift the pins into place. As each pin is lifted into place by the pick, the torque wrench keeps each pin in place by turning the cylinder a small amount. After all of the pins are in place, the torque wrench is able to turn the cylinder completely freely and thus release the lock. *(© iStockphoto.com/Stephen Shockley)*

One advantage that investigators have against unlawful lock picking is that only the most expert lock picking done without haste leaves no visible trace. A lock that has been picked will typically have telltale scratches where the torque wrench was pushed against the metal, and, if disassembled, the lock will reveal marks on the pins where the pick pressed. Sophisticated crime scene investigators know to look for signs of lock picking when other signs of forced entrance are missing. In some cases, signs of lock picking and analysis of the methods used can aid investigators in determining the details of a crime that can lead to identification and prosecution of a suspect.

Robert Bockstiegel

Further Reading

Black, Carl. *Opening Combination Padlocks: No Tools, No Problem*. Boulder, Colo.: Paladin Press, 2002. Brief volume focuses specifically on the picking of combination padlocks, laying out the process in straightforward language.

Hampton, Steven. *Improvised Lock Picking: Secrets from the Master*. Boulder, Colo.: Paladin Press, 2003. Gives instructions in common techniques for picking simple locks using household items. Organized by lock type for easy use.

McCloud, Mark. *Lock Picking Basics*. Urbana, Ill.: Standard, 2004. Condensed version of McCloud's work cited below focuses on the most common types of locks and the simpler techniques for lock picking.

_______. *Visual Guide to Lock Picking*. 3d ed. Urbana, Ill.: Standard, 2002. Presents a detailed examination of the picking of both simple and complicated modern locks. Many pictures and graphic illustrations help to demonstrate lock designs and picking tools and techniques.

Phillips, Bill. *Master Locksmithing: An Expert's Guide to Masterkeying, Intruder Alarms, Access Control Systems, High-Security Locks, and Safe Manipulation and Drilling*. New York: McGraw-Hill, 2007. Comprehensive volume is intended to help locksmiths prepare for the Registered Professional Locksmith Test. Also includes basic information about electronic security systems.

See also: Crime scene investigation; Tool marks; Trace and transfer evidence.

Louis XVII remains identification

Date: Findings announced on April 19, 2000

The Event: Scientists announced that mitochondrial DNA analysis of a sample taken from a heart that had been kept in a jar in a basilica near Paris since the late eighteenth century revealed the heart to be that of Louis XVII, a young boy who was heir to the throne of France.

Significance: For more than two hundred years, various claims had been made regarding the lost son of King Louis XVI and Marie-Antoinette of France. Forensic analysis of mitochondrial DNA established that Louis XVII died in prison in 1795.

Louis XVII, known for most of his life as Louis-Charles, was the second son of King Louis XVI and Marie-Antoinette of France. He was born on March 27, 1785, and became heir apparent upon the death of his older brother in 1789. As the French Revolution was beginning (1789), the royal family was imprisoned. With the execution of Louis XVI on January 21, 1793, the young boy became the titular King Louis XVII at the age of eight. Consequently, he was a threat to the revolutionaries should the royalists attempt to reestablish the monarchy. The boy was separated from the rest of his family

The "King" in *Huckleberry Finn*

Of the many literary claimants to the title of King Louis XVII, perhaps the most famous is the scoundrel known as the king in Mark Twain's novel Adventures of Huckleberry Finn *(1884). In chapter 19, Huck and Jim allow two itinerant con men aboard the raft on which they are traveling down the Mississippi River. The younger man startles his new companions by announcing that he is the rightful duke of Bridgewater. After pondering the matter, the older man later makes an even more amazing claim. Huck describes the moment:*

" . . . You ain't the only person that's ben snaked down wrongfully out'n a high place."

"Alas!"

"No, you ain't the only person that's had a secret of his birth." And by jings, he begins to cry.

"Hold! What do you mean?"

"Bilgewater, kin I trust you?" says the old man, still sort of sobbing.

"To the bitter death!" He took the old man by the hand and squeezed it, and says, "The secret of your being: speak!"

"Bilgewater, I am the late Dauphin!"

You bet you Jim and me stared, this time. Then the duke says:

"You are what?"

"Yes, my friend, it is too true—your eyes is lookin' at this very moment on the pore disappeared Dauphin, Looy the Seventeen, son of Looy the Sixteen and Marry Antonette."

"You! At your age! No! You mean you're the late Charlemagne; you must be six or seven hundred years old, at the very least."

"Trouble has done it, Bilgewater, trouble has done it; trouble has brung these gray hairs and this premature balditude. Yes, gentlemen, you see before you, in blue jeans and misery, the wanderin' exiled, trampled-on and sufferin' rightful King of France."

E. W. Kemble's illustration of the bogus king (left) meeting the equally bogus "duke of Bridgewater" in the first edition of *Huckleberry Finn.*

and imprisoned. He was beaten and malnourished by his jailers, and he died of tuberculosis on June 8, 1795, in the Temple Prison, Paris. After his body was autopsied, the physician Philippe-Jean Pelletan smuggled the boy's heart out of the prison and preserved it in wine alcohol.

Rumors were widespread that young Louis XVII had been smuggled out of prison and another boy substituted in his place. When the monarchy was restored nineteen years later, many young men came forward claiming to be Louis XVII. The most famous among them was Karl Wilhelm Naundorff, who died in Delft, the Netherlands, in 1845. His gravestone lists him as Louis Charles, Duc de Normandie, Louis XVII. In 1950, Naundorff's coffin was reopened, and the right humerus (the long bone of the upper arm) was removed so that tests could be performed to determine whether Naundorff had been poisoned. The bone remained thereafter in the Dutch Forensic Science Laboratories. In addition, locks of Naundorff's hair were taken from the coffin and sealed in envelopes, which were deposited in the Delft town archives.

In 1993, research groups in the Netherlands and France were given access to the Naundorff samples for analysis. From these samples, they extracted mitochondrial DNA (mtDNA), amplified segments of the hypervariable regions by polymerase chain reaction (PCR), and sequenced the DNA (deoxyribonucleic acid). The researchers also had access to hair samples from Marie-Antoinette, her mother (Maria Theresa of Austria), and two of her sisters (Maria Johanna Gabriela and Maria Josepha). Hair samples from other descendants of Marie-Antoinette were also made available. Mitochondrial DNA is inherited maternally. The results of the mtDNA comparisons ruled out Naundorff as Louis XVII.

In 1999, the French government allowed scientists to take a 500-milligram sample of the heart taken by Pelletan (which had been kept in a jar at the Basilique Saint-Denis, north of Paris). Analysis showed that the mtDNA from the heart was identical to that of Marie-Antoinette and her maternal relatives, establishing that the heart was that of Louis XVII. The data on this research were published by Els Jehaes and colleagues in 2001. In June, 2004, 209 years after the young king's death, a funeral mass was celebrated for Louis XVII at the Basilique Saint-Denis, and the heart of the boy was placed in a royal crypt near the graves of his parents.

Ralph R. Meyer

Further Reading

Cadbury, Deborah. *The Lost King of France: A True Story of Revolution, Revenge, and DNA*. New York: St. Martin's Press, 2002.

Jehaes, Els, et al. "Mitochondrial DNA Analysis of the Putative Heart of Louis XVII, Son of Louis XVI and Marie-Antoinette." *European Journal of Human Genetics* 9 (2001): 185-190.

Meyer, Anna. *Hunting the Double Helix: How DNA Is Solving Puzzles of the Past*. New York: Thunder's Mouth Press, 2005.

See also: Anastasia remains identification; Columbus remains identification; DNA extraction from hair, bodily fluids, and tissues; Exhumation; Mitochondrial DNA analysis and typing; Nicholas II remains identification; Polymerase chain reaction; Skeletal analysis.

Luminol

Definition: Chemical substance widely used in presumptive or nonspecific tests for blood during crime scene examinations.

Significance: Blood is often clearly visible at crime scenes, but in some cases crime scene examiners need to be able to detect and visualize blood evidence that is not readily apparent. The chemical substance known as luminol is used for this purpose.

Crimes against persons often result in the shedding of blood, and blood is usually visible at the scenes of such crimes. Bloodstain pattern analysts can examine visible bloodstain evidence to determine, for example, whether blood on a wall or a floor could have gotten there through impact spatter, arterial spurting, or passive dripping. In some circumstances, however, bloodstains require enhancement because only traces of blood can be seen by the naked eye; in other cases, investigators may believe that blood is likely to be present at a scene even though no blood is immediately visible. Enhancement of bloodstains also might be necessary when blood is on a surface that makes it difficult to see (such as a dark-colored or highly patterned fabric), when attempts have been made to clean bloodstains or they have become diluted in other ways (such as by rain or by traffic through the area of interest), or when investigators need to follow a trail of shoe prints or drag marks.

Crime scene investigators often use the chemical substance 3-aminophthalhydrazide, known as luminol, to make latent bloodstains visible. Blood contains hemoglobin, which transports oxygen in the blood. When a luminol solution is applied—usually sprayed over the area from a spray bottle—hemoglobin catalyzes the oxidation of the luminol to produce a faint, but distinct, blue-white luminescence, or glow. This luminescence is short-lived. Luminol is very sensitive; in ideal conditions, it can detect blood even if the blood is extremely diluted.

Because of the characteristics of the luminescence, examination of a crime scene with luminol is usually conducted in the dark. At outdoor crime scenes, examiners must wait until nighttime and arrange for nearby streetlights and other sources of light to be turned off before the luminol examination begins. For indoor crime scenes, all windows and doors can be screened off with black plastic to block any incoming light. Before applying the luminol, examiners need to wait until their eyes are accustomed to the darkness, so they will be able to see the luminescence. A solution of luminol is then sprayed over the scene and any luminescence observed. Although the glow can be photographed, this is not always easy, so examiners must make full notes to document what they see.

The application of luminol is usually the last step taken by examiners at a crime scene. The liquid spray distorts any blood patterns, so these need to be observed before luminol is applied. This includes bloody shoe prints if shoeprint comparison work is needed. Because any dilution of blood samples can reduce the chances of successful DNA (deoxyribonucleic acid) analysis, samples should be collected before luminol is used whenever this is possible. Samples of any trace evidence of interest should also be collected before luminol is applied, as the spraying of the solution can disturb such evidence.

Luminol is a nonspecific test—that is, substances other than blood can give positive results. Examples of such substances that may be present at crime scenes include bleach, rust, and some paints. The appearance of the luminescence from these is different from that caused by blood, but nevertheless, crime scene examiners need to exercise care in the interpretation of positive results.

Douglas Elliot

Further Reading

Barni, Filippo, et al. "Forensic Application of the Luminol Reaction as a Presumptive Test for Latent Blood Detection." *Talanta* 72, no. 3 (2007): 896-913. Thorough article covers all aspects of luminol work in some depth.

James, Stuart H., Paul E. Kish, and T. Paulette Sutton. *Principles of Bloodstain Pattern Analysis: Theory and Practice*. Boca Raton, Fla.: CRC Press, 2005. Informative work on the analysis of blood patterns includes a chapter on the use of luminol.

Siegel, Jay A., Pekka J. Saukko, and Geoffrey C. Knupfer, eds. *Encyclopedia of Forensic Sciences*. San Diego, Calif.: Academic Press, 2000. Includes an informative entry on luminol that relates the successful use of the substance in a homicide case

See also: Benzidine; Blood residue and bloodstains; Blood spatter analysis; Crime scene investigation; Crime scene protective gear; Footprints and shoe prints; Presumptive tests for blood; Reagents; Serology.

M

Mad cow disease investigation

Date: Began in November, 1986

The Event: The lethal neurological disease bovine spongiform encephalopathy, commonly called mad cow disease, was first recognized in 1986 in Great Britain; the incidence of the disease peaked in 1992, and about 200,000 cattle were affected. The disease was transmitted to people who consumed contaminated beef, leading to a variant form of Creutzfeldt-Jakob disease that was first identified in 1995; the incidence of this disease peaked in 2000, and it has killed approximately two hundred people.

Significance: The investigation of mad cow disease and its control were hampered by the unique nature of the infectious agent, the long incubation time involved in the disease process, the lack of a rapid detection system for infected animals and people, and the inadequacy of tests for contaminated feed and food.

Bovine spongiform encephalopathy (BSE) is one of several spongiform encephalopathies that may be heritable or transmissible. The infectious agent that causes BSE in cattle and the related variant form of Creutzfeldt-Jakob disease (vCJD) in people is novel in that it does not contain any nucleic acid (DNA or RNA) and it does not elicit an immune response, making it difficult to detect other than at autopsy, when spongelike lesions are seen in the brain. The infectious agent appears to be a protein called a prion. Heritable spongiform encephalopathies are caused by mutations in the prion gene, producing abnormal prions that adopt an unusual conformation and clump together over time to cause the brain pathology and neurological symptoms characteristic of the diseases. The diseases can be transmitted to susceptible animals or persons through the insertion of fragments or extracts from diseased tissue into the brain or bloodstream or, much less efficiently, by ingestion.

Spongiform Encephalopathies and Human Risk

Scrapie, found in sheep, is the earliest known spongiform encephalopathy. First noted during the 1730's in Britain, it is present in most countries of the world, except for Australia and New Zealand. It is passed from animal to animal, probably through contact with saliva, urine, or feces. The infectious agents, abnormal prions, decay slowly in the environment and may take years to dissipate from a contaminated pasture. Scrapie has not been known to infect humans, either through husbandry or through consumption of meat or milk.

Chronic wasting disease is a transmissible spongiform encephalopathy of deer, elk, and moose. It was first observed in 1967 in a captive mule deer in Colorado and has been identified in thirteen U.S. states and two Canadian provinces. No transmission to humans has been documented.

Since appearing in 1986, BSE has been diagnosed in twenty-nine countries. It occurs in cattle between two and eight years of age and is fatal. In the course of the disease, the animals lose coordination and show extreme sensitivity to sound, light, and touch. Although BSE may be transmitted from mother to calf, the major cause of the BSE epidemic in Britain was cattle feed containing contaminated ruminant-derived protein. Sick or dead animals, as well as parts of the carcasses of slaughtered animals not sold for human consumption, are routinely converted to a protein-rich supplement.

As cattle feed became increasingly contaminated with BSE, the epidemic exploded. The incidence of the disease peaked in 1992; cases of BSE decreased after the feeding of ruminant-derived protein to cattle was banned. In Europe, more than four million at-risk cattle were destroyed. As of May, 2007, 188,535 cattle had been identified with the disease; this is a substantial underestimate, however, because cattle disposed of before age two would not show outward signs of the disease, and until 1990 few of these animals would have been tested.

Since the British outbreak, most developed countries have established BSE surveillance programs, and fewer than 100 new cases are reported per year. As of the end of 2007, 15 cases of BSE had been detected in North America, 12 in Canada (one imported from Britain) and 3 in the United States (one imported from Canada).

When the British BSE outbreak occurred, concerns arose in regard to the implications of BSE for human health, despite the fact that scrapie was long known not to be a risk to humans. A surveillance unit was established in 1990, and 10 cases of vCJD were reported in 1996. In Britain, the incidence of vCJD peaked in 2000. As of May, 2007, 170 such cases had been identified worldwide; this is an underestimate given that only in Britain must any possible vCJD case be reported to a surveillance unit.

Consumption of contaminated beef was likely the source of vCJD; cooking does not inactivate the infectious agent. The ability of BSE to cross species barriers is one of its most insidious features. It has also been transmitted to zoo animals and domestic cats inadvertently fed contaminated meat or feed.

Perspective and Prospects

The BSE epidemic arose in Britain because protein supplements fed to cattle were derived from cattle that contained the abnormal prions. In the United States, the protein supplements fed to cattle come primarily from soybean meal. The origin of the infectious agent is likely to have been a spontaneous mutation of bovine prions that led to an abnormal conformation. The abnormal prions were amplified through the feeding of ruminant-derived protein back to cattle. It would be possible to create a BSE epidemic by incorporating the infectious agent, which is difficult to detect and to destroy, in an area's food, water, or blood supplies. Manufacturing the agent would be a daunting task, however, and malicious use of the agent would not offer instant gratification in view of the long incubation period (years to decades) necessary for the disease to manifest itself.

BSE Cases in the United States

The Centers for Disease Control and Prevention provides the following information about the three cases of bovine spongiform encephalopathy that have been identified in the United States.

- The first known case of BSE in the United States was identified in December, 2003. On December 23, 2003, the U.S. Department of Agriculture (USDA) announced a presumptive diagnosis of BSE in an adult Holstein cow from Washington State. This diagnosis was confirmed by an international reference laboratory in Weybridge, England, on December 25. Preliminary trace-back based on an ear-tag identification number suggested that the BSE-infected cow was imported into the United States from Canada in August, 2001. The preliminary trace-back identification of the animal was later confirmed by genetic testing.
- On June 24, 2005, the U.S. Department of Agriculture announced receipt of final results from The Veterinary Laboratories Agency in Weybridge, England, confirming BSE in a cow that had conflicting test results in 2004. This cow was from Texas and represented the first endemic case of BSE in the United States.
- On March 13, 2006, the U.S. Department of Agriculture announced the confirmation of BSE in a cow in Alabama. The newly confirmed case was identified in a non-ambulatory (downer) cow on a farm in Alabama. The animal was euthanized by a local veterinarian and buried on the farm. The age of the cow was estimated by examination of the dentition as 10 years. It had no ear tags or distinctive marks; the herd of origin could not be identified despite an intense investigation.

Front pages of London newspapers on March 21, 1996, after the British health secretary announced that scientific evidence had been found to connect a new strain of Creutzfeldt-Jakob disease in humans with bovine spongiform encephalopathy, or mad cow disease. *(AP/Wide World Photos)*

Continued monitoring of BSE and vCJD is warranted. In addition, surveillance of the food supply should persist to prevent consumption of meat from BSE cattle. Bans on feeding ruminant-derived protein to cattle must be maintained and enforced until methods can be developed to ensure the destruction of the abnormal prions they may contain.

James L. Robinson

Further Reading

Harris, D., ed. *Mad Cow Disease and Related Spongiform Encephalopathies*. New York: Springer, 2004. Collection of essays by international experts in their fields provides an introduction to prion biology and up-to-date reviews of BSE in cattle, vCJD in humans, and chronic wasting disease in deer.

Packer, Richard. *The Politics of BSE*. New York: Palgrave Macmillan, 2006. Former head of the British Ministry of Agriculture, Fisheries and Food provides a full and candid analysis of the BSE outbreak in Great Britain and responses to it. Includes an informative chapter on the official BSE inquiry.

Prusiner, Stanley B. "Detecting Mad Cow Disease." *Scientific American* 291 (July, 2004): 86-93. The discoverer of prions describes new tests that may permit rapid detection of abnormal prions in cattle and humans.

_______. "The Prion Diseases." *Scientific American* 272 (January, 1995): 48-57. Explains the history of prion diseases, including mad cow disease, and the basis for the prion theory, which Prusiner developed and for which he was awarded the Nobel Prize in Medicine in 1997.

Schwartz, Maxime. *How the Cows Turned Mad: Unlocking the Mysteries of Mad Cow Disease*. Berkeley: University of California Press, 2004. Provides a history of prion diseases from the description of scrapie in the eigh-

teenth century to modern transmission among animals and humans.

See also: Autopsies; Blood agents; Botulinum toxin; Epidemiology; *Escherichia coli*; Food and Drug Administration, U.S.; Food poisoning; Food supply protection; Nervous system; Pathogen transmission; Toxicological analysis.

Mandatory drug testing

Definition: Testing for the presence of illicit substances in individuals' bodies as a condition of employment, school attendance, or participation in sporting competitions.

Significance: As illegal drug use was increasing in the United States during the 1980's, the U.S. government first established mandatory drug testing for individuals in the military and then quickly expanded such testing to include all federal employees. As it became apparent that employees whose bodies were drug-free were less likely to have on-the-job accidents, to use sick time, or to perform poorly at work, increasing numbers of government and private-sector employers instituted mandatory drug testing for employees.

Mandatory drug testing in the United States began on September 15, 1986, with the federal government, when President Ronald Reagan signed Executive Order 12564 to establish a drug-free workplace. Based on this executive order, Congress passed the Drug-Free Workplace Act of 1988, which in turn led to the establishment of mandatory guidelines for federal workplace drug-testing programs. The law requires that all federal employees be completely free of illicit drug use, even when they are not working.

Mandatory drug testing in the United States was originally applied to employees of the federal government only, but many state governments and private employers soon also instituted drug-testing laws and regulations. Mandatory drug testing is divided into federally regulated and nonfederally regulated testing; testing that is not federally regulated includes that done by private businesses, sports organizations, and schools. In the years since mandatory drug testing was first regularly used in the United States, a number of different devices and techniques have been employed to carry out the testing, some with more reliability than others.

The Supreme Court on Drug Testing

In its ruling in *Skinner v. Railway Labor Executives Association* (1989), the U.S. Supreme Court held that federal regulations requiring drug testing of railroad employees involved in train accidents do not violate the Fourth Amendment to the U.S. Constitution. Under its statutory authority to set safety standards, the Federal Railroad Administration required employees to take breath or urine tests if they were involved in serious train accidents or if they violated safety rules. A court of appeals ruled that the tests could not be required without individualized suspicion, but the Supreme Court disagreed. Writing for a seven-to-two majority, Associate Justice Anthony Kennedy concluded that mandatory drug tests are reasonable in view of the government's interest in safe transportation and that it is not practical to require warrants because of the speed at which evidence of drug abuse is absorbed by the human body. A requirement of suspicion, moreover, could place the traveling public at risk because an employee's performance could be impaired long before enough evidence is available to establish suspicion.

The same day the Court issued its decision in *Skinner*, it also announced its approval of drug testing for customs inspectors in *National Treasury Employees Union v. Von Raab* (1989). Later, in *Vernonia School District v. Acton* (1995), the Court upheld random drug testing for students who participate in interscholastic sports. In *Chandler v. Miller* (1997), however, the Court invalidated a Georgia policy requiring all political candidates to submit to drug testing.

A technician places a urine sample to be tested for drugs in the tray of a gas chromatograph; the computer screen to the left displays the results of the analysis. *(Custom Medical Stock Photo)*

Federal Guidelines

Guidelines for drug testing of federal employees were established by the Substance Abuse and Mental Health Services Administration (SAMHSA) in September, 1994. At the time these guidelines were established, SAMHSA was under the direction of the National Institute on Drug Abuse (NIDA). The guidelines involved testing for only five specific categories of drugs, known as the NIDA 5: cannabinoids (that is, marijuana and its metabolite, THC), cocaine, amphetamines (including methamphetamine), opiates (including heroin, codeine, and morphine), and phencyclidine (PCP). The SAMHSA guidelines permit testing laboratories to report quantitative results only for these drugs, but many laboratories offer additional testing for drugs such as synthetic painkillers (for example, oxycodone), benzodiazepines (including Valium and Xanax), and barbiturates.

Whatever the drug being tested for, the SAMHSA guidelines call for an initial test known as a screening test. If the results of this initial test are negative, they are reported as such, and no further testing is done. If the initial results are positive, a follow-up test, known as a drug confirmation test, is done to verify or disprove the original findings. According to the SAMHSA guidelines, the confirmation test must be conducted on the initial sample using a technique that is completely different from the one used in the original test. All confirmation tests must be equal to or greater than the original tests in sensitivity.

Substances Available for Testing

Various substances obtained from the human body can be analyzed for the presence of drugs or their breakdown products (metabolites). Although it has been found that analysis of blood yields valid and reliable results, blood testing is rarely used to determine the presence of drugs because of the invasive nature of such testing. Urine drug testing is probably the most commonly used screening technique. Procedures for collecting urine samples for analysis must ensure that the persons to be tested are indeed the sources of the urine and that no substitutions have been made. Also, the samples obtained must be pure and undiluted.

Increasing numbers of drug screens are being conducted with samples of saliva, as the samples are easily collected, cannot be altered, and yield valid and reliable results similar to those obtained through blood testing. Detection of drugs and their metabolites in saliva is possible immediately after drug use and for up to three days following use. Sweat drug screens involve the use of patches that are applied directly to the skin for ten to fourteen days; this technique is rarely used because of security and detection issues. Hair testing provides reasonably accurate results; such testing can reflect drug use for a period of at least three months prior to testing.

Uses of Drug Testing

Many employers conduct mandatory drug tests of potential employees as a condition of employment prior to hiring. Because such a preemployment test is done only once for each person and at a predictable time, the person to be tested may simply avoid drug use for a specified period prior to that time in order to test negative.

Some employers also conduct random drug testing of employees, testing various persons at unpredictable times, making it difficult for drug users to avoid detection. This procedure is both the most effective use of drug testing as a deterrent to drug use and the most controversial. Many critics have argued that random drug testing constitutes an unreasonable invasion of privacy. The U.S. Supreme Court addressed this issue in 1989, ruling that random drug testing is legal for federal employees. Subjects must truly be chosen randomly, however; specific individuals cannot be targeted. An alternative to random drug testing for all employees is "for-cause" testing, in which individuals are drug tested only when their actions raise questions about possible drug use.

The least common application of mandatory drug testing is known as postincident testing—that is, drug testing that is required for individuals involved in workplace accidents or other incidents. It is often beneficial for an employer to prove that an individual was or was not under the influence of drugs or alcohol at the time a problematic incident occurred.

Robin Kamienny Montvilo

Further Reading

Belenko, Steven R. *Drugs and Drug Policy in America: A Documentary History*. Westport, Conn.: Greenwood Press, 2000. Presents a historical perspective on attitudes toward drug use in the United States and discusses federal policies aimed at controlling drug use from the mid-nineteenth century to the end of the twentieth century.

Husak, Douglas N. *Drugs and Rights*. New York: Cambridge University Press, 1992. Explores arguments for and against the right of society to place limits on the use of drugs for recreational purposes. Includes discussion of the philosophical underpinnings of mandatory drug testing and the ethics involved.

Jenkins, Amanda J., and Bruce A. Goldberger, eds. *On-Site Drug Testing*. Totowa, N.J.: Humana Press, 2002. Collection of essays by scientific experts discusses the various devices available for on-site drug testing. Explains each test's principles and assesses its advantages and disadvantages.

Karch, Steven B. *Workplace Drug Testing*. Boca Raton, Fla.: CRC Press, 2007. Examines U.S. regulations and guidelines for mandatory drug testing in the workplace and explores protocols for specimen collection and testing techniques. Includes an interesting comparison of policies and practices of workplace drug testing in the United States, Europe, Australia, and South America.

Tunnell, Kenneth D. *Pissing on Demand: Workplace Industry Drug Testing and the Rise of the Detox Industry*. New York: New York University Press, 2004. Brief volume explores the ethical implications of mandatory drug testing and questions whether such testing infringes on human rights. Also explores the techniques involved in mandatory drug testing and means of circumventing them.

See also: Athlete drug testing; Chain of custody; Drug abuse and dependence; Drug confirmation tests; Drug Enforcement Administration, U.S.; Ethics of DNA analysis; Gas chromatography; Harrison Narcotic Drug Act of 1914; Illicit substances; Mass spectrometry; Sobriety testing.

Markov murder

Date: September 7-11, 1978

The Event: Georgi Markov, a defector from communist Bulgaria, was poisoned with ricin in London.

Significance: Forensic science was instrumental in determining the cause of death and the method used in Markov's murder, establishing that the likely perpetrator acted with the assistance of a sophisticated organization such as the Soviet Union's secret police, the KGB.

Born in Bulgaria on March 1, 1929, Georgi Markov became a famous writer. Although some of his works were censored by Bulgaria's communist government, Markov was a government-accredited author, and he was allowed to travel to Italy to visit his brother. In 1969, he defected to the United Kingdom and began broadcasting for the British Broadcasting Corporation (BBC) World Service and the U.S.-sponsored Radio Free Europe, in which capacity he frequently criticized the Bulgarian communist regime. The Bulgarian government hated Markov's criticism and decided to have him killed, turning to the Soviet Union's KGB for assistance.

Bulgarian KGB agents attempted and failed twice to kill Markov before they succeeded in implanting in his leg a small sphere containing the deadly poison ricin (a substance derived from castor beans) on September 7, 1978. Before he died a few days later, Markov said that a man had poked him in the leg with the tip of an umbrella while he was waiting for a bus on Waterloo Bridge in London. The man, who apologized for bumping him, spoke in a foreign accent. Later, Markov noticed a small red pimple on his calf. The next day, he developed a high fever and was admitted to a London hospital, where he died three days later.

British authorities ordered forensic pathologists to conduct a complete autopsy. They found a pinhead-sized spherical pellet made of 90 percent platinum and 10 percent iridium embedded in Markov's calf. The pellet had two small holes forming an X-shaped cavity in which traces of ricin were found. The poison had been sealed in the pellet with a sugary substance that melted at body temperature. Ricin is fatal even in small quantities and has no known antidote.

Although forensic science could not confirm that the pellet was inserted into Markov by the tip of an umbrella, the specialized construction of the pellet left no doubt as to the involvement of a sophisticated group such as the KGB. Subsequently, a number of high-ranking KGB defectors, including Oleg Kalugin and Oleg Gordievsky, confirmed that the KGB was involved in the assassination.

Richard L. Wilson

Further Reading

Audi, Jennifer, et al. "Ricin Poisoning; A Comprehensive Review." *Journal of the American Medical Association* 294, no. 18 (2005): 2342-2351.

Cook, David, Jonathan David, and Gareth Griffiths. "Retrospective Identification of Ricin in Animal Tissues Following Administration by Pulmonary and Oral Routes." *Toxicology* 223 (2006): 61-70.

Evans, Colin. *The Casebook of Forensic Detection: How Science Solved One Hundred of the World's Most Baffling Crimes*. Updated ed. New York: Berkley Books, 2007.

See also: Assassination; Autopsies; Biological weapon identification; Kennedy assassination; Poisons and antidotes; Puncture wounds; Quantitative and qualitative analysis of chemicals; Ricin; Trace and transfer evidence.

Marsh test

Definition: Arsenic detection technique invented in 1836.

Significance: James Marsh's highly sensitive arsenic test revealed murderers and helped to establish the value of the testimony of scientific experts in criminal trials.

For centuries killers used arsenic, in large part because it was undetectable. Many murderers went unpunished while in some cases innocent persons were instead convicted of poisoning based on circumstantial evidence and confessions extracted by torture.

By the early nineteenth century, scientists had devised simple tests for the presence of arsenic in other substances. Chemists performed one standard method by bubbling hydrogen sulfide gas through a solution of the test material. The formation of a yellow precipitate—arsenic sulfide—revealed the presence of arsenic. The test did not always persuade jurors, however.

In 1832, an eighty-year-old English farmer named George Bodle drank his morning coffee and soon experienced severe stomach cramps.

He suffered symptoms characteristic of poisoning and then died. When a justice of the peace investigated the death, he discovered that John Bodle, George's grandson, had bought arsenic from a local pharmacist. John was arrested and tried for murder.

Using a standard arsenic test, chemist James Marsh analyzed the coffee that George Bodle had drunk as well as Bodle's organs. A yellow precipitate indicated the presence of arsenic. By the time Marsh displayed the evidence in court, however, the precipitate had become discolored, and an unconvinced jury reached a verdict of not guilty.

Disappointed by these results, Marsh invented a new arsenic test, one that revealed arsenic itself rather than a chemical reaction byproduct. Marsh performed his technique by heating a sample of suspect food or human tissue with strong acid to destroy organic matter and dissolve any arsenic. Next, he added pieces of metallic zinc, which converted dissolved arsenic to arsine, a gas. When arsine gas passed through a heated glass tube, it decomposed into hydrogen gas and metallic arsenic. Marsh collected metallic arsenic on the cooler part of the tube, where it formed a black, shiny deposit. A tube that contained such an "arsenic mirror" could be sealed and stored.

In 1840, the Marsh test became the first analytical method of toxicology introduced during a criminal trial. Marie Lafarge stood accused of killing her husband, Charles. Her weapon, according to the prosecution, had been cake, milk, and eggnog brimming with arsenic. Experts, including the great forensic toxicologist Matthieu-Joseph-Bonaventure Orfila, used the Marsh test to analyze food evidence and samples of tissues from Charles's body. They found arsenic, and Marie was convicted and sentenced to life imprisonment.

When Marsh's technique was performed with care, it could detect as little as one-fiftieth of a milligram of arsenic, and it could identify any trace amounts of arsenic in the chemicals used to perform the test. Although it was not perfect, the Marsh test proved adequate to expose a number of murderers in famous poison trials of the Victorian era.

Phill Jones

Further Reading

Emsley, John. *The Elements of Murder: A History of Poison*. New York: Oxford University Press, 2005.

Gerber, Samuel M., and Richard Saferstein, eds. *More Chemistry and Crime: From Marsh Arsenic Test to DNA Profile*. Washington, D.C.: American Chemical Society, 1997.

Wagner, E. J. *The Science of Sherlock Holmes: From Baskerville Hall to the Valley of Fear, the Real Forensics Behind the Great Detective's Greatest Cases*. Hoboken, N.J.: John Wiley & Sons, 2006.

See also: Arsenic; Chemical agents; Forensic toxicology; International Association of Forensic Toxicologists; Poisons and antidotes; Quantitative and qualitative analysis of chemicals; Toxicological analysis.

Mass graves

Definition: Burial sites containing the remains, often commingled, of numerous persons.

Significance: When mass graves are discovered, the services of forensic scientists are required to determine how and when those interred there died and, in cases of genocide or other kinds of homicide, to gather clues about the perpetrators. Perhaps the most important part of the investigation of mass graves is the identification of the persons buried in them. Through DNA analysis, scientists can bring together the remains of individuals that have become commingled with those of others, and they may be able to identify individuals so that their remains can be returned to family members.

Mass graves generally contain the remains of persons who have been casualties of war or genocide or the victims of catastrophic events, such as natural disasters or disease epidemics. Dozens, hundreds, or even thousands of bodies may be interred in such graves, which are often just pits dug in the ground in which bodies have been hurriedly placed and covered over with earth. In some cases, the bodies in mass graves have been burned or doused with lye to hasten decomposition. Typically, the sites of such graves lack identification markers.

In the forensic investigation of the site of a mass grave, the remains are carefully exhumed so that they can be examined for evidence of cause and time of death as well as for clues regarding the persons responsible for the mass burial. Identification of those whose remains lie in the grave is of great importance, both because knowing who the victims are can point to likely perpetrators and because identifying the victims enables authorities to return the remains to family members.

Although forensic odontology (analysis of teeth and dentistry), fingerprinting, and other methods of identification are sometimes useful in such cases, often the most effective and efficient way to establish the identities of remains collected from mass graves is through the comparison of DNA (deoxyribonucleic acid) extracted from the remains with the DNA of possible surviving relatives or other remains of known identity. Because bodies often lie in mass graves for years before they are discovered, exposed to the effects of the elements, insects, and animals, other methods of identification may be impractical.

Identification of a deceased person through the use of DNA requires DNA samples from possible relatives for comparison. In the case of mass graves, it is sometimes difficult for investigators to determine enough about the persons buried to know where any surviving relatives of those persons may be found. For example, many mass graves contain the bodies of prisoners of war, and the burial sites provide little information regarding where the buried individuals may have lived. Investigators must often seek possible surviving relatives far from the locations of such graves.

In Bosnia and Herzegovina, Croatia, Poland, Slovenia, Vietnam, and other countries around the world, teams of forensic scientists have performed DNA analysis on the remains of individuals buried in mass graves that were created during war and in periods of genocide. By analyzing DNA samples extracted from bones and teeth exhumed from the graves and comparing the resulting DNA profiles with those of persons believed to be possible relatives of the dead, scientists have been able to establish the identities of many victims.

A forensic anthropologist cleans a skull found in a mass grave outside Ciudad Juárez, a Mexican border town near El Paso, Texas. In 2007, the Chihuahua state attorney general's office estimated that as many as twelve hundred bodies may have been buried at the site by drug traffickers between 1991 and 2005. Investigators used DNA testing, forensic sculpting, and other techniques to identify the bodies. *(Tomas Bravo/Reuters/Landov)*

Dwight G. Smith

Further Reading

Barbaro, Anna, Patrizia Cormaci, and Aldo Barbaro. "DNA Analysis from Mixed Biological Materials." *Forensic Science International* 146, supp. 1 (Fall, 2004): S123-S125.

Buckleton, John, Christopher M. Triggs, and Simon J. Walsh, eds. *Forensic DNA Evidence Interpretation*. Boca Raton, Fla.: CRC Press, 2005.

Butler, John M. *Forensic DNA Typing: Biology, Technology, and Genetics of STR Markers*. 2d ed. Burlington, Mass.: Elsevier Academic Press, 2005.

Haglund, William D. "Recent Mass Graves: An Introduction." In *Advances in Forensic Taphonomy: Method, Theory, and Archaeological Perspectives*, edited by William D. Haglund and Marcella H. Sorg. Boca Raton, Fla.: CRC Press, 2002.

See also: Anastasia remains identification; Asian tsunami victim identification; Beslan hostage crisis victim identification; Buried body locating; Croatian and Bosnian war victim identification; DNA extraction from hair, bodily fluids, and tissues; Exhumation; Forensic anthropology; Forensic archaeology; Genocide; Holocaust investigation; September 11, 2001, victim identification; Tattoo identification.

Mass spectrometry

Definition: Technique in which ions of a sample are formed and subsequently separated according to their mass-to-charge ratio.

Significance: Because each element's molecules yield a unique mass spectrum, forensic scientists use the sensitive and versatile technique of mass spectrometry to identify conclusively the components of a variety of sample types, including drugs, explosives, and ignitable liquid residues in arson debris.

Almost any type of sample can be analyzed by mass spectrometry, either through direct introduction of the sample or through use of the mass spectrometer as a detector for another analytical technique. In forensic science, gas chromatography-mass spectrometry (GC-MS), liquid chromatography-mass spectrometry (LC-MS), and inductively coupled plasma-mass spectrometry (ICP-MS) are among the more common techniques in which mas spectrometry is used as a detector for the preceding technique.

The instrument used in mass spectrometry, the mass spectrometer, consists of three major parts: the ion source, the mass analyzer, and the detector. Because ions are being formed, the instrument operates under vacuum to prevent collisions of the sample ions with other atmospheric gases.

Ion Source

Ions of the sample are produced in the ion source. Electron impact (EI) ionization and chemical ionization (CI) are perhaps the most commonly used ionization methods in forensic science. In EI, the sample is bombarded with high-energy electrons from an electron beam, causing fragmentation of the sample into ions of varying masses. The fragment ions formed are characteristic of the original sample.

In CI, a reagent gas (commonly methane) is first ionized through interaction with the electron beam. The resulting reagent gas ions then react with sample molecules to form sample ions. CI results in significantly less fragmentation than does EI ionization and is useful to determine the molecular weight of the sample.

Mass Analyzer

The sample ions formed are then directed to the mass analyzer, which separates the ions according to their mass-to-charge ratio (m/z). In most ionization processes, only singly charged ions are produced, so the m/z indicates the mass of the ion. Different types of mass analyzers are available, including magnetic sector, quadrupole, and time-of-flight (TOF) mass analyzers.

The magnetic sector analyzer consists of a magnet to which a magnetic field is applied. Under the influence of the magnetic field, ions travel in curved paths toward the detector. For a given value of the applied magnetic field, only ions of a given m/z will reach the detector; ions of other m/z collide with the surface of the spectrometer and are not detected. The magnetic field values are thus scanned in order to detect ions of all m/z.

The quadrupole mass analyzer is commonly used in such so-called hyphenated techniques as GC-MS and ICP-MS. This analyzer consists of four parallel rods arranged in two pairs; one pair is positioned above the other, essentially defining the corners of a square. A combined electric and radio frequency field is applied to opposite pairs of rods. Ions travel through the space defined by the rods and reach the detector. For a given electric/radio frequency field combination, only ions within a very narrow m/z range can reach the detector; all other ions hit the rods and are not detected. The electric/radio frequency field is thus varied during the analysis to allow ions of all m/z to reach the detector.

In the TOF analyzer, sample ions are separated based on the time they take to drift down a flight tube and reach the detector. Smaller ions drift more quickly and reach the detector ahead of larger ions. The time taken for the ion to reach the detector is converted into an m/z value by the data system.

Detector

Electron multipliers are commonly used as detectors in mass spectrometry because of their ability to amplify the ion signal. The detector consists of a curved glass tube that is coated with a substance that readily emits electrons, such as lead oxide. As ions from the mass analyzer hit the surface of the multiplier, electrons are emitted and travel farther along the multiplier tube, striking the surface and causing the emission of even more electrons. By the time the end of the multiplier is reached, a cascade of electrons is produced, which is measured. The more ions there are of a given m/z, the more intense the measured signal is, because more electrons are emitted from the surface.

Data are displayed in the form of a mass spectrum, which is a plot of ion intensity versus m/z. The forensic scientist can use the mass spectrum to identify a molecule conclusively based on the pattern of fragment ions observed, which is unique to that molecule.

An agent at the South Carolina Law Enforcement Forensic Science Division uses mass spectrometry coupled with gas chromatography to identify the different drugs present in a biological sample. *(AP/Wide World Photos)*

Mass Spectrometry in Forensic Science

In GC-MS and LC-MS, samples are injected into the chromatography system and separated in the normal manner. Separated sample components then pass into the mass spectrometer for subsequent detection. Because narrow chromatography columns are used in GC, the carrier gas flow rates are compatible with the mass spectrometer; hence the GC column passes through a short transfer line directly into the mass spectrometer. The transfer line is heated in order to prevent loss of the separated analytes (the substances being analyzed) during transfer. Coupling LC with MS is more difficult, as the mobile phase solvent must be removed and the separated analytes must be transformed from solution into the gaseous state.

ICP-MS is slightly different from the other hyphenated techniques; in this case, the ICP is the ion source. Sample solutions are introduced into the ICP at atmospheric pressure, the solvent is evaporated, and the sample is ionized. The interface between the ICP and the MS consists of two metal cones, each with a pinhole aperture. The sample ions pass through the first aperture into a chamber with lower pressure and then through the second aperture into the mass analyzer, which is maintained at even lower pressure. Once in the mass analyzer, ions are separated and detected as described previously.

Ruth Waddell Smith

Further Reading

Bell, Suzanne. *Forensic Chemistry*. Upper Saddle River, N.J.: Pearson Prentice Hall, 2006. Provides informative description of the forensic applications of mass spectrometry.

Houck, Max M., and Jay A. Siegel. *Fundamentals of Forensic Science*. Burlington, Mass.: Elsevier Academic Press, 2006. Good general textbook provides a brief description of the instrument components of mass spectrometers.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005. Presents discussion of mass spectrometry techniques in relation to forensic applications, including forensic toxicology, identification of illicit substances, and DNA analysis.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007. General introductory text provides a brief overview of mass spectrometry.

Siegel, Jay A. *Forensic Science: The Basics*. Boca Raton, Fla.: CRC Press, 2007. Text includes a general discussion of mass spectrometry illustrated with the example of cocaine.

See also: Analytical instrumentation; First responders; Forensic geoscience; Gas chromatography; Laser ablation-inductively coupled plasma-mass spectrometry; Micro-Fourier transform infrared spectrometry; Soil; Spectroscopy.

Medical examiners. *See* Coroners; Forensic pathology

Medicine

Definition: Scientific field that encompasses all activities and technologies involved in the process of restoring and maintaining human health and preventing disease.

Significance: In addition to its health maintenance and restoration functions, modern medicine maintains a significant role in preventing disease through research and discovery of disease-causing organisms and the development of vaccines to prevent their spread. Medicine's most prominent role in the forensic sciences lies in the reinforcement of the relationship between cause and malady as it applies to criminal or malpractice cases.

Medicine is a social science that began with the earliest and even the smallest human social units. Tribes discovered ways to alleviate pain, stem blood flow, heal wounds, and cure common ailments through the judicious and often experimental use of local herbs. As tribal units grew in number, some members became specialized in these techniques and became the "healers" or "shamans" of their tribes. They were tasked with day-to-day healing and also with the transmission of medical information from one generation to the next.

The transition from tribal medicines to modern medical science is embedded in the growth of human civilization. The formal start of modern medicinal use is considered to have taken place in Mesopotamia, but ancient societies of tribes and other social units practiced the healing arts thousands of years prior to the civilizations of the ancient Near East. The formalization of medicine as a distinctive science undoubtedly dates first from the Egyptians and shortly thereafter from the Alexandrian Greeks, who acquired medical information from their conquest of India and Egypt and introduced it to civilizations of the Mediterranean.

Early Egyptian and Indian Medicine

The Greeks learned much from the Egyptians, who, in turn, had learned from the civilizations of Mesopotamia. Ancient Egyptian physicians treated diseases in ways both physical and spiritual. They developed a basic understanding of anatomy and used this knowledge to perform surgeries more than forty-five centuries ago.

Ancient papyrus accounts reveal that Egyptians knew how the body worked and had a broad understanding of the heart, the pulse, blood, and breathing. These documents clearly show that the Egyptians knew about the spleen, heart, anus, and lungs and their functions. They also addressed female issues such as menstrual flow and birthing problems, and the records include a reference to the first known female physician, Peseshet, who lived and practiced in the Fourth Dynasty (c. 2613-c. 2494 B.C.E.). The first medical hospital, called "the Life," was established in the Second Dynasty (c. 2775-c. 2687 B.C.E.), and by the Twelfth Dynasty (c. 1991-c. 1786 B.C.E.), Egyptian workers had pensions, medical insurance, and sick-leave benefits.

Physicians in the subcontinent of India in ancient times also demonstrated an understanding and knowledge of medicine and dentistry. A tradition called Ayurveda, now more than two thousand years old, encompassed religious beliefs important in healing as well as instruction in herbal practices that demonstrated the understanding of the concept of holistic healing of diseases. The early Ayurvedic text known as the Charaka Samhita defined the purpose of medicine: to cure the diseases of the sick, to protect the healthy, and to prolong life. Toward these goals, the text detailed medical examination, diagnosis, treatment, and prognosis for many sicknesses; among many other procedures, it described rhinoplasty and cataract surgery. The study of medicine involved acquiring a knowledge of distillation, operative skills, and skills in cooking, horticulture, metallurgy, sugar manufacture, pharmacy, mineral analysis and separation, metal compounding, and preparation of alkalis. Training took up to seven years, and students had to pass a medical board test before they could become physicians.

Ancient Greek, Roman, and Islamic Medicine

Hippocrates, considered the father of medicine, was born in Greece in about 460 B.C.E. He believed that observation and recording of patients' symptoms were critical aspects of patient care. In the twenty-first century, Hippocrates is best remembered for his ultimate contribution to the growth of medicine, which is embodied in the Hippocratic oath.

The ancient Romans were a practical people, and their medicinal science emphasized public health and personal hygiene. Functional toilets, baths, water pumps, and a city sewage system improved health by making possible a constant supply of clean water. To prevent disease, the Romans embarked on a major program of draining marshes, which, they correctly believed, bred disease-carrying mosquitoes.

Among the major medical advancements made by ancient Islamic civilizations were contributions to the fields of anatomy, ophthalmology, pharmacology, pharmacy, physiology, and surgery. Islamic physicians set up universities and wrote many texts of their findings that were used in universities in the Middle East and Europe. The text *De gradibus* connected mathematics to medicine in its quantification of drug dosages. Many medical tools invented in ancient times by Islamic physicians are still in use in the twenty-first century; these include forceps, ligatures, surgical needles, the scalpel, the curette, the retractor, the surgical spoon, the surgical hook, the surgical rod, the bone saw, the speculum, plasters, and catgut.

Medieval to Modern Medicine

Advances in medical science in Europe slowed during the Middle Ages, in part because of the Roman Catholic Church's dominance over Europe. The Church pressed the idea that human illnesses were caused by sin and insisted that only repentance and redemption could alleviate pain and suffering. In the late Middle Ages, however, many universities were established, and students were encouraged to challenge traditional and folkloric beliefs. This enabled a resurgence of the medical field during the Renaissance that has continued to the present. A major part of this growth involved the discovery and application of techniques from the Muslim world and from India.

The French biologist Louis Pasteur played a major role in the development of modern medical science by helping to prove the germ theory of disease during the 1870's. His name has entered the English language in the word "pasteurization," the name given to a technique used to remove harmful organisms from milk and other liquids without damaging the basic chemistry of the partially sterilized liquids. *(Library of Congress)*

The transition of medicine into a modern science occurred over the course of the past two centuries with the recognition of disease causation as well as a revolution in thought concerning how patients are treated and how diseases can be prevented. Joseph Lister developed and used antiseptics during the late eighteenth century, and Louis Pasteur created a vaccine for rabies and developed the process now known as pasteurization, which made milk and wine safer to drink. Pasteur's experiments demonstrated a causal link between microorganisms and diseases that led to the development of germ theory. Florence Nightingale introduced changes into medicine through her role as a nurse, focusing on alleviating patient suffering and mortality caused by lack of hygiene and nutrition.

The application of scientific method and research produced many new developments in medicine. In addition to concerns with the physical body, modern medicine expanded its role to include mental illness as a new category. Eventually, advancements such as genetic screening and cancer prevention programs were included within the role of medicine.

Medicine and Forensic Science

Forensic medicine, a branch of both health sciences and forensic sciences, is charged with determining and interpreting medical facts in legal cases. Forensic medicine is especially concerned with the areas of biology, pathology, and psychiatry that may be important in criminal and other court cases. It encompasses everything from the signing of birth and death certificates and negotiating insurance claims to performing autopsies and presenting expert medical testimony in courtroom trials. Because mainstream medicine, as taught in hospitals and medical schools, is such an established and accredited science, the testimony of forensic medical examiners is considered extremely credible evidence.

Forensic medicine also includes such common legal medicine procedures as paternity testing, determination of cause of death, psychological evaluation of suspects or witnesses, and DNA (deoxyribonucleic acid) analysis of crime scene materials and samples from suspects and victims. A forensic medical expert must know all about human anatomy and human capabilities related to body structure and abnormalities that might be caused by crimes or malpractice. Such knowledge plays a major role in crime scene reproduction, which may lead to indicative or exclusionary testimony.

Forensic pathology focuses on determination of the cause of death in legal cases; this area of specialty includes the study of the structural changes caused by disease or injury. A coroner or medical examiner performs an autopsy to determine the exact cause of death, but often cause of death is obvious upon arrival at the crime scene. Investigators are trained to look for bullet wounds, strangulation marks, evidence of drug overdose, and similar evidentiary details, depending on the type of crime. The forensic pathologist and coroner work together to gather information from the crime scene and autopsy, and this information becomes evidence in court.

Toxicological analyses of diseased persons or of dead bodies are also important in both the practice of medicine and the application of forensic medicine. Toxicology studies can determine the physiological cause of death and provide information about the daily life of an individual or about the time immediately before death. Forensic toxicological analyses can provide information about suspects as well. Some cases have been dismissed based on toxicological evidence that proved the suspects may have been in an altered state of mind caused by negative reactions to pharmaceutical drugs at the time the crimes were committed. Negative reactions to prescription drugs can cause delusions, momentary psychosis, and panic attacks, and in cases such as these, the individual's state of mind is at issue.

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Further Reading

Adelman, Howard C. *Forensic Medicine*. New York: Chelsea House, 2007. Brief work provides basic information on the applications of medicine in forensic science.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005. General text devotes a section to the discussion of forensic pathology and related specialties, many of which involve medical training.

Payne-James, Jason, Anthony Busuttil, and William Smock, eds. *Forensic Medicine: Clinical and Pathological Aspects*. San Francisco: Greenwich Medical Media, 2003. Collection of essays by specialists in various disciplines is a useful reference source aimed at forensic pathologists and physicians as well as law-enforcement personnel.

Shepherd, Richard. *Simpson's Forensic Medicine*. 12th ed. London: Arnold, 2003. Introductory textbook addresses the medical examination of both the living and the dead for purposes related to law enforcement and legal proceedings. Includes discussion of ethical issues.

See also: Ancient science and forensics; Anthropometry; Autopsies; Coroners; Epidemiology; Forensic pathology; Living forensics; Parasitology; Product liability cases; Toxicological analysis.

Megan's Law

Date: First law enacted in 1994

The Law: Combination of statutes requiring sex offender registration and community notification regarding sex offenders that were passed in New Jersey in 1994 and then adopted on the federal level.

Significance: The landmark legislation passed in New Jersey served as a prototype for many U.S. state statutes concerning sex offenders as well as for federal legislation aimed at addressing the problem of sex offender recidivism.

Megan's Law helped to increase the powers of U.S. states that had already established sex offender registries by extending the work of the agencies in charge of the registries beyond simple registration into the realm of various forms of notification. To meet basic registration requirements, sex offenders, upon release from prison or some kind of community placement, must provide local law-enforcement authorities with their names, descriptions of the crimes of which they were convicted (which, because of plea bargaining, may well be very different from their actual offenses), and their new addresses. Most laws also require released sex offenders to provide authorities with regular updates of their address information.

Notification goes beyond registration in that it involves informing the public of the locations of released sex offenders living in their areas. This in turn usually involves some type of assessment of offender risk level. Offenders may be assessed by crime type (pedophilia automatically requires some type of notification, for example), or law-enforcement authorities may use a formal risk assessment instrument that considers prior criminal record. In some communities, prosecutors are responsible for assessing and classifying released sex offenders; in others, these duties are carried out by officials serving on the board of the sex offender registry.

Offender Classification

Sex offenders are usually classified in terms of a three-tier risk system that has implications for the type of notification the public receives. Level I offenders are those who present a relatively low degree of recidivism and dangerousness. Information about such offenders is typically not available to the public; only the personnel of law-enforcement agencies, correctional institutions, and departments of youth or social services have access to this information.

Level II offenders present a moderate degree of recidivism risk and dangerousness. Members of the public have access to information on these offenders through requests to their local police departments or sex offender registry boards, and information about Level II offenders may automatically be sent to certain institutions, such as schools.

Level III offenders pose a high degree of recidivism risk and dangerousness, and information on these offenders may be presented to the public without request, through press releases, mailings, or Internet postings. Offender risk level also has implications for the length of the registration period. Level III offenders must meet registration and address change notification requirements for the remainder of their lives.

Background

Megan Kanka was a seven-year-old girl living in New Jersey with her family when she became a victim of child sexual molestation and murder in July, 1994. The offender, Jesse Timmendequas, invited her into his home, purportedly to see his puppy. He then molested Megan and strangled her with his belt. Timmendequas lived across the street from the victim's family with two other sex offenders, and he had previously served six years in a secure sex offender treatment center in New Jersey. After these facts were reported following Megan's death, members of the community were outraged that they had not been forewarned about Timmendequas's presence in their midst; in response, they conducted mass demonstrations and petitioned the governor for a change in the law. Shortly after the incident, the New Jersey state legislature passed the Violent Crime and Law Enforcement Act, which was known as Megan's Law. It included both registration and notification requirements for dangerous sex offenders.

The Jacob Wetterling Crimes Against Children and Sexually Violent Offender Registration Act, part of President Bill Clinton's 1994 Crime Act, required states to establish effective registration systems for convicted child molesters and other sexually violent offenders. Offenders in these categories had to register for ten years, and those assessed to be "sexually violent predators" had to continue to register until they were no longer placed in this category. The states were required to release this registration information to law enforcement and to the public when warranted.

A federal version of Megan's Law, passed in 1996, incorporated a form of mandatory community notification to ensure public safety. The federal law also created a financial incentive for states to set up sex offender registration and tracking systems: They were given until September of 1997 to do so, or they risked losing 10 percent of an antidrug allocation from a state and local law-enforcement grant program. The Pam Lyncher Sexual Offender Tracking and Identification Act, passed in October, 1996, required the Federal Bureau of Investigation (FBI) to establish a national sex offender registry and to strengthen the earlier registration requirements. Aggravated offenders and recidivists, as well as sexually violent predators, had to register for life.

Impacts

Since the passage of these laws, a small but growing body of empirical studies has been conducted to evaluate their impacts. The studies have generally been exploratory in nature (that is, they have not been designed to test previously derived hypotheses) given that the laws themselves are still relatively new. Most have employed survey or archival data methodologies.

Some important general trends have been revealed by this research. One Massachusetts study focused on 136 sex offenders whose repetitive crimes resulted from mental disorders (but who were not legally insane). These subjects were randomly selected from 400 offenders incarcerated in a maximum-security institution. Only 25 percent of the sample would have been eligible for the registry based on previous offense history (prior registry-eligible convictions). Preventive notification efforts obviously could have a chance of being effective only for

President Bill Clinton signs the federal version of Megan's Law, named for child murder victim Megan Kanka of New Jersey, on May 17, 1996. Behind the president, from left, are Megan's mother and brother, Congressman Dick Zimmer of New Jersey, and John Walsh, host of the television show *America's Most Wanted. (AP/Wide World Photos)* this minority of offenders. However, 90 percent of the offenders with earlier sex crime arrests were eventually convicted of Massachusetts registry-eligible crimes.

This study also looked at twelve predatory stranger crimes to see if the Massachusetts law would have prevented them. The offenders' work and geographic locations were analyzed, including the distance to their respective crime scenes. The researchers found a good chance for prior victim notification in four of the cases and a poor to moderate chance in two others. The "good chance" offenders lived close to their victims. Even in these cases, however, the effectiveness of the law assumes that police can be notified and that the potential victim receives the notification and acts on it. It further assumes that the victim's actions are successful in eliminating the possible victimization. Even with all these assumptions satisfied, the end result may be a displacement of the sexual offender to another jurisdiction where he or she is not as well known and no notification is performed. This highlights the potential importance of national and international notification efforts.

Another study surveyed mental health professionals regarding their views about sex offender registry Web sites. This survey of 133 randomly selected members of the Association for the Treatment of Sexual Abusers (ATSA) produced very mixed projections about the impact of sex offender registries and notification efforts. More than 80 percent of the sample felt that community notification efforts through the Internet (arguably the most sophisticated and widespread form of notification) would not affect the number of child victims each year. It was noted that not all sex offenders appear in the Web sites of all states (some come from out of state, some are first timers, and in some states only information on the most serious offenders is posted online). In addition, pedophiles are strongly driven; their crimes are repetitive and compulsive, and they are not necessarily deterred by the threat or actualization of public notification.

As the researchers noted, not all potential victims have Internet access or use it frequently enough to stay on top of all the Web sites providing sex offender information. The sites may also engender a false sense of security—that is, site visitors may believe that if particular adults are not included on the sites, then they must be no threat. This study concluded that notification, like many other forms of technology with criminal justice applications, is a means to an end. It does not in and of itself explain why these crimes occur and how to deter or prevent them effectively.

In this sample of mental health professionals, 62 percent expressed fears about possible vigilantism against those appearing on the Web sites (from neighbors, employers, and even the police), but several other studies have found that less than 5 percent of registered sex offenders have reported any form of harassment. This does not, however, include unreported incidents.

Future Considerations

Observers have suggested that a need exists for more cross-jurisdictional sharing of sex offender registration and notification information over wider geographic regions. Some sex offender notification statutes may need to be revised to allow for this. The importance of sharing information across jurisdictions is highlighted by documented cases of offenders who have deliberately moved across state lines so that they can successfully "slip through the cracks" and not register at all.

A number of commentators have pointed out the need for sex crime investigation and therapy programs that go beyond registration and notification efforts. This is especially important given the research findings that indicate that many sex offenders were not registry-eligible before their current offenses were committed. The statutes alone, no matter how effective, do not address the problem of what motivates sex offenders to recidivate.

Eric Metchik

Further Reading

Beck, Victoria S., and Lawrence F. Travis III. "Sex Offender Notification: A Cross-State Comparison." *Police Practice and Research* 7, no. 4 (2006): 293-307. Presents an empirical comparison of the impact of passive versus aggressive notification procedures in two midwestern states.

Gaines, Jonathan. "Law-Enforcement Reactions to Sex Offender Registration and Community Notification." *Police Practice and Research* 7, no. 3 (2006): 249-267. Reports the results of a telephone and mail survey of police personnel in charge of Web sites that post community notification information about registered sex offenders.

Levenson, Jill S., and Leo P. Cotter. "The Effect of Megan's Law on Sex Offender Reintegration." *Journal of Contemporary Criminal Justice* 21, no. 1 (2005): 49-66. Discusses the findings from a survey of convicted Florida sex offenders that focused on their experiences and perspectives concerning registration and notification.

Meloy, Michelle L. *Sex Offenses and the Men Who Commit Them: An Assessment of Sex Offenders on Probation*. Boston: Northeastern University Press, 2006. Examines trends in the criminal justice response to sex offenders. Includes discussion of Megan's Law.

Welchans, Sarah. "Megan's Law: Evaluations of Sexual Offender Registries." *Criminal Justice Policy Review* 16, no. 2 (2005): 123-140. Presents a meta-analysis of specific aspects of Megan's Law from the perspectives of treatment personnel, offenders, and communities.

Zevitz, Richard G. "Sex Offender Placement and Neighborhood Social Integration: The Making of a Scarlet Letter Community." *Criminal Justice Studies* 17, no. 2 (2004): 203-222. Uses survey methodology to explore how Megan's Law has affected perceived social integration and the fear of crime.

See also: Child abduction and kidnapping; Forensic odontology; Geographic profiling; Psychopathic personality disorder; Rape; Sexual predation characteristics; Violent sexual predator statutes.

Mens rea

Definition: Latin term for the state of mind, or intent, of a person at the moment the person performs a criminal act.

Significance: The concept behind *mens rea* is central to the notion that because people have free will they are legally responsible for acts they intend to commit. If intent is absent from the act, there is no crime. It is thus the burden of the prosecution to find evidence that proves the intent behind criminal actions. Proving intent is especially important in cases relating to crimes such as murder and arson.

Under most laws in the United States, the intent of those who commit criminal acts must be proven in order for courts to convict them. Without intent, there is no crime or violation of the law; however, criminal negligence may be an exception to the intent rule. The American system of law is predicated on the concept of free will: When persons committing crimes do so of their own free will, there is intention to commit the acts. The Latin phrase that describes the "guilty act" is *actus reus*. The law demands that *mens rea* and *actus reus* must be coupled for there to be a crime.

Of several different types of criminal intent, the most frequently encountered is general intent. General intent is implied by an individual committing a criminal act. For example, a person walks into a store, takes an item, and leaves the store without paying for it; this act (*actus reus*) is defined as a theft, one generally classified as shoplifting. The fact that the item has been taken implies that the person intended to take it. The intent to steal is thus implied by the mere act of stealing itself.

Another type of intent, one that must be proved by the prosecution, is specific intent. Burglary is an example of a type of crime that requires proof of a specific intent to steal or commit a felony. If a person enters a store wearing a long coat with numerous pockets sewn inside and fills the pockets with items removed from the store and leaves without paying, that person has committed a burglary. The coat is designed for the single purpose of secreting items so that the wearer may remove them from the store without paying for them (*actus reus*). Wearing a coat specifically designed to secrete items in the store shows a specific intent to steal, the requisite *mens rea* required for burglary, a specific-intent crime.

Conditions that mitigate intent include mental impairment and mistake. For example, a person who is mentally incompetent to form the requisite intent is likely not to be held responsible for what otherwise would be a criminal act. Although there may be the presence of *actus reus*, there is an absence of *mens rea*; therefore, no crime has been committed. Likewise, a mistake can legitimately negate intent. For example, a person who enters a parking lot and gets into another person's car by mistake is not guilty of attempted car theft because there is no intent to steal or to tamper with another's vehicle.

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Mens Rea and the Crown Jewels

The 1967 British film *The Jokers* is a big-heist story played mostly for laughs, but its premise rests firmly on the serious legal principle of *mens rea*. Oliver Reed and Michael Crawford play brothers David and Michael Tremayne, who enjoy pulling off clever stunts. The brothers set themselves the greatest challenge of all: stealing Britain's Crown Jewels from the Tower of London. In contrast to most thieves, they do not expect to get away with their loot. Indeed, they plan to return the jewels even if they are not caught, taking their satisfaction from doing the impossible.

The brothers also expect to reap rewards from the publicity that a successful caper will generate. That raises the question of how they expect to stay out of prison if they succeed. The key to their scheme is their motive: By placing sealed confessions with lawyers, with instructions for their opening after the date of the planned heist, the brothers seek to establish in advance that they have no intention of permanently depriving the queen of her jewels; they wish merely to call public attention to the inadequacy of the security protecting the jewels. Under the principle of *mens rea*, therefore, they cannot be guilty of a crime. How their story actually unfolds, however, is another matter.

Further Reading

Alexander, Larry, and Kimberly D. Kessler. "*Mens Rea* and Inchoate Crimes." *Journal of Criminal Law and Criminology* 87, no. 4 (1997): 1138-1193.

Gonzalez, Jorge C. "Punishing the Causer as the Principal: *Mens Rea* and the Interstate Transportation Element of the National Stolen Property Act." *San Diego Law Review* 38, no. 2 (2001): 629.

Katz, Leo. *Bad Acts and Guilty Minds*. Chicago: University of Chicago Press, 1987.

Moore, Michael S. *Act and Crime: The Philosophy of Action and Its Implications for Criminal Law*. New York: Oxford University Press, 1993.

See also: ALI standard; Arson; Expert witnesses; Forensic psychiatry; Forensic psychology; Guilty but mentally ill plea; Homicide; Insanity defense; Legal competency.

Mercury

Definition: Silver-colored element, also known as quicksilver, that is the only metal that takes a liquid form at room temperature.

Significance: Although mercury and its compounds have many industrial, medical, and agricultural uses, mercury vapor and some mercury compounds are both insidious and extremely toxic. Forensic scientists are sometimes called upon to trace the sources of cases of mercury poisoning.

The discovery of mercury in an Egyptian tomb built some thirty-five hundred years ago proves that humanity's fascination with the element is of long standing. Because metallic mercury almost seems alive as it flows, it became a key ingredient in the experiments of alchemists who thought gold was a compound that could be made from mercury and other metals. During the early eighteenth century, the distinguished scientist Sir Isaac Newton suffered periods of extreme depression that were probably caused by mercury poisoning acquired during his own alchemical experiments. In modern times, various uses of mercury—for example, as part of a process for mining gold and as an element in dental amalgam—have become controversial.

When mercury metal is released into the environment, microorganisms convert it into methylmercury by adding a methyl group (three hydrogen atoms and one carbon atom). Methylmercury has a strong affinity for the amino acid cysteine, and with cysteine attached, the body treats the combined molecule as a protein and allows it to cross both the placenta and the blood-brain barrier, making it particularly dangerous.

The worst case of widespread mercury poisoning in modern times occurred in Iraq during the late 1960's and early 1970's. After several years of poor harvest, the Iraqi government decided to import a special type of wheat from Mexico. When the grain arrived too late in the year for planting, the Iraqi farmers began feeding it to their livestock, despite warnings not to do so because the wheat had been treated with methylmercury fungicide. Seeing no immediate harm to the animals, the farmers and their families also ate the grain. After a few months, these people began to suffer central nervous system damage, and investigators traced the growing hospitalizations back to the coated wheat. Saddam Hussein's government ordered the farmers to turn the wheat in; violators of the order were to be shot. Some panicked farmers dumped their supplies of the wheat along canal banks, and from there mercury quickly entered the local ecosystem. An estimated 10,000 people died in this incident, and another 100,000 suffered some brain damage.

An earlier case of mass mercury poisoning occurred in the village of Minamata on the coast of the island of Kyūshū, Japan. During the early 1950's, people in the village began to stumble and tremble uncontrollably for no apparent reason. By 1959, nearly one hundred patients had been identified, and more than twenty of them had died. The cause was eventually determined to be methylmercury ingestion. The Chisso Corporation's chemical plant was releasing metallic mercury into the bay, where it was converted to methylmercury and absorbed by plants. Small fish ate the plants, and bigger fish ate the smaller fish, increasing the concentration of methyl mercury at each step, so that when people ate the fish, they developed mercury poisoning. Chisso was eventually forced to stop the pollution and initiated efforts to clean the bay of contamination.

Worldwide, top predators in the oceans, such as tuna, swordfish, and sharks, have extremely high methylmercury concentrations in their bodies. For this reason, pregnant women and nursing mothers are advised to exercise caution in eating the flesh of such fish.

Charles W. Rogers

Further Reading

Casdorph, H. Richard, and Morton Walker. *Toxic Metal Syndrome*. Garden City Park, N.Y.: Avery, 1995.

Eisler, Ronald. *Mercury Hazards to Living Organisms*. Boca Raton, Fla.: CRC Press, 2006.

Sadiq, Muhammad. *Toxic Metal Chemistry in Marine Environments*. New York: Marcel Dekker, 1992.

See also: Air and water purity; Atomic absorption spectrophotometry; Beethoven's death; Lead; Poisons and antidotes; Quantitative and qualitative analysis of chemicals.

Metal detectors

Definition: Electronic devices used to detect hidden metal objects.

Significance: Metal detectors are invaluable tools for law-enforcement and security personnel, enabling the location of hidden metallic objects at crime scenes and related areas as well as the screening of individuals for possible possession of weapons or contraband.

Law-enforcement investigators often use metal detectors to locate stray bullets at crime scenes, or to find cartridge cases that may have been left behind by perpetrators. Metal detectors are also used to locate and map the positions of buried human remains, as such devices can document the spatial positions of coins, belt buckles, key rings, and other items containing metal that people routinely carry with them. *(© iStockphoto.com/Oktay Ortakcioglu)*

At crime scenes, investigators often need to find metallic objects buried in soil or hidden in other materials. Metal detectors use the principle of electromagnetic induction to detect metal. The simplest detector consists of an oscillator that generates an alternating current that passes through a coil of wire. This produces an alternating magnetic field. When a piece of metal is relatively close to the coil, eddy currents are generated in the metal. The eddy currents produce their own alternating magnetic field, which is detected by a receiver in the metal detector.

Law-enforcement investigators often use metal detectors to locate stray bullets that may have become embedded in flooring, walls, furniture, and other objects at crime scenes and related locations, as well as to find cartridge cases that may have been left behind by perpetrators. Metal detectors are routinely used to map the locations and positions of buried human remains, as such devices can document the spatial positions of coins, belt buckles, eyeglasses, key rings, watches, and other items containing metal that people routinely carry with them. Metal detectors deployed in aircraft are particularly advantageous for locating metallic objects within soils that are underwater or otherwise inaccessible by road or by foot, perhaps because of steep terrain or vegetation cover.

Airport security personnel employ metal detectors as part of airline passenger screening, as the devices enable the detection of concealed weapons and contraband. Handheld detectors can be used to determine the precise locations of metal objects on a person. Although the use of metal detectors for security purposes in public schools is not a standard practice in the United States, some American school districts have begun using the devices as part of their efforts to prevent students from bringing onto school grounds weapons that could be used to commit crimes against other students and faculty.

Since the mid-1990's, metal detectors have become increasingly sensitive and light in weight. Compared with earlier models, the metal detectors available in the early twenty-first century use less battery power, discriminate better among different metals, and locate metallic targets at greater depths. Detectors have been developed that have the ability to indicate the approximate length of metallic objects, enabling security personnel to locate the objects more rapidly and take appropriate action. The best metal detectors are fully computerized. They use microchip technology for setting sensitivity, metal discrimination, tracking speed, filtering of noise, and threshold volume. Values for these parameters are stored in memory for future use.

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Further Reading

Baker-Jarvis, James, et al. *Metal Detector Studies: Research Materials*. Washington, D.C.: National Institute of Standards and Technology, 2002.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005.

Paulter, Nicholas G. *Users' Guide for Hand-Held and Walk-Through Metal Detectors*. Washington, D.C.: National Institute of Justice, 2001.

See also: Airport security; Buried body locating; Crime scene investigation; Crime scene search patterns; Forensic archaeology; Forensic geoscience; Physical evidence.

Meth labs

Definition: Clandestine facilities that produce the illicit drug methamphetamine, a highly addictive and powerful neurological stimulant.

Significance: Methamphetamine use is associated with numerous negative physical side effects, from rapid tooth decay to brain damage. Furthermore, manufacture of the drug involves the use of chemicals that are very volatile, toxic, flammable, and prone to explosion; it also produces dangerous toxic wastes. Because of the many dangers to society represented by methamphetamine use and production, law-enforcement agencies across the United States expend significant resources in efforts to reduce the manufacture of the drug.

Methamphetamine (also known as meth, speed, ice, crystal, and crank) is a powerful neurological stimulant that influences heart rate, body temperature, blood pressure, appetite, alertness, and mood. Most people who use this drug report immediate feelings of euphoria, increased energy and attentiveness, and decreased appetite and fatigue. Undesirable side effects associated with meth use include diarrhea, nausea, excessive sweating, insomnia, tremors, jaw clenching, panic attacks, increased libido with an inability to reach orgasm or physical release, and compulsion to repeat tasks over and over. Side effects associated with long-term chronic use include physical addiction, noticeable weight loss, rapid tooth decay (meth mouth), brain damage, muscle breakdown, compulsive skin picking, paranoia, delusions, hallucinations, and headaches.

Methamphetamine use has grown steadily in the United States since the last decade of the twentieth century. In a 2005 survey conducted by the National Association of Counties, 58 percent of U.S. county law-enforcement agencies listed methamphetamine as their number one drug problem. Police across the United States have shut down meth labs in rural farm locations, central-city areas, and suburbs. The chief factor in the growing use of methamphetamine may be that new manufacturing methods have made the drug easier to produce, and the chemicals needed are relatively easy to acquire. Detailed instructions on how to acquire these chemicals and cook them into meth are available on the Internet.

Manufacturing Meth

Underground methamphetamine labs can be divided into two types: super labs and small-scale labs. About 10 percent of meth labs are so-called super labs, capable of producing ten or more pounds of methamphetamine per production cycle. It is estimated that such facilities produce about 80 percent of all methamphetamine. These labs tend to be concentrated in Mexico and Southern California, and many are run by Mexican criminal organizations capable of acquiring ephedrine and pseudoephedrine (regulated substances that are the most important precursor chemicals used in the production of meth) in bulk quantities on the international market. This is because Mexico, unlike the United States, does not effectively control the importation of these chemicals. The major exporters of ephedrine and pseudoephedrine are China and India, and most of the ephedrine smuggled into the United States comes through Mexico.

About 90 percent of all meth labs are small-scale operations that produce only one to four ounces of methamphetamine per production cycle. The operators of these labs typically produce only enough meth to meet their personal needs and to finance the purchase of the chemicals needed to cook the next batch. The super labs are thus a far greater concern to law enforcement in terms of controlling the supply of meth, but the small labs pose greater dangers in the forms of explosions, fires, and hazardous wastes.

Methamphetamine is produced from precursor chemicals using relatively simple methods. Many of the base chemicals are found in household and farm products that are not feasible for governments to attempt to regulate, including paint stripper, camping fuel, carburetor cleaner (ether), drain cleaners (sulfuric acid), pool cleaner (muriatic acid), lye (sodium hydroxide), rock salt, lithium batteries, lighter fluid, matches, fireworks, road flares, antifreeze, and cold and allergy medications containing pseudoephedrine. Ephedrine and pseudoephedrine are the most difficult chemicals to acquire, because they are regulated by U.S. federal and state legislation.

The precursor chemicals used in methamphetamine production are diverted into the illicit drug market in various ways. To acquire such chemicals, meth makers may steal them, smuggle them across international borders, or fraudulently label them. They might bribe government officials and chemical distributors, buy the chemicals through undocumented cash transactions, or convert similar unregulated chemicals into the desired regulated chemicals. They might also buy the chemicals legally, in quantities just below the amounts that must be reported.

Hazards of Meth Production

The illicit production of methamphetamine is a very dangerous activity. Explosions and fires are a serious risk, especially if the toxic and combustible chemicals used to produce meth are exposed to too much heat, whether from the cooking process or from open flames. Sparks from electrical switches or equipment-generated friction can set off explosions. Furthermore, some producers of meth rig their labs with booby traps.

Poorly ventilated meth labs are particularly at risk of exploding and creating toxic fumes. The heating of the chemical red phosphorus, an ingredient used in the drug's production, creates a deadly gas that is used commercially for pest control and fumigation; this gas can kill in low concentrations.

The smoke produced from cooking meth deposits toxic residues on the floors, walls, ceilings, carpets, and furniture of whatever structure is being used as a lab. Each pound of manufactured methamphetamine produces about five to six pounds of hazardous waste, and meth producers take no special precautions when disposing of this waste. It is often buried, stored, or burned on or near lab sites, or it may be dumped into streams or rivers or poured down drains. In some areas, the dumping, burning, or burial of such waste can threaten the drinking-water supply and contaminate the septic system. The health risks created by the toxic waste produced by meth labs include dizziness, hypertension, skin and respiratory system damage, asphyxia, cardiac arrest, stroke, coma, and death.

Because of such toxic dangers, U.S. states have enacted laws that quarantine properties that have been found to be meth lab locations, not allowing occupancy until they have been thoroughly tested and decontaminated. Realizing this, many small-scale operators set up labs on rental property (such as in apartments, hotel and motel rooms, or self-storage units) and then disappear before their illegal activities are discovered. This allows them to avoid being held responsible for the hazardous material cleanup needed after their lab sites are found; it also protects them from losing property to asset forfeiture laws.

When a meth lab is discovered, law-enforcement authorities neutralize the obvious chemical hazards so that they do not explode, catch fire, or pollute the environment. Beyond this, the costs of additional cleanup and decontamination are generally the responsibility of the property owner, who usually must contract the task out to a certified hazardous material disposal company.

Government and Law-Enforcement Responses

To reduce the dangers posed by methamphetamine use and production, state and federal governments have passed legislation to control the sale and distribution of at least some of the precursor chemicals used to produce the drug. An effective strategy has been the regulation of sales of ephedrine and pseudoephedrine, especially over-the-counter sales of cold and allergy medications and mail-order and Internet-based sales of these drugs. In most U.S. states, customers must show identification and sign a log when purchasing these regulated products; in some states, these drugs are available only with a doctor's prescription. This type of regulation requires agencies to cross-reference sales across retail venues to prevent meth lab operators from simply buying their supplies in small amounts from multiple stores (known as smurfing). In addition, it has been suggested that clerks who work at chemical supply companies and pharmacies should be trained to detect and report suspicious purchases of materials commonly used to manufacture methamphetamine and to be wary of customers who exhibit signs of meth addiction (rotting teeth, open sores, and a chemical odor).

Criminal conspiracy cases can be brought against chemical and lab equipment companies that knowingly supply meth drug lab operators, and federal law allows for civil fines up to $250,000 for illegal diversion of chemical or lab equipment for the production of illicit drugs. Law-enforcement officers and investigators who respond to meth lab crime scenes should collect all chemical packages and containers found at these scenes, so that the manufacturers and suppliers of the precursor drugs may be identified.

Various chemicals used in the production of methamphetamine give off distinct odors, and the identification of these odors may reveal the presence of a meth lab. For instance, phosphine smells like garlic, sulfur smells like rotten eggs, ammonia smells like cat urine, and acetone smells like nail polish remover. Law-enforcement agencies can be greatly aided in their efforts to reduce the manufacture of methamphetamine when service workers such as postal carriers, garbage collectors, maintenance workers, and hotel and motel personnel are trained to notice and report to police the suspicious odors and activities indicative of the presence of a meth lab.

Investigators examine the ruins of a so-called meth super lab that exploded in flames on May 7, 2003, near Madera, California. The building reignited as the investigators tried to remove combustible red phosphorus from the site. *(AP/Wide World Photos)*

Daniel Pontzer

Further Reading

Hannan, Dan. "Meth Labs: Understanding Exposure Hazards and Associated Problems." *Professional Safety* 50, no. 6 (2005): 24-31. Discusses the public health exposure hazards and environmental problems associated with methamphetamine drug labs.

_______. "Reacting to Difficult Situations: What to Do Following the Discovery of an Illegal

Methamphetamine Drug Lab or a Tragic Death." *Journal of Housing and Community Development* 62, no. 4 (2005). Describes how to recognize the signs that a meth lab is operating in a location and addresses appropriate measures for communities to take in response.

Hunt, Dana E. "Methamphetamine Abuse: Challenges for Law Enforcement and Communities." *NIJ Journal* 254 (July, 2006): 24-27. Discusses why methamphetamine abuse is such a growing problem and offers suggestions regarding what police and communities should do to combat this threat.

Scott, Michael S., and Kelly Dedel. *Clandestine Methamphetamine Labs*. 2d ed. Washington, D.C.: U.S. Department of Justice, Office of Community Oriented Policing Services, 2006. Brief guide intended for law-enforcement agencies provides a general overview of the problem of meth labs and offers practical suggestions for responses.

See also: Amphetamines; Club drugs; Crime scene screening tests; Drug abuse and dependence; Drug paraphernalia; Illicit substances; Microcrystalline tests; Stimulants; Ultraviolet spectrophotometry.

Microcrystalline tests

Definition: Rapid tests in which questioned substances are mixed with reagents and identified based on the characteristic crystals formed.

Significance: Microcrystalline tests are widely used in forensic laboratories in the initial identification of various substances in evidence samples, particularly suspected drugs. These simple and rapid tests allow scientists to determine the likely presence of particular drugs before going ahead with more complex confirmatory testing.

Although microcrystalline tests can be used in the identification of blood, they are more commonly used in forensic drug analysis. When a seized drug sample is submitted for analysis, the forensic scientist is tasked with identifying the actual drug present, as this will determine subsequent penalties faced by the suspect. Often, rapid and simple tests are used first to determine the likely drug present before more detailed instrumental analysis is conducted to confirm the identity of the drug. When used as part of an analytical scheme for drug identification, microcrystalline tests are considered to be selective tests; that is, they are used to indicate the likely drug present, but these tests alone cannot definitively identify the drug.

The microcrystalline test is rapid and simple to perform. A small amount of the questioned sample is placed on a microscope slide, and a few drops of the microcrystalline test reagent are placed alongside the sample material. The analyst then views the slide under a microscope. Using a wooden stick, the analyst draws the reagent to the sample and observes the crystals that are formed when the two substances meet.

Particular drugs form crystals of characteristic sizes and shapes with different test reagents. For example, gold chloride can react with amphetamine to give crystals that are yellow, long, and rod-shaped. Similarly, heroin reacts with platinic chloride to form crystals that are branched with pointed blades. It is important that the analyst test a known standard at the same time with the same reagent as the questioned sample. In this way, the analyst can directly compare the sizes and shapes of the crystals formed by the known standard and the questioned sample under identical conditions.

In addition to the fact that microcrystalline tests are simple to perform and give rapid results, the materials required for such tests are readily available in forensic science laboratories. Microcrystalline tests can also be used to differentiate isomers, which are molecules that have the same molecular formula but different orientations in space. This is a great advantage for microcrystalline tests, because more complex techniques used to identify the chemical components of samples, such as mass spectrometry, are not capable of differentiating isomers.

Microcrystalline tests have some perceived disadvantages, but these are not necessarily limitations of the tests. For example, although microcrystalline tests are available for the drugs most commonly of interest in law-enforcement investigations, such tests are not available for all drugs. A second disadvantage often stated is that given drugs may form crystals of different shapes with different reagents. This is not necessarily a limitation, however, as the analyst should always compare a known standard with the questioned sample under similar conditions. If the known standard gives similar shapes as the questioned sample with the different reagents, then this increases confidence in the likely identity of the drug present in the questioned sample.

Ruth Waddell Smith

Further Reading

Bell, Suzanne. *Forensic Chemistry*. Upper Saddle River, N.J.: Pearson Prentice Hall, 2006.

Johll, Matthew. *Investigating Chemistry: A Forensic Science Perspective*. New York: W. H. Freeman, 2007.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007.

See also: Analytical instrumentation; Crime scene screening tests; Drug classification; Drug paraphernalia; Meth labs; Microscopes; Reagents; Serology.

Micro-Fourier transform infrared spectrometry

Definition: Type of absorption spectroscopy used in the identification of molecules.

Significance: Forensic scientists use micro-Fourier transform infrared spectrometry to identify the substances present in unknown microscopic or trace samples based on the substances' absorbance of infrared light.

Micro-Fourier transform infrared (micro-FTIR) spectrometry is a nondestructive technique used to identify unknown substances present within trace evidence samples. In micro-FTIR spectrometry, Fourier transform infrared (FTIR) spectrometry is coupled with microscopy; the technique uses a microscope to focus infrared light onto a particular part of a sample in order to create an infrared spectrum. When it is necessary to obtain the infrared spectrum of a microscopic sample—such as a single fiber, a bit of ink, or a small paint chip—a micro-FTIR spectrometer is used.

Micro-FTIR spectrometry uses infrared light to excite and detect bonds within molecules. The wavelengths of light that make the bonds in the molecules vibrate are absorbed by the bonds, and this information is used to form the infrared spectrum. The infrared spectrum of an unknown molecule gives information about the kinds of bonds and chemical functional groups present, which helps to identify the molecule. Even very similar molecules can have very different infrared spectra, which is why micro-FTIR spectrometry can be used to identify unknown substances in crime scene evidence samples.

During micro-FTIR spectrometry analysis, the sample is first placed beneath the lens of the microscope and brought into focus. While looking through the microscope, the forensic scientist can see a circle within the vision field that indicates exactly where the infrared light beam will pass during data acquisition. The sample must be positioned so that the circle is centered above the portion of the sample of interest. After the sample is aligned, data acquisition is completed and the infrared spectrum is created. The analyst can then interpret the infrared spectrum by using specialized computer software to compare the spectrum with the infrared spectra of known substances stored in a digital library.

The analysis of a single fiber typically requires the use of a micro-FTIR spectrometer because the sample can be aligned using the microscope to ensure that the infrared light beam will pass through the tiny fiber. The technique can usually determine not only the broad class the fiber belongs to but also the subclass as well. For example, different grades of nylon can be differentiated from one another using micro-FTIR spectrometry.

Paint chips from automobiles contain several layers of paint that are deposited during the manufacturing process. Using micro-FTIR spectrometry, individual paint layers may be analyzed independently from surrounding layers in order to get an infrared spectrum of a component layer. The micro-FTIR spectrometry microscope is able to focus on an individual layer on a thin cross section of a paint chip sample so that the layers do not need to be separated manually prior to analysis.

Ruth N. Udey

Further Reading

Bell, Suzanne. *Forensic Chemistry*. Upper Saddle River, N.J.: Pearson Prentice Hall, 2006.

Rubinson, Kenneth A. and Judith F. Rubinson. *Contemporary Instrumental Analysis*. Upper Saddle River, N.J.: Prentice Hall, 2000.

Siegel, Jay A. *Forensic Science: The Basics*. Boca Raton, Fla.: CRC Press, 2007.

See also: Analytical instrumentation; Electromagnetic spectrum analysis; Fibers and filaments; Fourier transform infrared spectrophotometer; Microscopes; Microspectrophotometry; Paint; Quantitative and qualitative analysis of chemicals; Spectroscopy; Tape; Trace and transfer evidence.

Microscopes

Definition: Research instruments designed to allow the visualization of objects too small to be seen by the naked eye.

Significance: Microscopes enable forensic scientists to observe details that are normally invisible to the naked human eye, allowing them to conduct thorough analyses of evidence samples that are frequently crucial to investigations.

Modern microscopes vary considerably from the earliest instruments developed in the seventeenth century, but the function of microscopes remains much the same as it was several hundred years ago. Microscopes are designed to magnify items that are too small for the human eye to see.

Two important concepts to understand regarding the general operation of microscopes are magnification and resolution (also called resolving power). Magnification is the increase in size of the image of the object that a microscope allows. This is expressed as a numeral with a multiplication sign; for example, a 400× image is four hundred times normal size. Resolution is the ability of the microscope to distinguish two items as unique; it is associated with the amount of detail that may be discerned within the image. Ideally, microscopes provide not only high levels of magnification but also high resolution. Among the many different types of microscopes in existence, forensic investigators most frequently rely on light microscopes, electron microscopes, and comparison microscopes in their work.

Light Microscopes

Light microscopes function by using a combination of lenses to alter the path of light to provide magnification and resolution. A light source passes light either through (transmitted) or around (reflected) the sample. A glass lens, called an objective lens, then detects a portion of the transmitted or reflected light and focuses it on a second lens, called the ocular lens. Because only a portion of the initial light passing through the sample is viewed, the size of the object is magnified. The total amount of magnification is determined by the product of the magnification of the individual lenses; for instance, an objective lens with a magnification power of 40× and an ocular lens with a 10× magnification would yield a total magnification of 400×.

Several types of light microscopes are available. Compound light microscopes, also sometimes called biological microscopes, use lenses placed in series to increase the magnification of objects. These microscopes may have either one or two ocular lenses. They are useful for examining samples that easily allow the passage of light and may be fixed in place on glass or plastic slides, such as bacteria, hair, or fibers. Another common form of the light microscope is the stereoscopic microscope, which uses lenses placed at different angles to produce a three-dimensional image, although usually at a lower magnification level than that of the biological microscope. The position of the stereoscopic microscope's light sources illuminates the surface of the specimen, making it useful for examining detail in larger objects. Forensic scientists often use stereoscopic microscopes in initially sorting evidence, such as fibers and hair, from other materials.

Comparison Microscopes

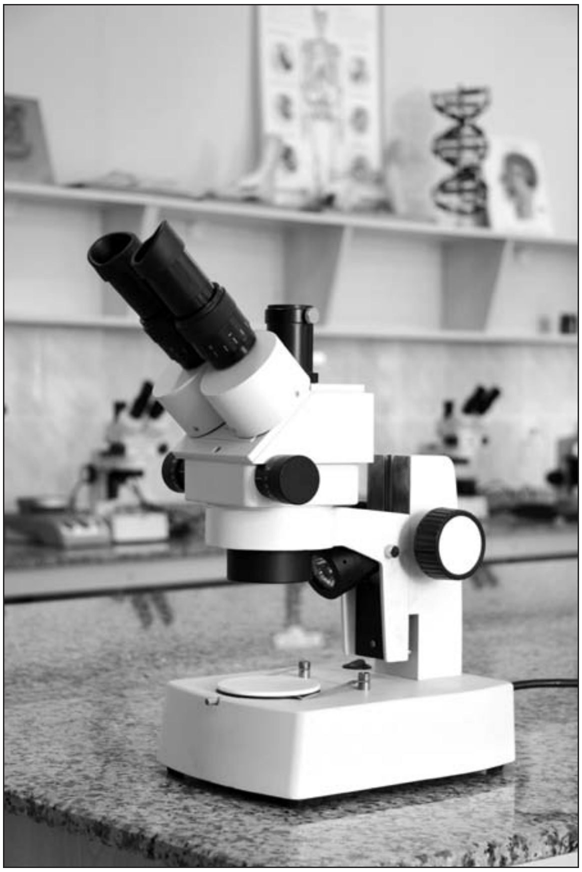
Comparison microscopes represent a special adaptation of light microscopes for use in forensic investigations. A comparison microscope is basically two light microscopes that have been combined into a single instrument with an optical bridge. This configuration allows the investigator to examine two samples at the same time. This is especially useful in ballistic tests, when forensic researchers compare the microscopic details on the surfaces of bullets, which are specific to the weapons from which they were fired. Forensic scientists may also use comparison microscopes when comparing other kinds of evidence samples, such as fibers, to samples from known sources.

Electron Microscopes

Although they are called microscopes because they serve to produce magnified images of objects, electron microscopes are very different in construction from light microscopes. In place of photons of light, electron microscopes use negatively charged electrons to obtain images. Because electrons are negatively charged, their paths may be controlled by magnets and electrical fields. In an electron microscope, after leaving the source, the electrons interact with the sample and are then detected by an imaging system. The imaging system relays the pattern of electrons to a computer, which then presents an image of the specimen. Electron microscopes have significantly higher magnification power and resolving power than do the best light microscopes; some can magnify images more than one million times and possess the ability to resolve individual atoms.

Several different types of electron microscopes have been developed, but the major ones used in forensic research are the transmission electron microscope (TEM) and the scanning electron microscope (SEM). In a TEM, the electrons pass through the specimen to a detector. As these electrons move through the sample, they interact with the atoms and molecules within the sample, which distorts the path of the electrons. The electrons are then collected by a collector, which in turn presents an image to the operator. TEMs are useful for examining the internal structures of cells and other samples. They have the highest magnification and resolving power of any kind of microscope.

Often the electron microscope of choice in a forensic lab is the SEM, which uses a beam of electrons to reveal the surface of a microscopic sample. As the electrons leave the source, they



An optical microscope, also known as a light microscope. *(© iStockphoto.com/iki reklam)* interact with the atoms and molecules on the surface of the specimen. Some of the electrons are scattered by the surface molecules, and other electrons cause X rays to be released. The scattered electrons and X rays are then collected by an imaging system, which provides a picture of the specimen's surface. Because different surfaces reflect electrons differently, forensic scientists using SEMs first coat some specimens in a metal, often gold, before scanning.

Michael Windelspecht

Further Reading

Blackledge, Robert D., ed. *Forensic Analysis on the Cutting Edge: New Methods for Trace Evidence Analysis*. Hoboken, N.J.: John Wiley & Sons, 2007. Collection of essays on forensic methods focuses on advances in technology and includes discussion of the use of microscopes.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005. Provides a complete overview of forensic investigations, including the use of various forms of microscopes.

Petraco, Nicholas, and Thomas Kubic. *Color Atlas and Manual of Microscopy for Criminalists, Chemists, and Conservators*. Boca Raton, Fla.: CRC Press, 2004. Highly illustrated manual describes analytical tests and testing procedures involving the use of microscopy.

Saferstein, Richard, ed. *Forensic Science Handbook*. 2d ed. Vol. 2. Upper Saddle River, N.J.: Prentice Hall, 2005. The fifth chapter of this book provides an excellent review of the principles of microscopy and the use of microscopes in forensic investigations. Includes detailed descriptions of how light microscopes are constructed.

See also: Analytical instrumentation; Ballistics; Check alteration and washing; Confocal microscopy; Counterfeiting; Crime laboratories; Fibers and filaments; Hair analysis; Micro-Fourier transform infrared spectrometry; Microspectrophotometry; Polarized light microscopy; Scanning electron microscopy; Writing instrument analysis.

Microspectrophotometry

Definition: Technique used to identify the components of very small samples through the combination of microscope and spectrophotometer.

Significance: Microspectrophotometry is useful in the analysis of many kinds of trace evidence. This technique enables forensic scientists to determine the microstructure and light absorption properties of very small samples. Microspectrophotometry is particularly valuable in examining hair, textile fibers, and paint.

In forensic science, many types of evidence samples are too small to be analyzed using a spectrophotometer. Such trace evidence can be analyzed using microspectrophotometry, however. This technique, which has been employed in forensic laboratories for more than forty years, combines optical microscopy with spectrophotometric measurements, such as ultraviolet (UV), visible, or infrared (IR) spectrometry.

Using a microspectrophotometer, a forensic analyst can examine a specimen under a microscope while simultaneously shining light on the specimen to obtain its absorption spectrum. The analyst can observe the sample at high magnification under the microscope to determine its physical characteristics, such as morphology and microstructure, and to select an area for additional analysis. The analyst can then use a spectrophotometer for further identification of the sample, such as to determine the sample's chemical composition. Depending on the type of spectrophotometer used, an examiner can collect visible, UV, or IR spectrophotometric measurements of the substance being viewed under the microscope.

Microspectrophotometry is particularly useful in the analysis of trace amounts of various substances collected from crime scenes, as such substances are often microscopic in nature. Microspectrophotometry is a quick and nondestructive method for examining trace evidence. By combining optical microscopy with spectrophotometric measurements, this technique provides forensic scientists with additional information to characterize trace evidence. It is useful for enabling analysts to determine sample homogeneity and other properties of specimens, such as the presence of inclusions or contaminants on the surface or structural defects.

Many trace evidence samples are colored microscopic particles of substances such as fibers, paints, and inks. One of the major applications of microspectrophotometry is in the determination of the exact color of an object or substance. Using microspectrophotometry, forensic scientists can conduct objective comparisons of the colors of very small specimens, such as fibers, paint chips, and ink traces. Important spectral differences between two specimens of similar color hues can be obtained using this technique. Such color differences may not be distinguishable through the use of optical microscopy alone. Microspectrophotometers facilitate accurate color measurement by allowing distinction between very similar colors and removing a possible source of error caused by the inability of the human eye to discriminate between certain similar colors.

Other applications of microspectrophotometry include the characterization of substances such as illicit drugs. Polymers such as plastics, fibers, and paints also have distinct UV/visible spectra that help in sample identification. The use of specially designed computer software in combination with microspectrophotometric analysis can facilitate accurate sample measurements.

C. J. Walsh

Further Reading

Houck, Max M., and Jay A. Siegel. *Fundamentals of Forensic Science*. Burlington, Mass.: Elsevier Academic Press, 2006.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005.

Johll, Matthew. *Investigating Chemistry: A Forensic Science Approach*. New York: W. H. Freeman, 2007.

See also: Analytical instrumentation; Confocal microscopy; Fibers and filaments; Fourier transform infrared spectrophotometer; Micro-Fourier transform infrared spectrometry; Microscopes; Paint; Spectroscopy; Tape; Trace and transfer evidence; Ultraviolet spectrophotometry.

Minnesota Multiphasic Personality Inventory

Definition: Widely used structured personality test, designed for adults ages eighteen to eighty-four, that yields a variety of validity, clinical, and content scores.

Significance: The Minnesota Multiphasic Personality Inventory is the most thoroughly researched measure of personality used in clinical settings and the most respected measure of personality for use in forensic evaluations and settings.

The Minnesota Multiphasic Personality Inventory (MMPI), first published by S. R. Hathaway and J. C. McKinley in 1943, was designed to be an aid in the diagnosis of personality and emotional disorders. A revised version, the MMPI-2, was published in 1989 and remains the version used with adults. In addition, a version intended for use with adolescents, the MMPI-A, was published in 1992.

The MMPI-2 is a true-false, self-report questionnaire consisting of 567 items. Subjects endorse or reject statements about themselves, such as "I never have trouble falling asleep," "I like good food," and "I am aware of a special presence that others cannot perceive." When an individual's test is scored, validity, clinical, and content scales are produced, and the results are reported as uniform T scores (that is, a mean of 50 and a standard deviation of 10). The validity scales attempt to determine the subject's attitude toward taking the test. For example, the Lie scale measures whether the subject is trying to "fake good" on the test. Ten clinical scales identify traditional psychological and emotional disorders; these scales are named Hypochondriasas, Depression, Hysteria, Psychopathic Deviate, Masculinity-Femininity, Paranoia, Psychasthenia, Schizophrenia, Mania, and Social Introversion-Extraversion. The instrument's fifteen content scales are named Anxiety, Fears, Obsessiveness, Depression, Health Concerns, Bizarre Mentation, Anger, Cynicism, Antisocial Practices, Type A, Low Self-Esteem, Social Discomfort, Family Problems, Work Interference, and Negative Treatment Indicators.

The MMPI-2 is the most widely used personality inventory in forensic settings. Reasons for its forensic popularity include its ease of administration, its objective scoring and interpretation, and its availability in different languages. In addition, the MMPI-2 provides response attitude (validity) measures, well-established clinical scales, good test-retest reliability, and resultant score profiles that can be readily explained in court. The MMPI-2 has been used in a broad range of forensic situations, including the assessment of competence to stand trial, sanity, malingering, and emotional damage. It has also been used to gather personality information for use in cases involving child custody, workers' compensation, accusations of incest and other sexual abuse, racial discrimination, and violent behavior.

Russell N. Carney

Further Reading

Graham, John R. *MMPI-2: Assessing Personality and Psychopathology*. 3d ed. New York: Oxford University Press, 2000.

Groth-Marnat, Gary. *Handbook of Psychological Assessment*. 3d ed. New York: John Wiley & Sons, 1997.

Pope, Kenneth S., James N. Butcher, and Joyce Seelen. *The MMPI, MMPI-2, and MMPI-A in Court: A Practical Guide for Expert Witnesses and Attorneys*. 3d ed. Washington, D.C.: American Psychological Association, 2006.

See also: Borderline personality disorder; *Diagnostic and Statistical Manual of Mental Disorders*; Expert witnesses; False memories; Forensic psychiatry; Forensic psychology; Insanity defense; Irresistible impulse rule; Legal competency; Parental alienation syndrome; Police psychology; Psychopathic personality disorder.

Miranda v. Arizona

Date: Ruling issued on June 13, 1966
Court: U.S. Supreme Court
Significance: When the U.S. Supreme Court held in *Miranda v. Arizona* that individuals subjected to custodial interrogation must be informed of their Fifth Amendment right against self-incrimination and their Sixth Amendment right to counsel, law-enforcement agencies across the United States had to make changes in their procedures for questioning suspects.

The case of *Miranda v. Arizona* dealt with the admissibility of statements obtained by the police during the interrogation of persons in police custody. On March 3, 1963, an eighteen-year-old girl was abducted and raped in Phoenix, Arizona. Ten days later, Ernesto Miranda was arrested by Phoenix police, taken to police headquarters, and placed in a lineup. The victim identified Miranda as her attacker. Miranda subsequently confessed to the crime and was sentenced to a term of twenty to thirty years on each count.

Miranda appealed his conviction on the grounds that he had not been advised of his right, under the Fifth Amendment to the U.S. Constitution, to remain silent when police questioned him. In 1965, the Arizona Supreme Court ruled that because Miranda had previously been arrested in California and Tennessee, he had knowingly waived his Fifth Amendment right, as well as his Sixth Amendment right to counsel before questioning, when he gave his confession to Phoenix police. Miranda appealed the decision to the U.S. Supreme Court.

In 1966, the U.S. Supreme Court reversed the Arizona Supreme Court in a five-to-four decision and established precedent rules for police custodial interrogation. The Supreme Court ruled that suspects taken into police custody must be informed of their rights to remain silent, to have counsel present during any questioning, and to be represented by state-appointed counsel if they cannot afford their own attorneys; suspects in custody must also be warned that anything they say can be used against them in a court of law. This information quickly became commonly known as the Miranda warnings or the Miranda rights.

The ruling of the Supreme Court mandates that any person taken into custody by law-enforcement officers must be given the Miranda warnings, so that if a suspect provides information under questioning, it can be shown that the individual intelligently waived the right to remain silent and the right to counsel. If the warnings are not given, the police cannot demonstrate that an intelligent waiver was obtained, and, as a result, any statement or confession made by the suspect is inadmissible in court.

Police must provide the Miranda warnings not only to suspects taken into custody but also to persons in any situation where questioning can result in the individuals' being deprived of a significant proportion of their liberty. In addition, once a person becomes the focus of an investigation and officers are questioning that person, the Miranda warnings must be given, whether the suspect is questioned at the police station, in a police car, on the street, or elsewhere.

In the *Miranda* ruling, the Supreme Court sought to balance the interests of law-enforcement officers and the constitutional rights of citizens. The Court recognized law-enforcement agencies' need to conduct investigations, but it wanted to ensure that police officers act within the constitutional bounds of the Fifth and Sixth Amendments.

Kimberly D. Dodson

Further Reading

Kelly-Gangi, Carol. *Miranda v. Arizona and the Rights of the Accused: Debating Supreme Court Decisions*. Berkeley Heights, N.J.: Enslow, 2006.

Vanmeter, Larry A. *Great Supreme Court Decisions: Miranda v. Arizona*. New York: Chelsea House, 2006.

See also: Cognitive interview techniques; Competency evaluation and assessment instruments; Interrogation; Legal competency.

Booking and the Miranda Warning

Before questioning arrestees in custody, law-enforcement officers read them their Miranda rights:

> You have the right to remain silent. If you give up the right to remain silent, anything you say can and will be used against you in a court of law. You have the right to an attorney. If you desire an attorney and cannot afford one, an attorney will be obtained for you before police questioning.

Miranda warnings are not needed prior to asking general booking questions. Arrestees are required by law to disclose their identities, and police may detain them until their identities can reliably be established. Some states, however, require that juvenile detainees automatically be read their Miranda rights, whether they are questioned or not.

Misconceptions fostered by media

Definition: Mistaken ideas about the work of forensic science held by the general public as a result of the ways in which fictional mass media, particularly television, portray the technology and personnel involved in forensic investigations.

Significance: Because the depictions of crime scene investigation and forensic science widely seen in fictional films and television programs are often incongruent with reality, some observers have voiced concerns about public perceptions of the functions that criminalists perform and the techniques used in the field of forensic science. It has been argued that misconceptions of forensic science fostered by the mass media may lead jurors to have unrealistic expectations about the strength of evidence and the forensic procedures available for use in actual criminal cases.

Forensic science has long been depicted in works of fiction. In the nineteenth century, Sherlock Holmes, the master detective character created by Sir Arthur Conan Doyle, used forensic investigation techniques. The comic-strip police detective Dick Tracy, created in 1931 by Chester Gould, also was depicted as being skilled in forensics. During the 1970's, the American television series *Quincy, M.E.* (1976-1983) featured stories about the activities of a medical examiner (forensic coroner) who worked to collect evidence on suspicious deaths that occurred in the Los Angeles area.

The number of television shows focusing attention on crime scene investigation and forensic science increased dramatically after 2000. Most notable among these are the programs that make up what is often referred to as the *CSI* franchise. On October 6, 2000, the Columbia Broadcasting System (CBS) aired the first episode of a new series titled *CSI: Crime Scene Investigation*; the show quickly became enormously successful, and CBS subsequently added two spin-off series, *CSI: Miami* (2002) and *CSI: NY* (2004). Other networks also began to air dramatic series featuring forensic science prominently. *Crossing Jordan* (2001-2007), which focused on the cases of a fictional medical examiner in Boston, became part of the National Broadcasting Company (NBC) lineup. In 2005, the Fox television network began airing the series *Bones*, which is loosely based on the cases of real-life forensic anthropologist Kathy Reichs.

In addition to fictional series, television networks, particularly cable networks, began to present forensic science-themed documentary programs. One example is *Forensic Files*, which the cable network Court TV (now truTV) began airing in 2000; this program presents information from real cases, step by step from initial investigation to case resolution.

Misrepresentations of Forensic Science

The fictional television programs that focus attention on crime scene investigation and forensic science misrepresent these fields of study in a variety of ways. These programs frequently suggest, for example, that crime scene and forensic evidence is processed very quickly. In fact, most one-hour episodes feature anywhere from one to three crimes investigated and cleared by the police; it is rare for any crime to be left unsolved in one episode and carried over to another. The reality of forensic evidence processing is much more complex than typical television shows depict, however. Forensic evidence is not processed within sixty minutes of when it is collected or even within a week. In many states, evidence labs are so backed up that investigators must wait from six months to a year for test results that will allow them to move their cases forward.

In addition, television programs are frequently inaccurate in their depictions of the types of evidence commonly gathered at crime scenes and the types of information that evidence can reveal. For instance, such programs often

Emily Deschanel, who plays forensic anthropologist Temperance Brennan, on the set of the television series *Bones*. *(AP/Wide World Photos)* feature situations in which blood, traceable DNA (deoxyribonucleic acid), or some other evidence is physically left at crime scenes and is extracted by investigators for analysis. In reality, however, the discovery of traceable evidence at crime scenes is much more rare than these programs suggest. Generally, the types of evidence most frequently left at crime scenes are tool markings and fingerprints. Forensic scientists thus do not spend the majority of their time analyzing blood and DNA evidence; instead, they spend most of their time doing toxicology screens and comparing fingerprints.

Television programs that feature crime scene analysis and forensic science techniques frequently show investigators relying heavily on computer databases that provide information that aids them in their work. In reality, the power of such databases to aid investigators is limited, and much more work goes into using the databases than these shows suggest. One example is how fingerprint analysis is depicted on television. Characters on these programs are often shown running fingerprint analyses that result in single positive matches, but the reality is that an automated fingerprint identification system (AFIS) can identify only possible matches. The final matching of prints is actually the responsibility of the examiner.

Television programs often present crime scene and forensic science evidence in a way that suggests to viewers that the evidence is beyond reproach, always accurate, and never problematic. In fact, many of these programs include in their scripts positive and affirmative statements that remove the "human element" from crime scene and forensic investigation. The audience is told that the character investigators simply follow the evidence and objectively interpret the evidence. These programs rarely depict cases in which problems arise with evidence samples or with the crime labs that test the evidence. They also do not tell stories in which the available forensic evidence fails to solve a crime. In fact, however, the human element is an important part of crime scene and forensic science. Human error and faulty practices have led to problematic test results in crime labs in several states, including California, Pennsylvania, Texas, Washington, and West Virginia.

The *CSI* Effect

The popularity of fictional television programs that feature forensic science has raised some concerns among legal scholars and practitioners regarding whether individuals who serve as jurors on criminal trials may be influenced by these programs' depictions of crime scene investigation and forensic science. This possible influence is often referred to as the "*CSI* effect." Many prosecuting attorneys have contended that jury members who are regular watchers of *CSI* and similar programs are likely to hold distorted beliefs about what police can do and ought to do from a forensics standpoint in preparing cases for trial, and they bring those beliefs with them into the deliberation room. From the standpoint of prosecutors, jurors' television-based exaggerated expectations regarding forensic science make the job of obtaining criminal convictions much more difficult.

Defense attorneys, in contrast, have argued that the *CSI* effect is actually beneficial to prosecuting attorneys and makes the task of defending clients more difficult. Defense attorneys argue that because these programs almost always present crime scene work and forensic science as infallible, jury members are not typically aware of the potential for problems with evidence.

Only a few researchers have examined the validity of claims regarding the *CSI* effect. In one study, N. J. Schweitzer and Michael J. Saks examined the issue by asking mock jurors about their television viewing habits and then requiring the mock jurors to read a transcript of testimony from a forensic scientist in a case in which the evidence for conviction was weak; the jurors would be likely to return a guilty verdict only if they found the forensic science evidence believable. In this study, a higher percentage of non-*CSI* viewers (29 percent) stated that they would convict compared with regular *CSI* viewers, but the difference was not statistically significant.

Similarly, Kimberlianne Podlas examined the veracity of *CSI* effect claims by surveying 254 mock jurors. She found no *CSI* effect; that is, heavy viewers of *CSI* were not more likely than nonviewers to vote for acquittal because of their beliefs regarding what can be accomplished by investigators. Podlas has suggested that if there is a *CSI* effect, it takes the form of producing a belief in potential jury members that evidence is infallible.

In perhaps the most comprehensive study of the *CSI* effect undertaken to date, Donald E. Shelton, Young S. Kim, and Greg Barrak also surveyed mock jurors about their television viewing habits and willingness to convict in a variety of different types of cases. These scholars concluded that there is no relationship between viewing *CSI* and other forensics-related television programming and willingness to convict an offender in a case. Shelton and his colleagues have suggested that the seemingly increasing demand by criminal juries for scientific evidence may have more to do with a broader "technology effect" than with the *CSI* effect; that is, as society becomes more and more technologically advanced, citizens expect that technological improvements will carry over into the world of criminal investigation.

Kevin G. Buckler

A forensic scientist runs a computer analysis of a DNA sample at the Vermont Forensic Lab in Waterbury, Vermont. One of the most common misconceptions fostered by dramatic television series about forensic investigations is that evidence such as DNA samples is processed quickly. The reality is that it may take years for some samples to be processed. A study made in 2003 estimated that 550,000 DNA samples collected at crime scenes were awaiting processing. *(AP/Wide World Photos)*

Further Reading

Podlas, Kimberlianne. "'The *CSI* Effect': Exposing the Media Myth." *Fordham Intellectual Property, Media, and Entertainment Law Journal* 16 (Winter, 2006): 429-465. Presents an empirical assessment of claims regarding a *CSI* effect. Reports no support for assertions of such an effect and warns against the creation of reforms to address a problem that empirical evidence has suggested does not exist.

Schweitzer, N. J., and Michael J. Saks. "The *CSI* Effect: Popular Fiction About Forensic Science Affects Public Expectations About Real Forensic Science." *Jurimetrics* 47 (2007): 357-364. Reports on an empirical study that examined the veracity of claims about the *CSI* effect and found moderate evidence for an effect.

Shelton, Donald E., Young S. Kim, and Greg Barrak. "A Study of Juror Expectations and Demands: Does the '*CSI* Effect' Exist?" *Vanderbilt Journal of Entertainment and Technology Law* 9, no. 2 (2006): 331-368. Reports the findings of a study that examined claims of a *CSI* effect and found no evidence of such an effect on the expectations of mock jurors. Suggests that, instead, there is evidence of a broader "technology effect" increasing the evidence expectations of potential jurors.

Tyler, Tom R. "Viewing *CSI* and the Threshold of Guilt: Managing Truth and Justice in Reality and Fiction." *Yale Law Journal* 115, no. 5 (2006): 1050-1085. Provides an overview of the *CSI* effect claims and presents an argument that *CSI* viewing may have the effect of increasing the likelihood of guilty verdict.

See also: Celebrity cases; *Cold Case*; *CSI: Crime Scene Investigation*; Defensive wounds;

Forensic Files; Forensic psychology; Journalism; Literature and forensic science; Sherlock Holmes stories; *Silence of the Lambs, The*.

Mitochondrial DNA analysis and typing

Definition: Form of DNA typing in which the genetic material found inside cellular mitochondria is analyzed.

Significance: Mitochondrial DNA analysis is often used when traditional DNA typing methods are unsuccessful because of biological degradation. The technique is employed in cases involving hair, teeth, skeletal remains, and other difficult forensic samples. It has also been used to identify missing persons and the victims of mass disasters.

Mitochondria are cellular organelles responsible for bodily energy production. Human mitochondria contain a circular genome of 16,569 bases, the bulk of which encodes thirty-seven RNA (ribonucleic acid)/proteins. The remaining segment, termed the control region, regulates DNA (deoxyribonucleic acid) replication and transcription.

The noncoding nature of the control region has allowed mutations (or polymorphisms) to accumulate over time, most of which are located in two hypervariable regions: HV1 and HV2. Scientists conduct mitochondrial DNA (mtDNA) typing by obtaining the HV DNA sequences and comparing them with the reference sequence known as the Anderson sequence or the Cambridge Reference Sequence. Differences between the sample mtDNA and the reference sequence are reported based on the type of polymorphism (base change, insertion/deletion) and its nucleotide position. For instance, if mtDNA from a hair has a C at position 152 while the reference sequence has a T, the DNA type (termed a haplotype) for that individual would be reported as 152C. Any other polymorphisms are reported as well, and the frequency of that haplotype in humans can be determined.

MtDNA typing does not have the discriminatory power of nuclear DNA analysis; however, there are instances in which mtDNA is the only DNA recoverable, particularly from materials of forensic interest. This can be the case for shed hair, aged bone or teeth, nails, and mummified tissue, among others. Nuclear DNA contained in such samples may be degraded, whereas mtDNA, owing to its high copy number (hundreds or thousands of copies per cell) and protection afforded by the mitochondrion, is still analyzable.

Another key feature of mtDNA is that it is maternally inherited, with all mitochondria stemming from the egg. As a result, siblings and other maternal relatives share the same mtDNA haplotype. This feature has made mtDNA typing an invaluable tool in forensic science. The Armed Forces DNA Identification Laboratory uses mtDNA to identify skeletal remains recovered from war casualties by comparing mtDNA samples from potential relatives. The Federal Bureau of Investigation (FBI) operates laboratories that focus solely on mtDNA analysis.

Several historical mysteries have been resolved using mtDNA. In 1998, mtDNA analysis was used to identify the remains of the Vietnam War service person interred in the Tomb of the Unknowns at Arlington National Cemetery as U.S. Air Force First Lieutenant Michael Blassie. Similarly, mtDNA aided in the identification of the members of the Romanov family, the last Russian royal family, who were murdered during the Bolshevik Revolution in 1918.

Michael J. Mutolo and David R. Foran

Further Reading

Butler, John M. *Forensic DNA Typing: Biology, Technology, and Genetics of STR Markers*. 2d ed. Burlington, Mass.: Elsevier Academic Press, 2005.

Cox, Margaret, et al. *The Scientific Investigation of Mass Graves*. New York: Cambridge University Press, 2008.

Hummel, Susanne. *Ancient DNA Typing: Methods, Strategies, and Applications*. New York: Springer, 2002.

See also: Anastasia remains identification; Argentine disappeared children; Autopsies; DNA extraction from hair, bodily fluids, and tissues; DNA sequencing; DNA typing; Forensic anthropology; Jefferson paternity dispute; Louis XVII remains identification; Mass graves; Nicholas II remains identification; September 11, 2001, victim identification.

Multisystem method

Definition: Laboratory technique that uses electrophoresis and enzymatic activity stains simultaneously to identify isozymes of three different blood proteins from bloodstains.

Significance: The multisystem method for bloodstain analysis revolutionized bloodstain typing in forensic science. By making it possible to test for several isozymes from crime scene bloodstains simultaneously, it dramatically decreased sample sizes, increased efficiency, and reduced the costs of analyses without sacrificing resolution or accuracy.

Bloodstain evidence is critically important to criminal investigators. Analysis of crime scene blood begins with the identification of the ABO blood type, which is useful but too vague to identify a particular suspect conclusively. Tests with greater specificity are required to identify the person from whom a bloodstain originated with a high probability.

Blood proteins are abundant and sometimes quite stable in dried blood and provide the means to identify a specific suspect. Many blood proteins are encoded by genes whose DNA (deoxyribonucleic acid) sequences are polymorphic—that is, they differ from person to person. These different forms of the same gene are called alleles. Different alleles encode proteins called isozymes that possess roughly the same biological functions but have slightly different physical properties.

Blood isozymes are analyzed by means of electrophoresis, a laboratory procedure that separates protein molecules on the basis of their size and charge. A portion of a dried blood sample is dissolved in water and loaded into a gel medium that is immersed in an ionized buffer solution. The application of an electrical current through the solution initiates the migration of the proteins through the gel medium, but each protein migrates in a distinct direction and at a distinct rate. Protein electrophoresis results in a pattern that can be fixed, stained, and interpreted by an analyst. The varying isozymes of numerous blood enzymes and protein systems make it unlikely that any two individuals, except identical twins, would possess identical enzyme and protein constitutions.

In 1978, two American forensic scientists, Brian Wraxall and Mark Stolorow, developed the multisystem method that simultaneously analyzed three different blood isozymes from the same bloodstain. After separating blood proteins by electrophoresis in a starch/agarose gel mixture, they used activity stains that specifically colored one particular enzyme and all its isozymes. By consecutively staining the gel with three different activity stains, Wraxall and Stolorow analyzed three proteins with one technique, reducing by two-thirds the quantity of material required for the test and also the time necessary to conduct it.

The goal of forensic blood analysis is to link a bloodstain to an individual with the highest possible probability. Because each isozyme occurs at a known frequency within particular populations, it is possible to exclude persons from the pool of suspects progressively until only one individual is left who could possibly match the set of specific blood group, type, and isozymes.

Michael A. Buratovich

Further Reading

Rainis, Kenneth G. *Blood and DNA Evidence: Crime-Solving Science Experiments*. Berkeley Heights, N.J.: Enslow, 2007.

Wilson, Colin. *Written in Blood: A History of Forensic Detection*. New York: Carroll & Graf, 2003.

Wraxall, Brian, and Mark Stolorow. "The Simultaneous Separation of the Enzymes Glyoxalase I, Esterase D, and Phosphogluco-

mutase." *Journal of Forensic Sciences* 31, no. 4 (1986): 1439-1449.

See also: Analytical instrumentation; Blood residue and bloodstains; Crime scene investigation; DNA extraction from hair, bodily fluids, and tissues; DNA fingerprinting; Electrophoresis; Kidd blood grouping system; Luminol; Presumptive tests for blood; Serology.

Mummification

Definition: Process of preserving a body by desiccation.

Significance: Ancient peoples developed procedures for mummifying human and animal remains, but mummification is also a natural process that can occur if a body is kept in a very dry environment, where putrefaction is retarded. Forensic scientists are sometimes called upon to examine mummified remains.

Putrefaction, or decomposition, begins at death in warm, humid environments and consists of two processes, autolysis and bacterial action. Autolysis, the self-digestion of body tissues, leads to softening and liquefaction. Bacterial action results in the conversion of soft tissues to liquids and gases. If both processes are stopped, mummification will result. As both processes require water and moderate temperatures, dehydrating a body or cooling a body to freezing or below will stop putrefaction and allow mummification to occur. Mummification can take place in very cold environments, in warm, dry air, or in dry, porous earth. The body retains its general shape, but the skin may appear to be shriveled around the skeleton.

Ancient Mummification

The oldest known practice of intentional mummification is attributed to the Chinchorro people of northern Chile around 5000 B.C.E. They dismembered, disemboweled, and dried the body and then reassembled the skeleton, filling the cavities with straw and reattaching limbs with plant fibers and sticks. Then they covered the body with black mud, which they sculpted into a human form with a face. The resulting hybrid—something between a corpse and a statue—was apparently a way of remembering the dead. Mummification was not reserved for the elite in Chinchorro culture, as many children and even stillborn fetuses were preserved in this way. Subsequently, other South American cultures practiced mummification. Many Incans were deliberately mummified in the dry, cold climate of the Andes mountain range.

The ancient culture most widely known to practice mummification is that of Egypt from the period as early as 3000 B.C.E. The process of mummifying the dead was tied to the Egyptians' beliefs about the afterlife and the role of the preserved body as a resting place for the soul. The procedures evolved over time, but they consisted generally of the following. All internal organs were removed, except usually the heart, and the body was filled and covered with natron (a mixture of salts that desiccated the body and inhibited bacterial activity). After approximately forty days, the natron was removed from the corpse and the cavities were filled with resin-impregnated cloth to restore their shapes and then with resin. Finally, the body was wrapped in several layers of linen.

The effectiveness of the process used by the Egyptians is attested to by the preservation of many mummies from ancient times to the present day, including those of pharaohs Ramses II (who died in 1213 B.C.E.) and Tutankhamen (who died around 1323 B.C.E.). Mummification was important to all ancient Egyptians, but only the wealthy could afford the expense of the full process. Animals were also mummified to accompany the dead in the afterlife.

In 1994, Dr. Robert Brier of the University of Maryland Medical School successfully replicated the Egyptian procedure, proving its effectiveness. The preserved body has been maintained for future study.

Modern Mummification

Ever since Napoleon's invasion of Egypt in 1798, the world has been fascinated with an-

Archaeologists prepare a mummified body for an exhibition at the National Museum in Lima, Peru. This mummy and the others to be displayed with it are approximately five hundred years old. The dry, cold air of the upper levels of the Andes creates excellent conditions for mummification. *(AP/Wide World Photos)*

cient Egypt and its mummies, leading some people to revisit the idea of mummification. The most famous modern mummified remains are those of Vladimir Ilich Lenin, the Russian revolutionary, and Eva Perón, the wife of Argentine president Juan Perón. When Lenin died in 1924, his body was embalmed and placed on display at the Kremlin in Moscow. The procedure used remains a state secret and is ongoing, requiring periodic immersion of the remains in a preservative. When Eva Perón died in 1952, she was embalmed and her body fluids were replaced with wax. In both cases, the bodies are so well preserved that they seem lifelike.

In the 1970's, a process known as plastination was developed in which the water and lipids of the body are replaced with silicon, epoxy, and polymers. The result is a very realistic and virtually indestructible "mummy."

Mummification of people as well as their pets was made commercially available in 1975 at Summum, a nonprofit philosophical and spiritual organization in Salt Lake City, Utah. In the procedure Summum uses, the internal organs are removed, washed, and placed back in the body, which is then immersed in a preservative solution. The body is then cleaned and wrapped in cotton gauze, which is covered with a polyurethane membrane and then with fiberglass and resin. Finally, the body is encased in a bronze or stainless-steel casket. This appears to be a modernized version of the ancient Egyptian process.

Natural Mummification

It is no coincidence that ancient mummification developed in the arid regions of South America and Egypt. Such dry climates retard the putrefaction process and naturally lead to mummification. In such areas, a body buried in sand, which acts as a drying agent, would be desiccated and mummified; one natural mummy, known as Ginger, dating to 4000 B.C.E. in predynastic Egypt, is exceedingly well preserved. Natural mummification has also occurred when bodies have been left in very dry environments, such as attics. The absence of the smell that accompanies putrefaction may hide such deaths for many months or years.

One of the more interesting cases of natural mummification is that of the body that has come to be known as Ötzi the Iceman or the Tyrolean Iceman. The remains, with clothes and tools intact, were discovered in 1991 in the Alps and dated to 3300 B.C.E. The man had apparently fallen into a rocky hollow, where he was covered with snow and his body was preserved as in a deep freeze. Subsequent investigation using multislice computed tomography suggested that he was killed by an arrowhead into the back of his left shoulder that severed an artery; he likely bled to death. This mummy continues to provide anthropologists and historians with valuable information about technology, human health, and nutrition in Copper Age Europe.

James L. Robinson

Further Reading

Arriaza, Bernardo T. *Beyond Death: The Chinchorro Mummies of Ancient Chile*. Washington, D.C.: Smithsonian Institution Press, 1995. Full report on the oldest mummies is informative for both nonspecialists and anthropologists.

Chamberlain, Andrew T., and Michael Parker Pearson. *Earthly Remains: The History and Science of Preserved Human Bodies*. New York: Oxford University Press, 2001. Readable and well-illustrated volume describes ancient, modern, and natural mummification.

Fowler, Brenda. *Iceman: Uncovering the Life and Times of a Prehistoric Man Found in an Alpine Glacier*. New York: Random House, 2000. Presents a thorough account of the discovery and study of the Tyrolean Iceman.

Ikram, Salima, and Aidan Dodson. *The Mummy in Ancient Egypt: Equipping the Dead for Eternity*. Cairo: American University in Cairo Press, 1998. Offers comprehensive discussion of how Egyptian mummies were made, wrapped, adorned, and sheltered.

See also: Adipocere; Ancient criminal cases and mysteries; Decomposition of bodies; Mitochondrial DNA analysis and typing; Peruvian Ice Maiden.

Murder. *See* Homicide

Mustard gas

Definition: Vesicant, or blister-causing, agent that has been used in chemical attacks against humans, most often during wartime.

Significance: As the potential for terrorist chemical attacks on civilian targets has increased, first responders within local communities worldwide who are responsible for the safety of civilian populations are being trained in combating various chemical agents, including mustard gas.

When two chlorine atoms, eight hydrogen atoms, four carbon atoms, and one sulfur atom are combined in the right manner and under the right conditions, they create the highly toxic compound known as mustard gas. Mustard gas is part of a class of chemicals known as organohalogens, which combine with carbon and other elements. Well-known organohalogens include the agricultural chemical DDT (dichloro-diphenyl-trichloroethane), the war gas phosgene, and chlorofluorocarbons (or freons). The majority of both natural and synthetic organohalogens have little or no toxicity, but, as an expression among chemists notes, "the dose makes the poison."

Mustard gas, also known as sulfur mustard, is the most common agent associated with chemical warfare. Although mustard gas has been used most often during wartime, it has become increasingly clear since 1995, when members of the Aum Shinrikyo religious movement perpetrated a sarin gas attack on a Tokyo subway train, that the use of chemical weapons by terrorist organizations is a real possibility. The Web site of the U.S. Centers for Disease Control and Prevention (CDC) includes several pages providing information on mustard gas, including how to detect an attack and how to respond to one. Nerve agents are more modern types of chemical weapons, but vesicant agents are much easier to produce than nerve agents; terrorists are thus much more likely to use vesicant agents than nerve agents in chemical attacks.

History

Mustard gas was first deployed as a weapon by Germany in 1917, during World War I. Approximately one month after its introduction to the battlefield, British casualties from just mustard gas were almost equal to all previous casualties resulting from the use of other gas chemical agents that German forces had been employing for several years. The next use of mustard gas was by the Italians during their attempt to conquer present-day Ethiopia in 1935. Since that time, mustard gas has remained much the same, and it is a weapon that is fairly easy to manufacture.

Mustard gas was also purportedly used during the Iran-Iraq War (1980-1988), which saw the extensive use of chemical weapons. Since the international Chemical Weapons Convention went into force in 1997, stockpiles of mustard gas have been in the process of being systematically destroyed, at least by those countries that are signatories to the convention, including the United States and Russia.

How It Works

In a mustard gas attack, the agent is usually released through the air either by artillery shells or by bombs; the agent can also be deployed through water supplies. With strong winds, an air release of mustard gas can spread the agent over distances of several miles. In normal conditions, the gas will stay in the area for approximately two days, but in colder climates it can linger much longer.

When the gas is inhaled or ingested or comes into direct contact with the skin or eyes, it begins to cause irritation. The agent begins to attack the skin cells, causing severe irritation and damaging DNA (deoxyribonucleic acid); it quickly penetrates the skin and assaults the organs within the body and damages the respiratory tract. It also can damage eyesight if the eyes are exposed. The accompanying blistering of the skin can be very painful and creates a high potential for infection. If the exposed person survives the initial exposure, the agent will continue to attack the body's immune system, which can cause difficulty in dealing with any associated infections from the exposure.

Federal Recommendations Regarding Mustard Gas

The Agency for Toxic Substances and Disease Registry, a federal public health agency of the U.S. Department of Health and Human Services, provides this information on U.S. government recommendations concerning mustard gas, or sulfur mustard.

The federal government considers sulfur mustard an extremely hazardous substance. In 1985, Congress directed the U.S. Army to begin destroying the stockpile of U.S. chemical agents including sulfur mustard. As a result, the U.S. Army's Chemical Stockpile Disposal Program (CSDP) was started. As part of this program, the U.S. Army has continued to study how workers and the general public might best be protected from harm by sulfur mustard. The U.S. Army is the primary source of safety recommendations for sulfur mustard. The federal government has recommended maximum concentrations in air to which the general public should be exposed for different lengths of time. The maximum concentration for long-term exposure is 0.0001 milligrams per cubic meter of air. Higher concentrations may be tolerated for shorter periods. Stored quantities of 500 pounds or more must be reported to the State Emergency Response Commission, the fire department, and the Local Emergency Planning Committee. Spills of over 1 pound must be reported to the National Response Center.

Symptoms and Treatment

The effects of exposure to mustard gas are not normally recognized until a few hours after exposure. In the short term, exposure to the skin causes first red and itchy skin that rapidly changes to yellow blistering. In mild cases, eye exposure causes tearing, pain, irritation, and swelling. In high doses, mustard gas can cause temporary blindness, sensitivity to light, and severe pain in the eyes. If the mustard gas reaches the respiratory system, it can cause bleeding from the nose, sneezing, cough, sinus pain, shortness of breath, and possibly hoarseness. When it reaches the digestive tract it can cause diarrhea, nausea, vomiting, abdominal pain, and fever. It can also cause second- and third-degree burns on the skin and permanent blindness.

No antidote exists to combat exposure to mustard gas. As a preventive measure, moving to higher ground is advisable during gas attacks because the gas is denser than air, and so it tends to settle in low-lying areas. Persons who have been exposed to the gas are normally hospitalized and given standard medical attention in an effort to reduce the effects of the agent. Any clothing they were wearing that has been exposed to mustard gas is removed, and their bodies are thoroughly rinsed with clean water.

When victims' eyes have been exposed, they need to be flushed for approximately seven minutes.

Detection

Mustard gas exposure is usually detected after the fact, when suspicions are raised by the appearance at hospitals of persons with the symptoms described above. In the United States, when doctors suspect the presence of this chemical agent, they can send samples to the CDC to be analyzed against a database of chemical agents. Emergency first responders and law-enforcement agencies also have chemical monitoring equipment that can analyze the air for the presence or absence of specific chemical agents. These instruments use processes that vary from chromatography and spectrometry to photoionization and even the simple color-change method.

Michael W. Cheek

Further Reading

Coleman, Kim. *A History of Chemical Warfare*. New York: Palgrave Macmillan, 2005. Details the use of chemical weapons from World War I onward and analyzes chemical warfare accords and why countries chose not to use chemical weapons. Also discusses the potential for chemical terrorism in the present age.

Cordesman, Anthony H. *Terrorism, Asymmetric Warfare, and Weapons of Mass Destruction: Defending the U.S. Homeland*. Westport, Conn.: Praeger, 2002. Addresses a variety of potential threats to U.S. security, including chemical weapons. Provides information on vesicant agents and possible responses to chemical terrorist attacks.

Croddy, Eric A., with Clarisa Perez-Armendariz and John Hart. *Chemical and Biological Warfare: A Comprehensive Survey for the Concerned Citizen*. New York: Copernicus Books, 2002. Comprehensive study of chemical and biological weapons covers types of agents, potential for terrorists' use of such agents, and possible responses to the problem of chemical weapons.

Hammond, James W. *Poison Gas: The Myths Versus Reality*. Westport, Conn.: Greenwood Press, 1999. Provides historical information on the original use of poison gas weapons and then discusses the cultural perceptions of chemical weapons and why those conceptions exist.

Taylor, C. L., and L. B. Taylor, Jr. *Chemical and Biological Warfare*. New York: Franklin Watts, 1992. Covers the history and use of chemical weapons in warfare since World War I. Includes some discussion of biological agents and the challenges of banning their use.

See also: Centers for Disease Control and Prevention; Chemical agents; Chemical terrorism; Chemical warfare; Chemical Weapons Convention of 1993; Less-lethal weapons; Nerve agents; Soman; Tabun.

Mycotoxins

Definition: Natural secondary by-products of fungi that can produce toxic effects when ingested or inhaled.

Significance: Forensic scientists are sometimes called upon to identify mycotoxins and toxigenic molds, which can cause severe health problems with long-term exposure. Mycotoxins are also a concern to law-enforcement agencies because these agents can be readily isolated and thus have potential for use as biological weapons.

Mycotoxin production occurs when favorable environmental conditions allow fungi to grow on plants or plant-based materials. Mold and mycotoxin contamination can increase in extreme environmental conditions, such as drought, excessive precipitation, floods, sudden frost, and constant high humidity. Most of the world's croplands, forests, and population centers are in temperate zones, prime breeding grounds for toxigenic fungi. Estimates suggest that at any given time approximately 25 percent of the world's grain supply is contaminated with mycotoxins. It has also been estimated that at least 10 percent of all buildings in North America are contaminated with toxigenic molds at levels that pose a risk to health.

The severity of mycotoxicosis, or mycotoxin poisoning, depends on the toxicity of the mycotoxin, the extent of exposure, and the age and health of the victim. The human health impacts of mycotoxicosis are multiple, including allergies, chronic bronchitis, skin necrosis, respiratory failure, loss of bone marrow, liver and kidney failure, skin irritation, anorexia, tremors, vasoconstriction, headache, chronic fatigue, cancers, vomiting, gastric and intestinal irritation, hemorrhaging, tachycardia, severe immunodeficiency, neurocognitive dysfunction, anxiety, tremors, fibromyalgia, lupus, ataxia, and reproductive problems. Because of these toxic effects, mycotoxins are part of an ongoing controversy over their use as biological weapons to produce neurological impairment.

Toxigenic fungi associated with animal and human food chains are in three main genera: *Aspergillus*, *Fusarium*, and *Penicillium*. Although *Aspergillus* and *Penicillium* species are important mycotoxin producers—*Penicillium* alone can produce twenty-seven different mycotoxins—*Fusarium* are most significant in their effects on crops, poultry, livestock, and farmworkers. *Claviceps* fungi are responsible for historical epidemics of ergotism, and *Stachybotrys chartarum*, considered one of the most poisonous molds on Earth, is commonly found in human dwellings.

Stachybotrys chartarum and *Chaetomium* are fungi often identified within domestic housing and considered the source of "sick house syndrome." The fungi are found in dark, moist indoor environments such as wall cavities, attics, basements, and ventilation systems. The fungi produce black spores resembling soot that grow aggressively on moist drywall and are carried by circulating air. Several high-profile sick house toxic tort cases have been litigated in the United States.

Trichothecene mycotoxin (T-2 mycotoxin), a derivative of *Aspergillus*, *Stachybotrys*, and *Fusarium*, is considered among the most potent naturally occurring toxins. T-2 mycotoxin is the only biological active toxin effective through inhalation, ingestion, and dermal exposure. Declassified U.S. government documents suggest that T-2 mycotoxins have been identified as agents of biological warfare since the mid-1970's in Laos, Afghanistan, Kampuchea, and the Arabian Peninsula. It has been asserted that T-2 mycotoxin exposure is a causal agent of the illness known as Gulf War syndrome.

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Further Reading

DeVries, Jonathan W., Mary W. Trucksess, and Lauren S. Jackson, eds. *Mycotoxins and Food Safety*. New York: Kluwer Academic, 2002.

Diaz, D. E., ed. *The Mycotoxin Blue Book*. Nottingham, England: Nottingham University Press, 2005.

Matossian, Mary Kilbourne. *Poisons of the Past: Molds, Epidemics, and History*. New Haven, Conn.: Yale University Press, 1989.

Money, Nicholas P. *Carpet Monsters and Killer Spores: A Natural History of Toxic Mold*. New York: Oxford University Press, 2004.

Rea, William J., et al. "Effects of Toxic Exposure to Molds and Mycotoxins in Building-Related Illnesses." *Archives of Environmental Health* 58, no. 7 (2003): 399-405.

See also: Air and water purity; Biodetectors; Biological terrorism; Biological warfare diagnosis; Biological weapon identification; Biological Weapons Convention of 1972; Biotoxins; Food supply protection; Forensic botany; Forensic toxicology; Inhalant abuse; Pathogen transmission; Pollen and pollen rain; Toxic torts; Toxicological analysis.

N

Napoleon's death

Date: May 5, 1821

The Event: After the French emperor Napoleon I was defeated by the British at the Battle of Waterloo in 1815, he was exiled to the remote island of Saint Helena, a British possession in the South Atlantic. He arrived on the island on October 17, 1815, and died there after less than six years of captivity at the age of fifty-one under circumstances that are still debated.

Significance: The question of whether Napoleon I died from natural causes or from criminal action, as some allege, has been an ongoing source of controversy among historians. Forensic science has played a small role in the examination of the available evidence in this case.

Physical as well as psychosomatic reasons could account for Napoleon I's deteriorating health condition some two years after the exiled former French emperor arrived to live on the desolate island of Saint Helena. Napoleon's father died from pyloric (lower stomach) cancer, so genetics may also have played a role. It is true, however, that more than one person may have had reasons to want the former emperor out of the way; this fact has lent credence to theories that Napoleon's cause of death may have been poisoning.

Sickness

By 1817, Napoleon was intermittently complaining of a number of physical problems, including a pain in his stomach, discomfort in his spleen or kidneys, frequent heavy sweating, nausea and vomiting, and weariness. The several British doctors who examined him, as well as the French-Corsican physician Napoleon's family eventually sent to care for him, Francesco Antommarchi, variously diagnosed chronic hepatitis, stomach cancer, an ulcerated stomach lining, and other ailments. The doctors subjected the often unwilling patient to such standard remedies of the time as emetics and bleeding.

Some of the physicians who were more astute than others suggested that Napoleon's lack of physical exercise and isolation were contributory causes; they encouraged Napoleon's predilection for horse riding and gardening. Indeed, when Napoleon felt well enough to engage in these activities, he became more energized. His seeming remission would then end, however, or he would become too depressed to want to engage in any activities and would instead spend long hours dozing or sleeping. He took part in socializing with the members of his dwindling entourage only intermittently.

By all accounts, Napoleon was very sensitive to his surroundings—his remoteness from family, Saint Helena's unhealthy climate, his rat-infested residence at Longwood House, and especially the demeaning attitude of his captors. The British governor of Saint Helena, Sir Hudson Lowe, insisted on calling him "General Bonaparte" instead of "Emperor," adding to Napoleon's unhappiness. In addition, the governor ordered that a British officer check on Napoleon daily to make sure he did not escape, despite the large British garrison and strong naval presence around the island that made flight practically impossible. Perhaps the most depressing for Napoleon was the hopelessness of his situation—that he would never be allowed to return to where he belonged.

Death

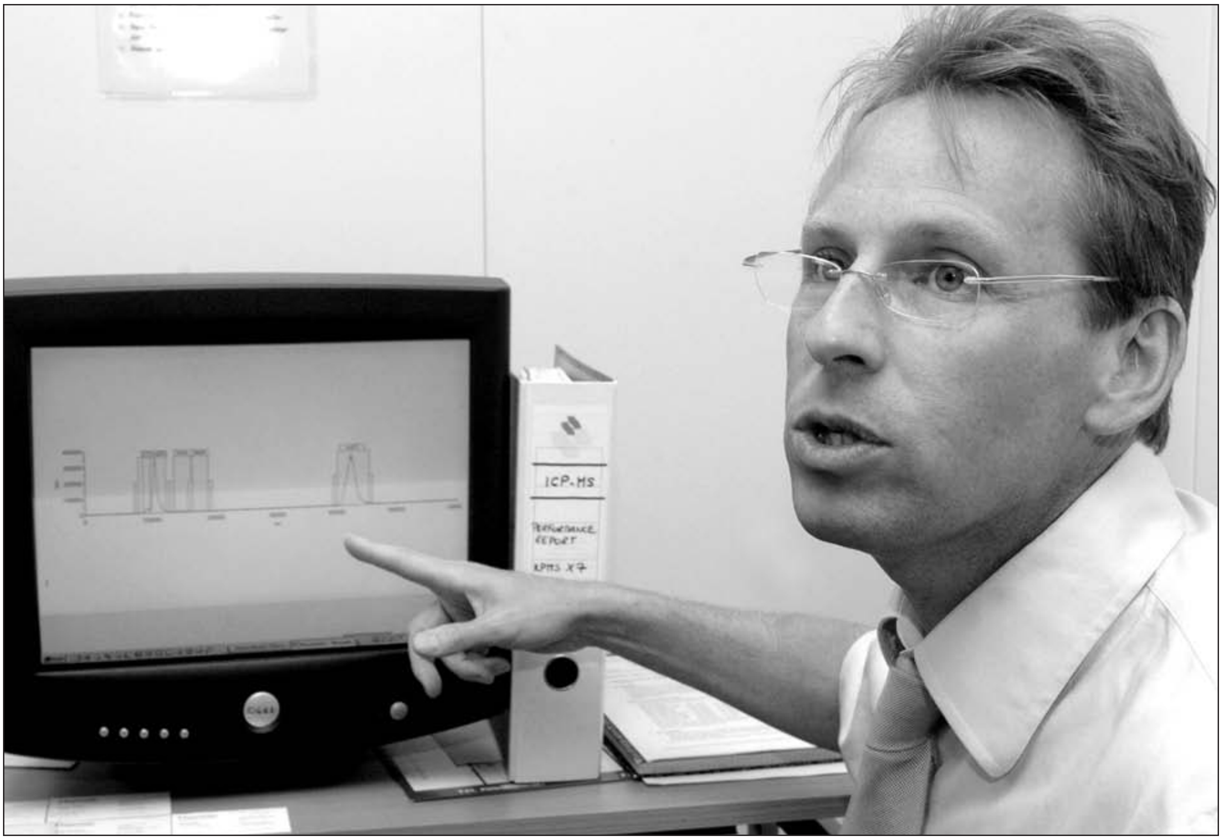
For political reasons, the British governor refused to accept any diagnosis of Napoleon's condition that would suggest that the former emperor had been mistreated in any way or even that he was adversely affected by the island's inclement climate. By 1821, however, Napoleon's condition had clearly deteriorated significantly. Dr. Antommarchi as well as the approximately half dozen British doctors who had examined the prisoner (or, because of Napoleon's refusal, had conferred with others who had seen him) eventually agreed with Napoleon's own prediction, voiced in December, 1820, that there was "no more oil in the lamp."

The end came in May, 1821. Napoleon had been confined to bed for some days, existing mainly on arrowroot and gentian, occasionally taking a sip of flavored water or a spoonful of wine mixed with water, and dozing much of the time. His mind began to wander, and he finally became delirious, repeating certain inarticulate words that have been variously interpreted. He died at 5:49 P.M. on the afternoon of May 5, surrounded by several members of his much-diminished entourage.

Autopsy

The autopsy was performed by Antommarchi, presumably because he was more experienced in postmortems than the six British physicians who attended the process (only five signed the autopsy report because the sixth was considered too junior in rank). The doctors agreed that the pylorus was surrounded by tumors and that Napoleon's ulcers were conceivably cancerous and had eaten into the stomach, but they disagreed on the condition of the liver—that is, on whether or not chronic hepatitis was also present. The doctors did not consider the possibility that physician error in Napoleon's treatment could have led to his death. Napoleon had been treated with large doses of almond-flavored calomel, a mercurial chloride used as a purgative, and this could have been a contributing factor in his death, especially if he also ingested arsenic in whatever form. Saint Helena's British governor favored an autopsy report that prioritized cancer as the leading cause of death.

The theory that Napoleon died from arsenic poisoning surfaced much later, when samples of his hair, which had been deeded to some of his



A toxicologist at France's University of Strasbourg shows on a computer the high levels of arsenic found in a sample of the hair of French emperor Napoleon I. This evidence gives weight to the theory that Napoleon was poisoned. *(AP/Wide World Photos)* entourage and family members, were examined microscopically and found to contain excessively high levels of arsenic (a substance readily available at Longwood House, where it was used to keep the large rat population under control). In addition, when Napoleon's body was moved from Saint Helena to Paris, France, in 1840, it was found to be in nearly perfect condition even though it had not been embalmed; this preservation and the fact that the body was also hairless both pointed to arsenic poisoning.

The leading suspect for administering the poison to Napoleon in small doses over time was the former emperor's chief chamberlain, Count Charles-Tristan de Montholon. Montholon had some connection with the count of Artois, later France's King Charles X, who may have feared a comeback and second coup d'état by the former leader. Montholon was also a major beneficiary of Napoleon's will; thus, if Napoleon's intention to leave the count two million francs was clear at an early date, Montholon had a financial interest in Napoleon's early demise. Another theory, however, is that Montholon did administer the poison to Napoleon in small doses, mixed with the former emperor's wine, to which he had access, but his intent was not to kill his benefactor; rather, he wanted to induce sufficient ill health for Napoleon to be allowed to return to his kin in Europe.

Given that Napoleon I's legend as a leader who has had few equals in the history of the world is well established, the French government has not been concerned with debates regarding his possible cause of death. Although it is possible that the techniques of modern forensic science could shed light on this issue, French authorities have shown little inclination to allow researchers to open the former emperor's coffin to subject his body to the tests that would be necessary to gather new evidence.

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Further Reading

Asprey, Robert. *The Reign of Napoleon Bonaparte*. New York: Basic Books, 2001. Pinpoints Napoleon's terminal illness as beginning on March 17, 1821.

Hibbert, Christopher. *Napoleon: His Wives and Women*. New York: W. W. Norton, 2002. Suggests that the arsenic found in Napoleon's body may have originated from a coloring in wallpaper containing copper arsenite and widely used at that time.

Johnson, Paul. *Napoleon*. New York: Viking Penguin, 2002. Brief biography is noncommittal about the cause of Napoleon's death.

McLynn, Frank. *Napoleon: A Biography*. 1997. Reprint. New York: Arcade, 2002. Comprehensive work on the emperor's life includes discussion of the politicization of Napoleon's autopsy report.

Weider, Ben, and Sten Forshufvud. *Assassination at St. Helena Revisited*. Rev. ed. New York: John Wiley & Sons, 1995. Interesting work by the two most persistent supporters of the thesis that Napoleon was deliberately murdered, with small doses of arsenic, by the one who stood to gain most from the crime, Charles de Montholon.

See also: Ancient criminal cases and mysteries; Arsenic; Autopsies; Beethoven's death; Decomposition of bodies; Document examination; Food poisoning; Hair analysis; Mummification; Taylor exhumation.

Narcotics

Definition: Substances with a stuporous effect, used in low doses to relieve moderate to severe pain, suppress coughing, and control diarrhea.

Significance: Although narcotics have many legal uses, these drugs are also widely abused. Law-enforcement agencies devote many of their resources to the investigation of crimes associated with the illegal manufacture, sale, and use of narcotics.

The word "narcotic" is derived from the Greek word *narkitos*, which means numbing. Narcotics are efficient pain reducers and cough suppressants. Short-term effects of narcotics include drowsiness, dry mouth, nausea, vomiting, and sweating. The narcotic drug class includes both opiates (drugs that are derived from opium) and opioids (manufactured drugs that produce the same effects as opiates). Opiate narcotics include codeine, oxycodone, and dihydrocodeine. Examples of opioid narcotics include meperidine (brand name Demerol), dextropropoxyphene (Darvon), and fentanyl.

Opium has been used for medicinal purposes for more than nine thousand years. The active substance in opium, called morphine, was first isolated in 1803. During the nineteenth century, opium and morphine preparations were considered "wonder drugs." They provided relief from diarrhea caused by two of the major killers of that era: cholera and dysentery. In 1874, heroin was synthesized from morphine for the first time. It quickly became a major ingredient in many tonics and medicines. In the United States, the Harrison Narcotic Drug Act went into effect in 1914; this law regulated the manufacturing and distribution of heroin and other drugs.

The opium poppy plant is the source of all opium, and opium is the source of all opiate drugs (morphine, heroin, codeine, and others). Although opium poppies grow wild in many areas of the world, most illicit cultivation of these plants occurs in Mexico, South America, and the areas known as the Golden Crescent (Pakistan, Afghanistan, and Iran) and the Golden Triangle (Myanmar, Laos, and Thailand). The roots of the opium poppy produce opium, most of which accumulates in the seed pod. Opium farmers make cuts on the seed pods so that the milky opium bleeds out. Once this opium resin hardens, it can be collected. A typical opium farm can yield nine to twenty pounds of opium per acre.

Most heroin users inject the drug, but it can also be smoked or snorted. Drug users who inject heroin risk becoming infected with hepatitis C or the human immunodeficiency virus (HIV) if they share needles or other drug paraphernalia. Many other narcotics, such as codeine and oxycodone, are available in pill form. Some narcotics, such as fentanyl, are administered through patches that are placed on the skin.

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Further Reading

Hicks, John. *Drug Addiction: "No Way I'm an Addict."* Brookfield, Conn.: Millbrook Press, 1997.
Laci, Miklos. *Illegal Drugs: America's Anguish*. Detroit: Thomson/Gale, 2004.
Sonder, Ben. *All About Heroin*. New York: Franklin Watts, 2002.

See also: Canine substance detection; Controlled Substances Act of 1970; Drug abuse and dependence; Drug classification; Drug Enforcement Administration, U.S.; Drug paraphernalia; Harrison Narcotic Drug Act of 1914; Opioids; Psychotropic drugs.

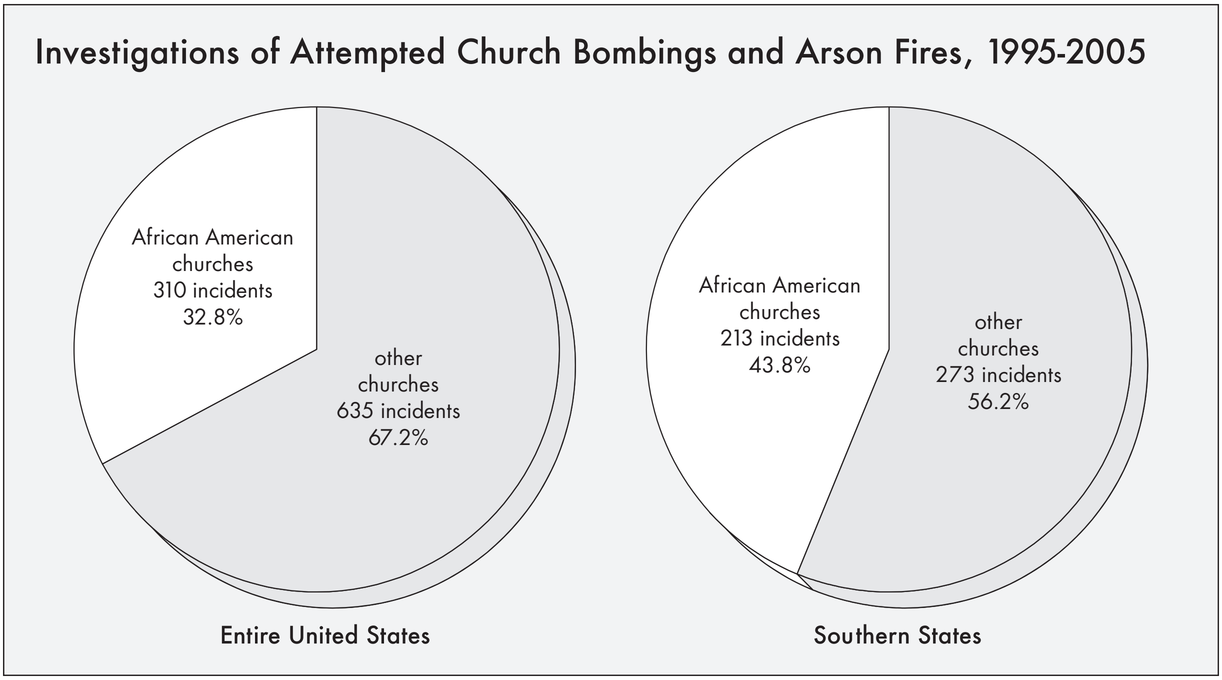
National Church Arson Task Force

Date: Formed in June, 1996

Identification: Federal organization established to coordinate federal, state, and local law-enforcement agencies in response to a dramatic increase in arson cases involving churches attended by African Americans.

Significance: The coordination of church arson investigations among law-enforcement agencies made investigations of church arson cases more efficient.

President Bill Clinton called for the forming of the National Church Arson Task Force (NCATF) in June, 1996. The agency was created within the Bureau of Alcohol, Tobacco, Firearms and Explosives under the umbrella of the U.S. Department of Justice. Congress assisted the president's efforts by passing the Church Arson Prevention Act of 1996. This act gave prosecutors more power to prosecute church arson cases and increased penalties for the crime, which included fines, prison sentences, and the death penalty. The act also made the collection of hate crime data part of the federal government's Uniform Crime Reports, a move that improved the tracking of bias-motivated crimes.



Source: National Church Arson Task Force, 2008. "Churches" include all houses of worship.

During the 1990's, the number of arson attacks targeting African American churches increased, particularly in the South. Arson has traditionally been a difficult crime to track and prosecute. Before the creation of the NCATF, it was difficult for law-enforcement agencies to assess the full scope of the church arson cases because records were not well kept. Arson fires are sometimes mislabeled as accidents, and the motivations behind arson cases can be unclear. Hate crime data were not examined separately.

With the creation of the NCATF, improved collection and tracking of church arson data revealed that church arson is not confined to churches with primarily African American congregations; churches attended by other ethnic and racial groups are also targeted. Also, many perpetrators are not motivated by hate or racism to burn or bomb churches. Some perpetrators are motivated by revenge or simply by the love of setting fires. NCATF statistics have shown that more than 90 percent of perpetrators of church arson nationwide are male, more than 80 percent are white, and more than 50 percent are between the ages of fourteen and twenty-four. Moreover, only about half of all churches targeted by arsonists have been attended predominantly by African Americans.

The task force has at its disposal specially trained agents, chemists, and laboratories and uses computer technology to analyze information and determine whether church fires are arson cases. During its first year, the NCATF investigated 429 church burnings. Its arrest rate was 35 percent—more than double the national arrest rate for arson. The NCATF was also actively involved in prevention efforts through the Federal Emergency Management Agency (FEMA), which established a clearinghouse for telephone inquiries and distributed arson prevention packets. The task force has also assisted in developing grassroots arson prevention programs.

Ayn Embar-Seddon and Allan D. Pass

Further Reading

Blackstock, Terri. *Trial by Fire*. Grand Rapids, Mich.: Zondervan, 2000.

Johnson, Sandra E. *Standing on Holy Ground: A Triumph over Hate Crime in the Deep South*. Columbia: University of South Carolina Press, 2005.

National Church Arson Task Force. *First Year Report for the President*. Washington, D.C.: U.S. Department of the Treasury, 1996.

_______. *Second Year Report for the President*. Washington, D.C.: U.S. Department of the Treasury, 1998.

See also: Accelerants; Arson; Blast seat; Bomb damage assessment; Bureau of Alcohol, Tobacco, Firearms and Explosives; Burn pattern analysis; Fire debris.

National Crime Information Center

Date: Established in January, 1967

Identification: Central U.S. database for crime-related information, maintained by the Federal Bureau of Investigation and available electronically to local, state, and federal law-enforcement agencies.

Significance: The National Crime Information Center provides law-enforcement agencies, both in the United States and abroad, with ready access to information on crimes, criminals, and crime victims, thus aiding in investigations of many different kinds, from searches for dangerous fugitives to the location of missing persons and property.

In 1965, officials with the Federal Bureau of Investigation (FBI) became concerned about steadily increasing crime rates across the United States and realized that, to address the problem, law-enforcement agencies across the nation needed to be able to collect and share information regarding crimes and criminals. The FBI created an advisory board to develop standards of operation for a new center that would be tasked with information sharing among law-enforcement agencies. The board was made up of FBI statisticians, who created and disseminated the agency's annual Uniform Crime Reports, and members of the International Association of Chiefs of Police. The FBI next approached the U.S. Commerce Department for assistance in procuring an appropriate telecommunications system that would be capable of warehousing and sharing information electronically at high speeds.

Two years later, in January of 1967, the National Crime Information Center (NCIC) began operations when high-speed computers went online at fifteen state and metropolitan-area police departments throughout the United States. These fifteen terminals were directly connected to a central computer housed in the FBI's Criminal Justice Information Services Division, located near Clarksburg, West Virginia. The new system allowed information sharing—between participating police departments and the FBI as well as among the police departments—to take place at unprecedented speeds. By the end of 1971, all fifty U.S. states and the District of Columbia were connected directly to the NCIC. Eventually, more than eighty thousand law-enforcement and criminal justice agencies in the United States and abroad gained secure access to the database. An advisory council of law-enforcement officials from all levels and department sizes functions to ensure that the database is meeting the needs of its many users.

Contents of the Database

When the NCIC initially went online, the database housed ninety-five thousand records in five separate file categories. These five original categories were wanted persons (divided into state fugitives and federal fugitives), stolen autos, stolen license plates, stolen guns, and other identifiable stolen articles. NCIC records were entered directly into the system by the law-enforcement agencies that had jurisdiction to investigate the crimes reported. With this safeguard, all NCIC users knew that the records were valid, as only the investigative agencies that posted the information could update or eventually clear the posted data. This procedure still remains in effect.

Since its inception, the NCIC has been expanded and updated significantly. By 2008, a total of eighteen file categories contained more than ten million records. Additionally, nearly twenty-five million criminal history records had been stored on the Interstate Identification Index, which is available through the NCIC. Among the most notable additions to the database since it began operations are the Missing Persons File, which helps law-enforcement agencies locate noncriminal missing adults and children; the U.S. Secret Service Protective File, which consists of information on individuals who pose a direct threat to the president of the United States; the Interstate Identification Index, which allows law-enforcement officers quick access to criminal history information, especially during traffic stops; the Violent Gang/Terrorist File, which contains information on criminal gangs and terrorist organizations; and the Convicted Sex Offender Registry.

Uses and Successes

Local law-enforcement agencies use the NCIC frequently to get information quickly about persons with whom officers come into contact during routine activities. For example, when a police officer makes a routine traffic stop, the officer radios the police dispatcher and provides information on both the driver and the vehicle, including license plate number and state driver's license information. The dispatcher enters this information first in a search of the state database to see whether the person stopped by the officer is wanted or missing in that particular state. If this search results in no hits, the dispatcher runs a federal check against the NCIC. If this search of the national database also returns no hits, it can be concluded that the person has not been in trouble with law enforcement or is not listed as a missing person in the United States.

This use of the NCIC has proven to be effective, at the least, in safeguarding the lives of patrol officers who may be dealing with potentially violent offenders during routine traffic stops. The success of this procedure has led some police departments to install computers in patrol cars so that officers can search state and federal databases directly, without taking the extra step of contacting dispatchers.

Overall, the NCIC has contributed substantially to improved law-enforcement services, from the apprehension of wanted suspects to

NCIC 2000

In 1999, the FBI enhanced the National Crime Information Center with NCIC 2000, which gave the system additional capabilities, including in the following areas:

- **Enhanced name search:** Uses the New York State Identification and Intelligence System (NYSIIS), which returns phonetically similar names (for example, Marko, Marco, or Knowles, Nowles) and derivatives of names (such as William, Willie, Bill).
- **Fingerprint searches:** Stores and searches the right index fingerprint. Search inquiries compare a print to all fingerprint data on file (wanted persons and missing persons).
- **Probation/parole:** The Convicted Persons or Supervised Release File contains records of subjects under supervised release.
- **Information linking:** Connects two or more records so that an inquiry on one retrieves the others.
- **Mug shots:** Allows for the entry of one mug shot per person record. One fingerprint, one signature, and up to ten other identifying images (scars, marks, tattoos) may also be entered.
- **Convicted Sex Offender Registry:** Contains records of individuals who are convicted sexual offenders or violent sexual predators.
- **SENTRY File:** Contains an index of individuals incarcerated in the federal prison system. Responses provide descriptive information and locations of the prisons.
- **Delayed inquiry:** Checks every record entered or modified against the inquiry log, and the entering and inquiring agency receives a response if any other agency has inquired on the subject in the past five days.

the location of missing persons and stolen cars. Two of the most notable criminal suspects who have been apprehended with the help of information contained in the database are James Earl Ray, who was arrested in 1968 for the assassination of the Reverend Martin Luther King, Jr., and Timothy McVeigh, key figure in the 1995 bombing of the Alfred P. Murrah Federal Building in Oklahoma City.

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Further Reading

Kessler, Ronald. *The Bureau: The Secret History of the FBI*. New York: St. Martin's Press, 2002. Offers a historical portrait of the agency and discusses its significance in efforts to combat crime in the United States.

_______. *The FBI: Inside the World's Most Powerful Law Enforcement Agency*. New York: Pocket Books, 1993. Provides a unique look into the investigative history of the FBI and its use of technology in solving crimes.

O'Hara, Charles E., and Gregory L. O'Hara. *Fundamentals of Criminal Investigation*. 7th ed. Springfield, Ill.: Charles C Thomas, 2003. Presents a detailed overview of the criminal investigative process, including the impacts of the uses of computer technology.

Pattavina, April, ed. *Information Technology and the Criminal Justice System*. Thousand Oaks, Calif.: Sage, 2005. Offers a comprehensive look at how technology has enhanced law-enforcement agencies' ability to catch criminals.

Theoharis, Athan G., with Tony G. Poveda, Susan Rosenfeld, and Richard Gid Power. *The FBI: A Comprehensive Reference Guide*. Phoenix, Ariz.: Oryx Press, 1999. Provides a detailed look at the FBI and its evolution over time.

See also: CODIS; DNA database controversies; Federal Bureau of Investigation; Federal Bureau of Investigation Laboratory; Integrated Automated Fingerprint Identification System; Integrated Ballistics Identification System; Interpol; National DNA Index System.

National DNA Index System

Date: Established in 1998

Identification: Computerized system for storing DNA profiles, maintained and operated by the Federal Bureau of Investigation and supported by the Combined DNA Index System, that permits state and local law-enforcement agencies to collaborate in identifying missing persons and matching DNA profiles of suspected offenders to unsolved crimes.

Significance: Technological advances in DNA analysis and computerized comparison of DNA profiles have created a powerful crime-solving tool at the national level. The National DNA Index System enables law-enforcement agencies to identify violent criminal offenders and match them to unsolved crimes across state lines, and it also possesses the power to exonerate the wrongfully convicted. The National DNA Index System allows law-enforcement agencies across the United States to communicate about and collaborate in criminal investigations at a level never before possible.

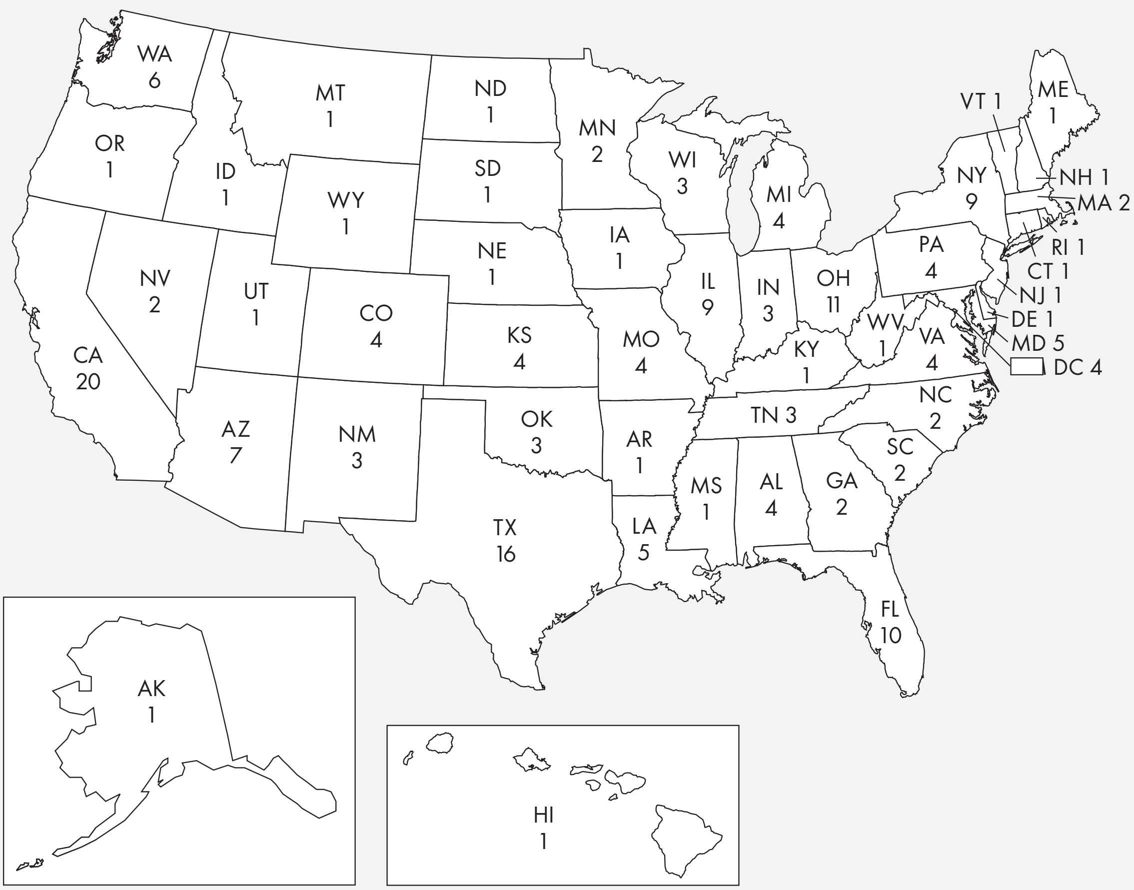
The National DNA Index System (NDIS) is an electronic resource of DNA profiles designed to aid in criminal investigations as well as searches for missing persons at the national level. Established in response to the Violent Crime Control and Law Enforcement Act of 1994 and operated by the Federal Bureau of Investigation (FBI), NDIS represents the highest level in the Combined DNA Index System (CODIS) hierarchy. CODIS, which began as a pilot project in 1990, represents a database of DNA profiles collected by law-enforcement agencies across the United States. CODIS is a computerized DNA profile processing system that provides law-enforcement agencies with the ability to search electronically for DNA profile matches. The CODIS hierarchy includes support at the national (NDIS), state (State DNA Index System, or SDIS), and local (Local

DNA Index System, or LDIS) levels. DNA profiles from the state and local levels constitute NDIS.

The primary purpose of NDIS is to assist in criminal investigations across state and local levels by providing an electronic database containing DNA profiles from participating laboratories across states. NDIS offers law-enforcement agencies in different states the opportunity to search for possible matches between suspected or convicted criminals and DNA profiles obtained from the scenes of unsolved crimes. This index system also enables the identification of serial offenders.

The federal DNA Identification Act of 1994 requires NDIS to record five DNA profile categories: DNA samples from individuals convicted of crimes, DNA samples recovered from crime scenes, DNA samples from unidentified human remains, DNA samples from relatives of missing persons, and reference samples from missing persons. Relatives of missing persons may contribute DNA samples to NDIS voluntarily; convicted offenders are given no notice or control over the collection and use of their DNA samples. In respect to criminal investigations, DNA samples from individuals convicted of crimes and DNA samples recovered from crime scenes are separated into two primary indexes, the offender index and the forensic index.

NDIS Labs in the United States



Source: Federal Bureau of Investigation, 2008.

Through NDIS, law-enforcement agencies can identify missing individuals, match offenders to previously unsolved crimes, and make connections between separate crime scenes.

To prevent personal identification from DNA profiles, no personal information is provided in NDIS, and only authorized personnel have access to identifying information. Each DNA profile in NDIS is connected only with the following information: identification of the particular laboratory or agency that submitted the profile, the name of the staff member associated with the DNA analysis, and an identification number for the specimen.

All fifty U.S. states contribute DNA profiles to NDIS, but the collection of DNA samples varies across states. As a result, some states submit more DNA profiles than do other states. The number of profiles submitted is not related to the level of crime in a state; rather, it is related to state laws that specify what types of offenders are required to submit DNA samples. For example, some states require submission of DNA samples in connection with only a small number of serious offenses, whereas other states permit law-enforcement agencies wide latitude in collecting DNA samples from suspects and convicted offenders. Some state laws permit the collection of samples from all persons arrested, whether or not they are ultimately convicted.

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Further Reading

Butler, John M. *Forensic DNA Typing: Biology, Technology, and Genetics of STR Markers*. 2d ed. Burlington, Mass.: Elsevier Academic Press, 2005.

Lazer, David, ed. *DNA and the Criminal Justice System: The Technology of Justice*. Cambridge, Mass.: MIT Press, 2004.

Lee, Henry C., and Frank Tirnady. *Blood Evidence: How DNA Is Revolutionizing the Way We Solve Crimes*. Cambridge, Mass.: Perseus, 2003.

See also: CODIS; DNA analysis; DNA database controversies; DNA fingerprinting; DNA isolation methods; DNA profiling; DNA recognition instruments; DNA sequencing; DNA typing; Federal Bureau of Investigation; Federal Bureau of Investigation Laboratory; Mass graves; National Crime Information Center; Postconviction DNA analysis; Short tandem repeat analysis.

National Institute of Justice

Date: Established in 1969

Identification: U.S. government agency responsible for researching crimes and investigation techniques as well as training state and local law-enforcement personnel in the most advanced investigative methods.

Significance: The National Institute of Justice has led the way in the development of improved techniques for law-enforcement investigation, including DNA analysis, biometric identification, and compilation of criminal records in electronic databases. The agency's establishment represented the first attempt by the U.S. government to conduct research into crime control and to spread that information to state and local law enforcement.

A dramatic increase in crime during the 1960's and the inability of state and local governments to deal with it goaded the U.S. Congress into passing the Omnibus Crime Control and Safe Streets Act of 1968. The law toughened criminal penalties and weakened restrictions on police investigation and interrogation. It also jump-started federal involvement in local crime control as Congress created a new agency within the Department of Justice. The National Institute of Justice (NIJ) became the research arm of the department; its mission was to analyze methods of controlling crime and of improving investigation and prosecution. Formed in 1969, the NIJ was unusual in that it was headed by a political appointee rather than by a member of the permanent government bureaucracy.

The NIJ is divided into the Office of Science and Technology and the Office of Research and Evaluation. The Office of Science and Technology provides training and research on the most advanced scientific techniques for law enforcement. Under the Office of Research and Evaluation, research divisions develop and direct evaluations in the areas of crime control and prevention, violence and victimization, and justice systems. This office also oversees an international research center.

The NIJ and Forensic Science

In response to the increasing scientific complexity of police investigations, the NIJ provides training to local and state law-enforcement agencies and prosecutors in the collection, interpretation, and presentation of scientific evidence such as DNA (deoxyribonucleic acid) analysis, biometric readings, and fingerprint analysis. The NIJ's Office of Science and Technology collaborated with other federal agencies to create a set of nationally recognized standards for DNA identification, and the agency trains law-enforcement personnel to use those standards when collecting and analyzing evidence.

The NIJ is part of the U.S. government's continuing efforts to update and improve the use of DNA analysis in criminal investigations. The agency joined with others as part of President George W. Bush's DNA Initiative, launched in 2003, to ensure that the newest and best technology is available to local law-enforcement agencies. The DNA project has also continued the work of a previous commission in studying how DNA testing might be used to free persons who have been convicted of crimes they did not commit.

In addition, the NIJ funds competitions within the private sector aimed at producing the best law-enforcement tools, including technologies in areas such as biometric identification systems, including voice matching, iris identification, and facial recognition. Among NIJ-funded studies on the test issues for biometrics was one concerning the most effective identification technology for keeping track of prisoners. The researchers concluded that iris recognition and fingerprint identification were more effective than simple facial identification. Another study tested the use of biometric iris identification as a security measure in a New Jersey school.

After the terrorist attacks on the World Trade Center and the Pentagon on September 11, 2001, the NIJ be-

The NIJ and Forensic Science

On its Web site, the National Institute of Justice describes the ways in which it supports advancements in forensic science.

Forensic science has greatly benefited from breakthroughs in broader areas of science and technology that make it possible for scientists to analyze evidence more quickly using ever smaller sample sizes that may be of poor quality.

The National Institute of Justice provides funding to:

- Develop tools and technologies.
- Better understand the impact of forensic science.
- Provide technology assistance to forensic laboratories.
- Enhance laboratory capabilities and capacity.

Tools and technologies. Demand exceeds capacity at most crime laboratories. NIJ develops innovative tools and technologies that will save time and money. These research and development projects provide:

- Faster, more reliable and widely applicable, less costly, and less labor-intensive tools for identifying, collecting, preserving, and analyzing crime scene evidence.
- Tools that provide more information about the source of evidence and circumstances surrounding the crime.

Understanding the impact of forensic science. NIJ has initiated several evaluations to assess the impact of forensic science on the criminal justice system—for example, training of first responders, perceptions of jurors, case processing.

Technology assistance and training. Through the Forensic Resource Network and the Forensic Science Technology Center of Excellence, NIJ provides assistance with quality assurance, evaluation, and implementation of new technologies and has developed several interactive training and field guidance documents.

Enhancing laboratories. NIJ provides funding to help laboratories streamline their operations, recruit qualified staff, and process more cases faster, with greater accuracy.

came involved in research concerning the use of DNA to identify victims of the disaster. The agency identified new methods of collecting DNA in mass-casualty incidents and also developed new methods for keeping track of thousands of DNA samples while ensuring fast and accurate matches. As a result of this work, the NIJ produced a handbook for use by law-enforcement agencies in the event of another mass-casualty terrorist attack.

The NIJ is also involved in research on computer crimes. The agency maintains a national software reference library that local and state law-enforcement agencies can use to investigate computer crime. This collaborative effort relies heavily on software donated by private firms and by other federal agencies such as the Federal Bureau of Investigation. Through the NIJ, law-enforcement agencies can access software that can enable them to trace attempts to hack computers as well as software that can help them to review the files on seized computers.

Making Law Enforcement More Scientific

The NIJ collaborates with other federal agencies and with state and local police departments to improve the technological and scientific capabilities of law enforcement. One of its first efforts was a movement to computerize all police records across the United States during the 1970's and 1980's so that record keeping would be more efficient and local, state, and federal police agencies would be able to share information on crimes and suspects. The NIJ provided both technological support and training for local police in the use of the new computerized system.

Also in the agency's early years, NIJ researchers emphasized victim studies, trying to understand how victims of crime are psychologically affected. The findings of these studies eventually led to legislation on victims' rights and the introduction of such procedures as the solicitation of victim impact statements in death penalty cases.

The NIJ collaborates with other federal agencies in efforts to find the best equipment for use by law-enforcement personnel, from body armor to traffic radar devices. The agency has conducted mock prison riots as training exercises for correctional officers, providing them with realistic experiences in using the latest technologies for handling rioting prisoners.

Since its founding, the NIJ has studied many other innovations in law-enforcement procedures and technologies, examining everything from private prisons to devices that allow police to "see" through walls. The NIJ also studies the impacts of the criminal justice mandates passed by Congress and state legislatures. For example, the 1994 Crime Act introduced community policing to limit crime and drug courts to handle the exploding number of drug cases. The NIJ studied and reported on the effectiveness of these techniques, documenting successes and failures and making suggestions for improvement.

Developing, testing, and disseminating improvements in technology for law enforcement constitute only part of the NIJ's duties. The agency is also involved in training law-enforcement personnel through both online seminars and on-site programs. The NIJ offers training to personnel at all levels of the criminal justice system, including police, judges, lawyers, and forensic scientists. One area of emphasis in NIJ training encompasses the collection, preservation, analysis, and presentation of DNA evidence.

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Further Reading

Cohn, Jeffery. "Keeping an Eye on School Security" *NIJ Journal* 254 (July, 2006). Reports on an NIJ study that examined the use of iris identification technology as a security measure in a New Jersey elementary school.

Connors, Edward, Thomas Lundregan, Neal Miller, and Tom McEwan. *Convicted by Juries, Exonerated by Science: Case Studies in the Use of DNA Evidence to Establish Innocence After Trial*. Washington, D.C.: National Institute of Justice, 1996. NIJ research report discusses a study initiated to identify and review cases in which convicted persons were released from prison as a result of posttrial DNA testing of evidence.

Miles, Christopher, and Jeffery Cohn. "Tracking Prisoners in Jail with Biometrics." *NIJ Journal* 253 (January, 2006). Describes an

NIJ-sponsored study that used fingerprint and iris analysis to track prisoners in a U.S. Navy brig and discusses how such technology could be used for other purposes, including security at public buildings.

National Institute of Justice. *The Future of Forensic DNA Testing: Predictions of the Research and Development Working Group*. Honolulu: University Press of the Pacific, 2005. Discusses advances in DNA collecting and testing as well as likely future uses of DNA analysis in law enforcement.

_______. *Investigative Uses of Technology: Devices, Tools, and Techniques*. Washington, D.C.: Author, 2007. Special report discusses techniques and resources for investigating technology-related crime.

See also: American Society of Crime Laboratory Directors; Biometric eye scanners; Biometric identification systems; Crime laboratories; DNA analysis; DNA recognition instruments; Federal Bureau of Investigation; Forensic Science Service; International Association of Forensic Sciences; Trace and transfer evidence.

National Transportation Safety Board

Date: Established on April 1, 1967

Identification: U.S. government agency responsible for investigating major transportation accidents involving motor vehicles, trains, airplanes, and ships.

Significance: Investigators for the National Transportation Safety Board use forensic science techniques to examine the causes of transportation accidents and make recommendations aimed at improving safety based on their findings.

The National Transportation Safety Board (NTSB) was created within the U.S. Department of Transportation in 1967 by President Lyndon B. Johnson. Initially, the NTSB was a political organization and thus susceptible to political manipulation, but in 1974 it was granted independent agency status. This meant that board members could not be removed by the president and that both the Republican and Democratic parties could nominate members to ensure partisan balance on the board.

The investigator in charge of the National Transportation Safety Board's investigation of the May, 1996, crash of ValuJet Flight 592 in Florida looks over some of the pieces of the airplane's wreckage collected at a hangar at a Miami airport a few days after the crash. *(AP/Wide World Photos)*

One of the smallest agencies within the federal government, the NTSB is responsible for investigating accidents and incidents involving most major forms of transportation. Although the work of the NTSB is perhaps most strongly associated with airplane crashes, the board is also responsible for the investigation of pipeline, railroad, and ship accidents as well as some accidents involving motor vehicles. Pipeline ruptures and accidents involving vehicles carrying hazardous waste fall under NTSB control, as do train derailments and collisions and any incidents causing injury or death to railroad employees. Marine accidents (such as ships running aground or sinking) and other incidents (such as fires) involving commercial cargo ships or passenger cruise ships also come under NTSB scrutiny. The highway accidents investigated by the NTSB are usually those involving multiple vehicles or large passenger vehicles, such as interstate buses. The board also examines accidents caused by failures in road construction and engineering.

Making Air Flight Safer

The NTSB focuses on finding the causes of the accidents it investigates and making recommendations to prevent future accidents. The NTSB categorizes the causes of accidents as resulting from mechanical failure, human error, or a mix of both. When NTSB investigators find mechanical failure as a cause of an airplane crash, this prompts NTSB recommendations to manufacturers that are intended to solve the problem and prevent future accidents.

Carrying out NTSB recommendations following a finding of human error in an airplane crash can require coordination among the NTSB, the airline, and the Federal Aviation Administration (FAA). For example, the crash of ValuJet Flight 592 in the Florida Everglades in 1996 was attributed to a fire in the plane's cargo hold caused by chemical oxygen generators. Following the NTSB investigation, the NTSB and FAA created new guidelines for airline cargo, including a requirement for active fire suppression devices, to prevent any other occurrence of the same kind of disaster.

NTSB and Forensic Science

Unlike most law-enforcement investigators, NTSB investigators have access to "eyewitness" evidence in almost every air crash. The flight data recorder, popularly known as the black box, provides evidence of a plane's mechanical functions before and during a crash, including any malfunctioning. The voice data recorder allows investigators to hear all conversations among the flight crew and between the crew and airport tower personnel. Both recorders are designed to survive crashes. The information provided by the recorders provides NTSB investigators with clues as to where they should look to explain the disaster. From there, they can examine parts of the plane that malfunctioned or interview members of the crew or tower personnel to find out what went wrong.

The ability of NTSB investigators to piece together what occurred immediately before and during an air disaster has put the NTSB in the forefront of forensic science. In the case of the explosion and crash of Trans World Airline (TWA) Flight 800 in the Atlantic Ocean in 1996, for example, NTSB investigators literally rebuilt the plane from recovered pieces and traced back what may have malfunctioned and led to the explosion. This effort required minute examination of every part of the plane, but the investigators eventually determined that the likely cause of the explosion and resulting crash was faulty wiring near a center fuel tank.

An NTSB Investigation

The National Transportation Safety Board provides this description of how the agency undertakes a major investigation.

When the Board is notified of a major accident, it launches a "Go Team," which varies in size depending on the severity of the accident and the complexity of the issues involved. The team may consist of experts in as many as 14 different specialties, coordinated by the investigator-in-charge. Each expert manages a group of other specialists from government agencies and industry in collecting the facts and determining the conditions and circumstances surrounding the accident. The investigative groups formed vary, depending on the nature of the accident, and may look into areas such as structures, systems, powerplants, human performance, fire and explosion, meteorology, radar data, event recorders, and witness statements, among others. After an investigation is completed, a detailed narrative report is prepared that analyzes the investigative record and identifies the probable cause of the accident.

Another crash, that of Air Midwest Flight 5481 soon after takeoff from Charlotte, North Carolina, in 2003, was attributed by the NTSB to plane maintenance problems but also to FAA regulations concerning passengers and their luggage. By not updating these regulations, the FAA had allowed the plane to fly with excessive weight that was unbalanced as the plane took off, leading to the crash. In this case, the NTSB conducted a more conventional forensic investigation, using simulations and eyewitness reports to determine how the weight had shifted within the plane during takeoff.

In investigating airplane manufacturing or design problems, the NTSB works with aircraft companies and examines how particular airplanes are constructed. Investigators also seek out information on any mechanical problems that have been noted with particular types of airplanes and records on the maintenance of the aircraft in question. After Alaska Airlines Flight 261 crashed into the Pacific Ocean in January, 2000, the NTSB investigated the possibility of both human and mechanical errors. Investigators concluded from their examination of mechanical aspects of the plane as well as maintenance records that the airline and the FAA were lax in their procedures and allowed some routine maintenance to be delayed beyond recommended times.

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Further Reading

Adair, Bill. *The Mystery of Flight 427: Inside a Crash Investigation*. Washington, D.C.: Smithsonian Institution Press, 2002. Presents an in-depth examination of a single crash investigation, delineating the work of the many groups that participated in reaching a conclusion and placing blame.

Bibel, George. *Beyond the Black Box: The Forensics of Airline Crashes*. Baltimore: The Johns Hopkins University Press, 2007. Describes in detail how NTSB investigators discover the causes of airplane crashes, including pilot error and mechanical malfunctions.

Cobb, Roger W., and David M. Primo. *The Plane Truth: Airline Crashes, the Media, and Transportation Policy*. Washington, D.C.: Brookings Institution, 2003. Discusses the NTSB and its investigations of plane crashes in the late 1990's. Addresses how outside influences, such as the news media, airlines and their unions, and aircraft manufacturers, have affected the conclusions reached by the agency.

Faith, Nicholas. *Black Box: The Air-Crash Detectives—Why Air Safety Is No Accident*. Osceola, Wis.: Motorbooks International, 1997. Provides information on how aircraft accident investigations are conducted and how the U.S. government uses the results of such investigations to improve air safety.

Krause, Shari Stamford. *Aircraft Safety: Accident Investigations, Analyses, and Applications*. 2d ed. New York: McGraw-Hill, 2003. Analyzes the causes of a number of specific airplane crashes, including human error, weather, and mechanical failure.

Lebow, Cynthia C., et al. *Safety in the Skies: Personnel and Parties in NTSB Aviation Accident Investigations*. Santa Monica, Calif.: RAND, 1999. Presents a synopsis of the challenges faced by the NTSB, discusses the agency's successes and failures in investigations, and offers a series of recommendations for maintaining and improving the agency.

Schiavo, Mary, with Sabra Chartrand. *Flying Blind, Flying Safe*. New York: Avon Books, 1997. Overview of the U.S. government regulatory system and the airline industry by the former inspector general of the Department of Transportation is critical of flight safety measures and the various agencies responsible for protecting the flying public.

See also: Accident investigation and reconstruction; Airport security; *Challenger* and *Columbia* accident investigations; Federal Bureau of Investigation; Flight data recorders; Sobriety testing; ValuJet Flight 592 crash investigation.

NDIS. *See* National DNA Index System

Nerve agents

Definition: Chemical weapons, usually liquid or gas, that incapacitate or kill by poisoning the nervous system.

Significance: Given the deadly nature of nerve agents and the possibility that such substances could be used in terrorist attacks, law-enforcement personnel must be familiar with the various types of nerve agents, decontamination procedures, and treatments for exposure.

The earliest use of poison gases as weapons took place during World War I; the agents used were vesicants, or blister-causing agents, such as chlorine gas, phosgene gas, and mustard gas. These injured by inflicting chemical burns on the lungs (and, in the case of mustard gas, on the skin and eyes as well). The gases had to be deployed in massive quantities (six hundred tons was a common amount), inflicted a low death rate, and soon dispersed, and gas masks provided sufficient protection to potential targets. Nerve agents, in contrast, are extremely toxic and can contaminate an area for days or weeks; protection of targets requires full body coverings in addition to masks.

Nerve agents function like modern organophosphate insecticides: They attack the nervous system. They inhibit the process by which cholinesterase neutralizes the neurotransmitter acetylcholine, thus clearing the nerve to transmit another signal. Acetylcholine then builds up in the nerves, causing the nervous system to malfunction; the nerves essentially transmit a continuous signal, causing the muscular system to lock up. The first symptoms—a feeling of tightness in the chest, dimming vision, and headache—may appear within seconds of exposure. Unconsciousness, coma, and death from respiratory paralysis follow within minutes or at most within a few hours. Survivors may suffer lasting impairment to their nervous systems.

G-Agents

Nerve gases are commonly divided into the three categories defined by the North Atlantic Treaty Organization (NATO): G-agents, V-agents, and Novichok agents. The first of these, the G-agents, were reportedly so named because they were German inventions. GA, or tabun, was discovered in 1936 by the German scientist Gerhard Schrader, who was researching insecticides. This agent is extremely toxic compared with the World War I vesicants and, unlike them, it is not simply a gas. At room temperature it takes the form of a liquid that evaporates slowly (albeit more rapidly than its successor G-agents). It is colorless and has only a faint odor, described as fruity.

Although its primary lethal mechanism is inhalation, liquid tabun will penetrate the skin; exposure to a single droplet can kill. When tabun is delivered by an artillery round or missile warhead, a large area is splattered with droplets, lethal in themselves, the vapors from which contaminate the air for an extended period of time. Because the droplets can kill through skin contact, a gas mask is insufficient protection; the body must be fully covered. Ordinary clothing, however, can make tabun even more dangerous, as it can trap droplets and hold them in contact with the skin.

Tabun's fumes are five times as dense as air, so they do not easily disperse into the atmosphere. Dangerous concentrations can thus remain for long periods in low-lying areas, including trenches and dugouts. Decontamination of areas contaminated with G-agents generally takes the form of rinsing the affected areas down with chlorine bleach. With tabun, however, this results in the release of toxic cyanogen chloride gas.

The second G-agent, known as GB or sarin, was invented by a German team in 1938. It is about twice as deadly as tabun (lethal skin dose for a human is less than a milligram) and so toxic that even its vapor can kill through skin exposure. Sarin evaporates more slowly than tabun, and thus its droplets can contaminate an area for a longer period.

Sarin has an unusual feature: It can be delivered as a binary agent, in the form of two or three harmless chemicals that, when mixed, convert into sarin. This makes sarin relatively safe to store, and it can be used in artillery shells, missile warheads, and bombs that are not dangerous until they are on the way to their targets.

Another G-agent, GD, or soman, was discovered by German scientist Richard Kuhn in 1944. GD, more deadly than sarin, can also be used as a binary agent. It is slower to evaporate than its predecessors and thus is a more persistent area contaminant. In its pure form it is colorless and has only a faint odor. In impure forms it can have a brown coloration and an odor resembling that of camphor.

GF, or cyclosarin, was invented in 1949. It is more persistent than its predecessors, evaporating at a speed about one-twentieth that of water and one-seventieth that of sarin. It is colorless and has a faint odor variously described as similar to peaches or shellac.

By the end of World War II, Germany had produced about twelve thousand tons of nerve agents. Although the Germans thus held a technological advantage over their enemies, they were reluctant to initiate chemical warfare for a simple reason: Most of their artillery, and much of their transport, was still horse-drawn, and efforts to design gas masks for horses had proven unsuccessful. The Allies' use of even World War I gases would have immobilized the Germans' artillery and stopped much of their resupply efforts.

V-Agents

The G-agents were succeeded in the years following World War II by the British-created V-agents, known as VE, VG, VM, and VX. Like the G-agents, these originated with researchers seeking to create insecticides (VG was briefly marketed for that purpose until it was withdrawn owing to its extreme toxicity).

Of these, VX was the only variant chosen for development as a war gas. VX was developed in Great Britain in the 1950's, and its secret was traded to the United States in exchange for information on construction of thermonuclear warheads. The Soviet Union reportedly developed its own version, known in the West as VR and in the Soviet Union as Substance 33, and produced more than fifteen thousand tons of it.

VX possesses all the characteristics that make nerve agents so deadly. It is viscous (its consistency has been likened to that of motor oil), so that it adheres to objects and persons. It can be delivered in binary form. It evaporates very slowly, at about one-fifteen-hundredth the rate of water. It is deadlier than its predecessors: A lethal skin dose is estimated at ten micrograms. When VX does evaporate, its fumes are nine times the density of air, so that it is not easily dispersed by wind.

Novichok Agents

For many years, VX represented the zenith of the development of nerve agents. That changed with Russia's development of Novichok (Russian for "newcomer") agents. Novichok agents take the form of a fine powder or dust that can evade modern chemical warfare protection equipment. These agents may be several times more potent than VX. Further, existing chemical agent detection systems may not detect Novichok agents, and antidotes may not function against them. The existence of these agents was revealed in 1992 by Russian chemists Lev Fedorov and Vil Mirzayanov, who were imprisoned after they went public.

Responses to Nerve Agent Attacks

Nerve agents are potent area-denial weapons. That is, an area that is attacked with the use of such weapons will be dangerous for unprotected humans for an extended period unless it is completely washed down with decontaminates (typically chlorine bleach, although steam and ammonia may be used in restricted areas). As the smallest missed droplet can kill, decontamination must be exceptionally thorough. Belowground areas must be flushed of any vapors.

Treatment of casualties is likewise complicated. First responders must themselves wear protective outfits. Unprotected personnel must not have contact with any exposed person until that person has been undressed, any known droplets of agent on the body have been neutralized, and the hair has been washed.

The earliest antidote used in response to exposure to nerve agents was atropine, which is itself a toxin. Atropine counters the effects of nerve agents by binding to nerve receptor sites and blocking excess acetylcholine. Biperiden, originally developed for use against Parkinson's

An operations supervisor stands between two one-thousand-gallon reactors where the nerve agent VX is chemically neutralized at the Newport Chemical Depot in Newport, Indiana. The Chemical Weapons Convention of 1993 requires signatory nations to destroy existing stockpiles of nerve agents. *(AP/Wide World Photos)*

disease, is also useful. Pralidoxime chloride (2-PAM chloride, known in the military simply as 2-PAM) offers a more direct and safe approach, in that it reactivates the acetylcholinesterase deactivated by the nerve agent. Treatment with 2-PAM must be begun more quickly than treatment with atropine, as 2-PAM takes effect more slowly. Military personnel are commonly issued kits containing self-injectors of atropine and 2-PAM if nerve agents are considered to be a risk. Diazepam can also be employed to counteract convulsions caused by nerve agents.

Employment of Nerve Agents

The deployment of nerve agents has been mercifully rare. During the Iran-Iraq War (1980-1988), Iraq used tabun, sarin, and cyclosarin against Iranian infantry and later used these agents to kill thousands of Kurds. In Japan, the Aum Shinrikyo religious cult used homemade sarin in a 1995 attack on the Tokyo subway system. Owing to the crude nature of the material used and a rather inept delivery system (leaky cans left in subway cars), casualties in that incident were held to twelve deaths and about five thousand hospitalizations.

The risk of future use may be curtailed by treaties. Early agreements such as the Geneva Protocol of 1925 forbade the use of poisonous gases, but not their manufacture and storage. More recently, the Chemical Weapons Convention of 1993, which entered into force in 1997, requires signatory nations to destroy existing stockpiles of nerve agents. In the United States, government efforts to destroy such stockpiles by breaking the substances down chemically and discharging the by-products into water have encountered objections from groups concerned with possible negative environmental impacts.

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Further Reading

Croddy, Eric A., with Clarisa Perez-Armendariz and John Hart. *Chemical and Biological Warfare: A Comprehensive Survey for the Concerned Citizen*. New York: Copernicus Books, 2002. Addresses the uses of sarin and other nerve agents as weapons.

Ellison, D. Hank. *Handbook of Chemical and Biological Warfare Agents*. 2d ed. Boca Raton, Fla.: CRC Press, 2007. Excellent reference source for information on agents used in chemical and biological warfare, including nerve agents.

Hammond, James W. *Poison Gas: The Myths Versus Reality*. Westport, Conn.: Greenwood Press, 1999. Provides historical information on the original use of poison gas weapons and then discusses the cultural perceptions of chemical weapons and why those conceptions exist.

Hoenig, Steven L. *Compendium of Chemical Warfare Agents*. New York: Springer, 2007. Describes and discusses the use of various agents that may be employed in chemical warfare, including how they can be identified at scenes of release and in the laboratory.

U.S. Army Chemical School. *Potential Military Chemical/Biological Agents and Compounds*. Ft. Leonard Wood, Mo.: Author, 2005. Military field manual provides extensive information on all chemical agents, their deadliness, and recommended treatments for exposure.

See also: Blood agents; Chemical agents; Chemical warfare; Chemical Weapons Convention of 1993; Mustard gas; Nervous system; Poisons and antidotes; Sarin; Soman; Tabun.

Nervous system

Definition: Bodily system that coordinates muscle activity, monitors internal organs, receives and interprets input from sense organs, and initiates actions in response to stimuli.

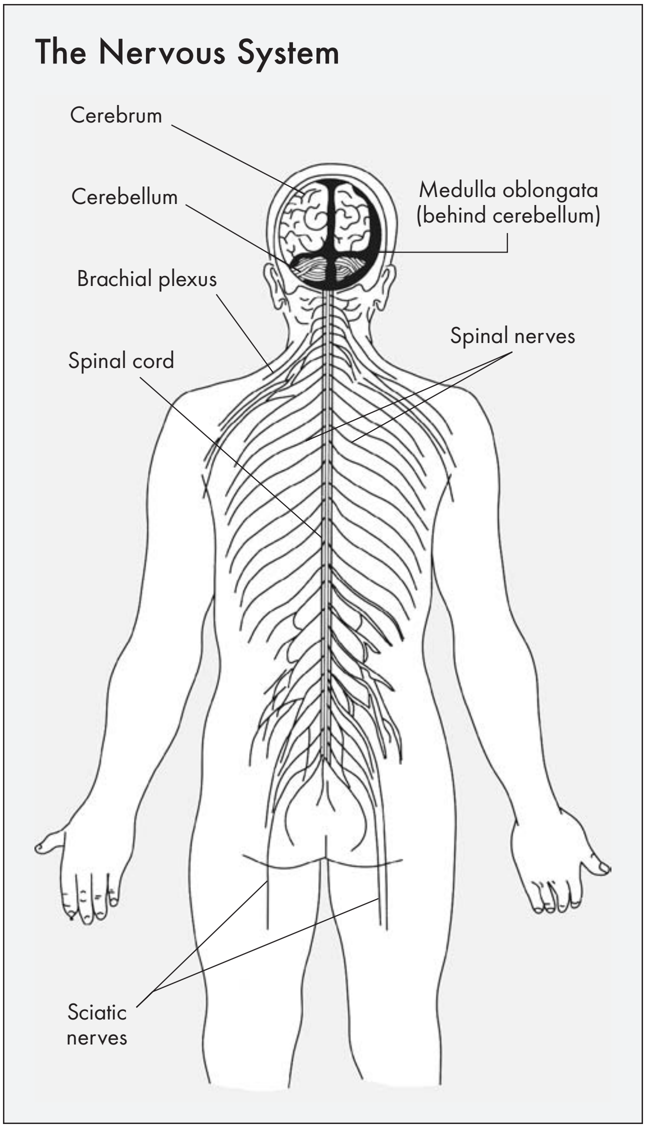
Significance: Information regarding the working of the human nervous system can be an important part of forensic evidence in legal cases involving persons whose mental functions and responses may have been impaired by toxins, including drugs or alcohol.

The basic units of the nervous system are specialized cells called neurons that are able to conduct stimuli. Neurons may be divided into three types: sensory neurons, which conduct sensations into the central nervous system; motor neurons, which conduct stimuli from the central nervous system to effector organs and muscles; and association neurons, which communicate stimuli between adjacent neurons.

Neurons are the only cells in the human body that can conduct stimuli. They exist in an electrical-chemical state that is said to be charged or polarized. When stimulated, the charge on the neuron is momentarily reversed in a process called depolarization or action potential. The action potential (stimulus) is initiated at one end of the neuron, the dendrites, and continues to the other end, the axons, from which neurotransmitters are released into the synapse between the neuron and the next neuron, effector gland, muscle, or organ. Arrival of sufficient quantities of neurotransmitters at the dendrites on the next neuron causes that neuron to exhibit an action potential along its length. In this way the stimulus is transmitted from neuron to neuron or from neuron to muscle.

Three Nervous Systems in One

The human nervous system can be subdivided into the central nervous system, consisting of the brain and spinal cord; the peripheral nervous system, consisting of nerves that carry information to and from the central nervous system; and the autonomic nervous system, which monitors



and maintains internal organs and their functions. The peripheral nervous system contains sensory receptors that respond to information from the external world and the individual's internal environment and sensory neurons that transfer this information to the central nervous system. It also contains motor neurons that carry information from the central nervous system to voluntary muscles, allowing movement. The peripheral nervous system regulates the activities of the body that are under conscious control. It controls all voluntary systems within the body, with the exception of reflex arcs.

The autonomic nervous system monitors and maintains the body's internal state. These maintenance activities are performed primarily without conscious control. The autonomic nervous system comprises two subdivisions with opposing functions: the parasympathetic division and the sympathetic division. Generally, the sympathetic division of the autonomic nervous system works to mobilize body activity to meet emergencies, whereas the parasympathetic division is responsible for maintaining body homeostasis at other times.

The central nervous system—the brain and spinal cord—serves as the main processing center for the entire nervous system and controls all the workings of the body. The brain receives sensory input from the spinal cord as well as from its own nerves. Much of its computational power is used to process various sensory inputs and to initiate appropriate and coordinated motor outputs. The spinal cord conducts sensory information from the peripheral nervous system to the brain and also conducts motor information from the brain to various effectors. Nerve impulses reaching the spinal cord are transmitted to higher brain regions. Signals arising in the motor areas of the brain that control movement and other responses travel down the spinal cord to synapse with motor neurons that deliver the stimulus to an organ or muscle. The spinal cord is also the center for certain reflexes in concert with the peripheral nervous system.

The brain is the ultimate controller of all body activities, including physiology and behavior. The brain is subdivided into a number of distinctive components, each with a specific function. The cortex is where neural integration occurs. Responses involving muscle movement are coordinated with another part of the brain called the cerebellum. Central to the brain is the thalamus, which is the center for pain reception and also serves to relay important incoming stimuli to higher parts of the brain. The hypothalamus is responsible for monitoring and maintaining water and mineral balance and appetite. The hippocampus is involved in memory. The deepest part of the brain, the medulla, controls such vital activities as breathing and heart rate.

Forensic Toxicology and the Nervous System

As the nervous system is ultimately responsible for all behavior, physiological function, and reflexes, an analysis of the forensics of the nervous system can have far-reaching consequences and can raise concerns in a number of areas, including injury and sickness, especially as these may relate to accidents or deaths. Specialists in neuropsychiatry, psychopharmacology, and toxicology thus evaluate the nervous system for evidence in cases of traumatic brain injury, post-traumatic stress disorder, and similar disorders that may follow injury.

Forensic investigations regarding the nervous system generally focus on the types and concentrations of chemicals detected in neurological cells and tissue fluids that surround and protect the nervous system. Using techniques of toxicology, forensic analysts evaluate the possible role of toxins or drugs that may affect or impair the nervous system to determine whether any toxins present are related to the cause of death or bodily injury. Neuropsychologists are concerned with evaluating basic chemicals in the brain and nervous system to determine whether underlying or root causes of neurological or behavioral disorders may have contributed to the crime or accident being investigated.

Dwight G. Smith

Further Reading

DiMaio, Vincent J. M., and Suzanna E. Dana. *Handbook of Forensic Pathology*. 2d ed. Boca Raton, Fla.: CRC Press, 2007. Comprehensive volume illustrates core aspects of modern forensic pathology.

Doerr, Hans O., and Albert S. Carlin, eds. *Forensic Neuropsychology: Legal and Scientific Bases*. New York: Guilford Press, 1991. Provides information on the legal system for neuropsychologists who may become involved in that system through participation as expert witnesses.

Dolinak, David, Evan W. Matshes, and Emma O. Lew. *Forensic Pathology: Principles and Practice*. Burlington, Mass.: Elsevier Academic Press, 2005. Reference volume covers all aspects of forensic pathology. Includes more than eighteen hundred color photographs.

Haines, Duane E. *Fundamental Neuroscience*. 2d ed. New York: Churchill Livingstone, 2002. Offers a thorough compendium of information about the structure and function of the human nervous system.

Kolb, Bryan, and Ian Q. Whishaw. *An Introduction to Brain and Behavior*. 2d ed. New York: Worth, 2005. Correlates brain structure and functions with the behaviors controlled or modified by the brain. Exquisitely written and highly detailed.

See also: Antipsychotics; Barbiturates; Brain-wave scanners; Halcion; Narcotics; Nerve agents; Sarin; Soman; Tabun; Truth serum.

Neuroleptic drugs. *See* Antipsychotics

Nicholas II remains identification

Date: Began in July, 1991

The Event: After the collapse of the Soviet Union in 1991, the remains of nine bodies reported to be those of Czar Nicholas II, members of his family, and retainers were found north of the city of Yekaterinburg, Russia. The family and others had been executed in 1918 by Bolshevik revolutionaries. The Russians gave the bodies a state funeral, but they also took samples from the bodies, which they sent to researchers at the Forensic Science Service laboratory in England and Carnegie Mellon University in the United States for positive identification. Peter Gill of the Forensic Science Service was the lead researcher on the project.

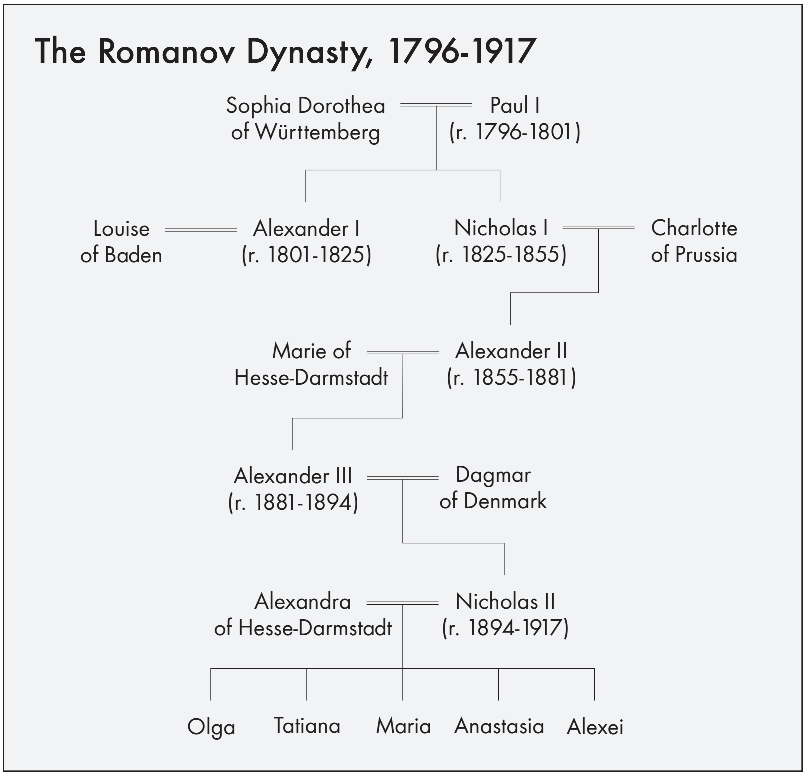
Significance: The positive identification of the body of the last Romanov ruler of Russia had substantial political and emotional meaning for Russian history. There had long been some mystery about the location of the body, and claims that some members of the royal family had escaped death had circulated during the course of the twentieth century. Forensic science was able to establish with certainty that the remains were those of the imperial family.

At the beginning of the Russian Revolution in early 1917, Czar Nicholas II of the Romanov dynasty was forced to abdicate his throne. Nicholas, his wife, Alexandra, and their children (four daughters and a son) were held under guard. After the Bolsheviks seized control of the government at the end of the year, civil war broke out in Russia, and the Bolsheviks moved their royal captives to the distant town of Yekaterinburg.

Vladimir Ilich Lenin, the new head of the Russian government, and other revolutionary leaders were afraid that the royal family would become a rallying point for the White Russian armies fighting against the Bolsheviks. On the morning of July 17, 1918, a group of Bolshevik soldiers herded the royal family as well as the family's physician and three servants into a basement and shot and killed them all.

In 1991, when the Russian government first unearthed the bodies thought to belong to Nich-

Alexei Nikitin, chief of a group of Russian scientists who examined the exhumed bones of the last Russian czar, Nicholas II, his family, their physician, and three servants, lays out the vertebrae of one of the servants in a forensics laboratory in Yekaterinburg in January, 1998. In the foreground are the skulls of the deposed czar and czarina; Nicholas's skull is on the right. *(AP/Wide World Photos)*



olas II and his family members, investigators attempted to establish their identities by generating computer images of the reconstructed skulls and then superimposing these images on photographs of the imperial family. Although the results, as well as the location of the remains, made it seem likely that the last czar had been found, this technique could not establish identification with a high degree of confidence. In addition, only nine bodies were found in the grave; the bodies of two of those executed had not yet been located.

The English and American researchers to whom the Russians sent samples from the bodies used both nuclear DNA (deoxyribonucleic acid) and mitochondrial DNA in their investigations. They began by extracting DNA from the nuclei of cells in bones. Using genetic fingerprinting, they were able to determine the sexes of the persons represented by the remains and to establish that five of the skeletons were from members of the same family.

For more positive identification, they then turned to mitochondrial DNA, which is transmitted only through mothers with almost no change over the course of generations. In particular, the D-loop portion of mitochondrial DNA tends to mutate little over the course of thousands of years. Members of European royal families who shared the maternal ancestry of Nicholas II donated blood samples, and the analysis established a probability of more than 98 percent that the last czar and his family had been located.

In 2007, Russian archaeologists announced that they believed they had found the remains of the two missing children of the imperial family, the Crown Prince Alexei and the Grand Duchess Maria, near the site where Nicholas, Alexandra, and the other three daughters were found. In early 2008, Russian forensic scientists who had performed analyses using teeth, bones, and other fragments from the remains noted that preliminary tests indicated a high degree of probability that the bodies were those of the Romanov children.

Carl L. Bankston III

Further Reading

King, Greg, and Penny Wilson. *The Fate of the Romanovs*. Hoboken, N.J.: John Wiley & Sons, 2003.

Klier, John, and Helen Mingay. *Quest for Anastasia: Solving the Mystery of the Lost Romanovs*. Secaucus, N.J.: Carol, 1997.

Warth, Robert D. *Nicholas II: The Life and Reign of Russia's Last Monarch*. Westport, Conn.: Praeger, 1997.

See also: Anastasia remains identification; Anthropometry; DNA analysis; DNA fingerprinting; Forensic anthropology; Louis XVII remains identification; Mitochondrial DNA analysis and typing; Skeletal analysis.

Night vision devices

Definition: Devices designed to allow operators to see in low light conditions without shining visible lights.

Significance: Using night vision devices, law-enforcement personnel can conduct surveillance at night or in dark indoor spaces without those who are being watched knowing that they are under surveillance. Such devices also benefit police in that they effectively remove the cover of darkness often used to hide criminal activities.

Night vision devices were first developed for military use during World War II, but they were not used extensively until the Vietnam War. Like many other military technologies, night vision equipment eventually found its way into civilian uses, including law enforcement.

Night vision equipment falls into two different technology categories: image intensification and thermal imaging. Image-intensification systems use low levels of visual light or infrared light just beyond the visual range. The heart of this kind of system is an image-intensifier tube. When light enters the tube, it strikes a material that releases electrons. The electrons are then accelerated down the tube, where they run into atoms releasing other electrons in a cascade effect, amplifying the effect of the initial light. The electrons then strike a phosphor screen, causing it to glow. Typically, a green phosphor screen is used because the human eye can differentiate many different levels of green light intensity. Image-intensifier tube technology has improved since it was introduced; light amplification has been increased from a factor of one thousand or less to a factor of more than fifty thousand.

Different types of night vision devices are often classified according to when they were developed and the types of technology they use. Early devices, or Generation 1 devices, amplified light by only a factor of one thousand or so and often required powerful infrared illuminators to light the targets. Generation 2 devices could operate under only moonlight, whereas Generation 3 devices can often operate using only bright starlight. No image-intensification system can operate in complete darkness, however, so many night vision devices come with small infrared illuminators for use when the ambient light level is too low. Most police departments in the United States are equipped with Generation 3 night vision devices.

A separate type of night vision technology uses thermal imaging. In these devices, thermal imaging cameras detect long wavelength infrared radiation. All living creatures give off thermal radiation. The warmer an object is, the more radiation it emits and the shorter the wavelength of the most intense radiation. Be-

A U.S. Air Force pilot tests panoramic night vision goggles. *(U.S. Air Force)* cause thermal imaging night vision systems use light emitted by objects, they can operate in total darkness. Fire departments sometimes use such systems to find people in smoke-filled rooms or to find smoldering hot spots after a fire has been brought under control. However, thermal imaging systems are far more expensive than image-intensification night vision devices, so they are less frequently used by police departments.

Raymond D. Benge, Jr.

Further Reading

Clemens, Candace. "From Starlight to Streetlight." *Law Enforcement Technology* 34 (May, 2007): 26-35.

Peterson, Julie K. *Understanding Surveillance Technologies: Spy Devices, Their Origins, and Applications*. Boca Raton, Fla.: CRC Press, 2001.

See also: Closed-circuit television surveillance; Electronic bugs; Facial recognition technology; Forensic photography; Imaging; Infrared detection devices; Satellite surveillance technology.

9/11. *See* September 11, 2001, victim identification

Nipah virus

Definition: RNA virus of the henipavirus group in the family Paramyxoviridae that causes disease characterized by fever and severe influenza-like symptoms with high mortality in animals and humans.

Significance: Nipah virus is an emerging pathogen of increasing occurrence in deaths of humans and domestic animals. The U.S. Centers for Disease Control and Prevention classifies Nipah virus as a Category C agent, the lowest of three categories of possible bioterrorism agents.

Nipah virus was first discovered in 1998 when domestic pigs in Malaysia experienced an outbreak of disease initiated by fruit-eating bats. Subsequent outbreaks occurred in India and Bangladesh. Outbreaks of the closely related Hendra virus, another henipavirus also spread by fruit bats, have occurred in horses in Australia. All these outbreaks were characterized by transmission from animals to humans, with high mortality. Regions of the world where fruit bats (also called flying foxes) are found include much of South Asia from Madagascar to Australia. These regions can be anticipated as sites of natural outbreaks of Nipah virus and Hendra virus, especially wherever domestic animals are raised in proximity to fruit bats.

Nipah virus is identified by its epidemiology, pathology with high mortality, and laboratory tests on blood and tissue of victims. It can be detected by serological tests that identify antibodies to viral proteins in blood. The virus has also been isolated from patients and grown in cells in culture, then further identified by antibody reactions to surface proteins of the virus and through its ultrastructure as seen in the electron microscope. Nipah virus RNA (ribonucleic acid) is detectable by the reverse transcriptase-polymerase chain reaction (RT-PCR) method. Forensic labs should retain blood and tissue samples from suspected victims of the virus for future tests and should take care to preserve the chain of evidence.

In animals, the symptoms of Nipah virus are mainly respiratory; in humans, symptoms are both respiratory and neurological. In humans symptoms begin as fever and headache, progressing to nausea, vomiting, weakness, coughing, and ultimately to respiratory distress and possibly very high fever and encephalitis. No effective treatment has yet been developed beyond supportive care. The mortality rate for humans who contract Nipah virus is often more than 50 percent. Vaccines have been developed that show promise; tests with hamsters and cats indicate that they offer significant protection from the disease.

Transmission of Nipah virus from fruit bats to animals most likely takes place through exposure to bat saliva, urine, or feces. Transmission to humans is likely from saliva and respiratory exudates in aerosols, with the further possibility of human-to-human transmission.

Outbreaks of Nipah virus infection outside the regions of fruit bat territory may be expected to have different causes, such as exposure to infected meat or to animals shipped from affected regions. One outbreak in humans took place because workers in a Singapore slaughterhouse were exposed to infected pigs from neighboring Malaysia in 1999. Potential exists for other episodes to take place outside the regions where Nipah virus occurs naturally, such as through transmission from travelers exposed during stays in fruit bat territory, through accidents in clinical or research laboratories, or through bioterrorist attacks.

R. L. Bernstein

Further Reading

Anderson, Burt, Herman Freedman, and Mauro Bendinelli, eds. *Microorganisms and Bioterrorism*. New York: Springer, 2006.

Flint, S. J., L. W. Enquist, V. R. Racaniello, and A. M. Skalka. *Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses*. 2d ed. Washington, D.C.: ASM Press, 2004.

Hsu, V. P., et al. "Nipah Virus Encephalitis Reemergence, Bangladesh." *Emerging Infectious Diseases* 10 (December, 2004): 2082-2087.

See also: Antibiotics; Biological terrorism; Biotoxins; Centers for Disease Control and Prevention; Ebola virus; Hantavirus; Hemorrhagic fevers; Smallpox.

Nuclear detection devices

Definition: Instruments used to detect nuclear radiation and to measure its properties.

Significance: Forensic science can aid law-enforcement authorities in the detection of radioactive materials and in establishing the levels of danger such materials present so that appropriate warnings can be disseminated. Given ongoing threats of international terrorism, nuclear detection devices are important tools for locating lost or stolen radioactive materials that might otherwise be used as weapons in some form.

Atomic nuclei emit two types of radiation: ionizing and nonionizing. Alpha particles (two protons and two neutrons bound together, making a helium-4 nucleus), beta particles (high-energy electrons or positrons), and gamma rays (streams of high-energy photons) are ionizing radiation. Each of these particles can knock electrons away from their parent atoms, leaving them ionized. Geiger counters detect such freed electrons, as do detectors made from the semiconductors germanium and silicon.

When electrons recombine with the positive ions, they emit flashes of light (scintillations). A scintillation detector might consist of a large, transparent crystal of sodium iodide that is shielded from outside light and optically coupled to a phototube. The phototube detects and amplifies the scintillation, and then it converts the light flash into an electrical signal. The larger the crystal, the weaker the source that can be detected. Cylindrical crystals 7.6 centimeters (3 inches) in diameter, with associated electronics, can be mounted on a helicopter that then flies low to detect radioactive sources on the ground. Larger detectors can be made from scintillator plastic such as polyvinyl toluene (PVT).

Neutrons are nonionizing radiation, so they must be made to interact with something like helium 3 in such a way that ionizing radiation will be produced. Neutrons are emitted by heavy elements that spontaneously fission, such as plutonium and uranium. Customs agents at points of entry into the United States use portals—two columns, 2 to 4 meters (about 6 to 13 feet) high—containing helium-3 neutron detectors and PVT gamma detectors. People, cars, trucks with shipping containers, and trains pass through such portals, which can detect radioactive isotopes and plutonium, but not highly enriched uranium (HEU). A small number of detector portals are available that can examine targets with X rays or neutron beams;

these can detect HEU. As it is generally thought that terrorists would find it easier to build bombs from HEU than from plutonium, it is particularly important that law-enforcement agencies be able to detect smuggled HEU.

Some detectors, including sodium iodide, germanium, and silicon, can measure the energy of gamma rays. The energy patterns are different for different atoms, so scientists can use the patterns as fingerprints to determine which isotopes are present. Germanium detectors have much finer energy resolution than do sodium iodides, but they must be held at very low temperatures (77 Kelvins, or –321 degrees Fahrenheit). A promising new detector material introduced during the early 1990's, cadmium zinc tellurium (CdZnTe), is a room-temperature superconductor. Improved detector portals will have energy-determining capability and will be able to determine which isotopes are present. A powerful new imaging gamma-ray camera that is under development should be able to spot a weak radioactive source up to 100 meters (328 feet) away.

Charles W. Rogers

Further Reading

Ahmed, Syed Naeem. *Physics and Engineering of Radiation Detection*. San Diego, Calif.: Academic Press, 2007.

Kleinknecht, Konrad. *Detectors for Particle Radiation*. 2d ed. New York: Cambridge University Press, 2001.

Saha, Gopal B. "Instruments for Radiation Detection and Measurement." In *Fundamentals of Nuclear Pharmacy*. 5th ed. New York: Springer, 2004.

See also: Environmental Measurements Laboratory; Nuclear spectroscopy; Radiation damage to tissues; Silkwood/Kerr-McGee case; Spectroscopy.

A detective with the New York City Police Department Counterterrorism Unit uses a radiation-detection device to inspect a truck at a checkpoint near the Holland Tunnel in June, 2007. *(AP/Wide World Photos)*

Nuclear spectroscopy

Definition: Technique for identifying tiny quantities of elements by detecting, recording, and graphically displaying the intensity and energy of their decaying gamma-ray emissions.

Significance: The most sensitive type of spectroscopy, nuclear spectroscopy is a valuable and frequently employed tool in forensic science because it can be used to identify and measure minute amounts of substances that may be undetectable through other techniques.

Nuclear spectroscopy is based on analysis of radiation emitted by unstable atomic nuclei in elements. Gamma decay occurs when unstable atomic nuclei give off excess energy through a spontaneous electromagnetic process. Gamma rays resemble X rays except they come from the nuclei of elements, instead of electrons, and they generally have higher energy than X rays.

Nuclear spectroscopy equipment displays a gamma ray's detection and energy by placing a dot on a monitor screen. If another gamma ray with the same energy is detected, a second dot is placed above the first. Eventually, the monitor displays a graphical image resembling a mountain range on which the vertical height of a peak represents the intensity of gamma rays of that energy and the horizontal position represents the energies of the gamma rays. This graphical mountain range is the gamma-ray spectrum. The positions and relative peak heights differ among different isotopes, and the plotted spectra can be used to identify the isotopes emitting the radiation. Each element has a fixed number of protons in its nucleus; isotopes of the same element all have identical numbers of protons but different numbers of neutrons. The magic of nuclear spectroscopy is that it is more sensitive than almost all other methods of detection. It can detect the presence of an isotope even if it is only a few parts per billion.

If an analyzed sample is not already radioactive, it may be made so through placement in a nuclear reactor, where neutron bombardment can make isotopes in the sample material radioactive. This technique was used in the so-called Beltway Sniper case in late 2002, when ten people were shot to death in the Washington, D.C., area. After several bullet fragments found by investigators underwent neutron activation, nuclear spectroscopy showed that bullets used at different sniping sites probably came from the same source. Eventually, John Allen Muhammad and Lee Boyd Malvo were convicted of the murders.

Another notable example of the application of nuclear spectroscopy to a murder case occurred in Russia. On November 1, 2006, Alexander Litvinenko, a former Russian spy who had been critical of Russian president Vladimir Putin, was poisoned with the radioactive metal polonium 210 in London, England. He died three weeks later from the damage done to his internal organs by alpha radiation. A simple Geiger-counter examination would show that he had ingested some kind of radioactive material and find traces of it in places where he had been. However, the amount necessary to kill Litvinenko—a tiny fraction of a milligram— was too small to be identified by any method other than nuclear spectroscopy. Nuclear spectroscopy was used not only to identify the polonium 210 but also to determine the impurities in the sample taken from Litvinenko's body. The sample was found to be unique to a particular nuclear reactor in Russia. However, Russia denied Britain's request to extradite Andrei Lugovoi, the chief suspect in Litvinenko's murder.

Charles W. Rogers

Further Reading

De Graaf, Robin A. *In Vivo NMR Spectroscopy: Principles and Techniques*. 2d ed. Hoboken, N.J.: John Wiley & Sons, 2007.

Ferguson, Charles D., and William C. Potter. *The Four Faces of Nuclear Terrorism*. New York: Routledge, 2005.

O'Hara, Charles E., and Gregory L. O'Hara. *Fundamentals of Criminal Investigation*. 7th ed. Springfield, Ill.: Charles C Thomas, 2003.

See also: Assassination; Environmental Measurements Laboratory; Nuclear detection devices; Radiation damage to tissues; Spectroscopy.

Number theory. *See* Cryptology and number theory

O

Oblique lighting analysis

Definition: Technique used in examining evidence that involves lighting an object from different angles to enhance the visibility of its surface features.

Significance: Forensic scientists often use the nondestructive imaging technique of oblique lighting analysis in examining many kinds of trace evidence. By viewing evidence samples under indirect angles of lighting, they may be able to detect faint and latent images on them. This technique can be particularly useful in the examination of documents, fingerprints, footprints, and other types of impression evidence.

In oblique lighting analysis, also known as side-light examination, the light source shone on an object is adjusted so that the light strikes the surface of the object being examined at a very low angle, which can enhance the visibility of features on the object's surface. Forensic scientists use oblique lighting to enhance contrast when they are examining questioned documents and many types of impression evidence. When using oblique lighting analysis, the investigator must determine the best angle and shadowing effect to produce the greatest contrast in impression.

In forensic science, one of the main uses of oblique lighting is in the examination of questioned documents. Optical examination using different light sources and lighting conditions, including oblique lighting, is a critical nondestructive first step in examining this type of evidence. Oblique lighting enhances image contrast and provides many clues about a document. An original document may be written on with enough force that handwriting impressions are transferred to any sheet of paper beneath it, resulting in indented writing. Tracing is a widely used method to forge signatures on documents and also results in indented impressions. Such impressions are not readily visible when examined using normal light, but they become apparent when illuminated with oblique lighting.

When light strikes the surface of a document at a very low angle, the result is a grazing illumination, with different amounts of light reflected from shadowed and nonshadowed areas of the document. Shining light at a shallow oblique angle causes the surface of a document to appear three-dimensional, which allows the impressions to be more easily viewed. The enhanced image that results is helpful for detecting many features of the document, such as the presence of indented writing, signs of erasure, imprinting, and other impressions.

Oblique lighting can also be used to analyze other types of impression evidence, such as fingerprints and footwear impressions. Shoe prints, for example, often leave residues on surfaces such as flooring, paper, glass, and plastic. Such latent footwear impressions are difficult to see under standard lighting conditions, but they may be detected and enhanced through the use of oblique lighting. Light shone at a low angle across the surface of interest will reflect off the residues and make the prints easier to see.

C. J. Walsh

Further Reading

Blackledge, Robert D., ed. *Forensic Analysis on the Cutting Edge: New Methods for Trace Evidence Analysis*. Hoboken, N.J.: John Wiley & Sons, 2007.

Ellen, David. *Scientific Examination of Documents: Methods and Techniques*. 3d ed. Boca Raton, Fla.: CRC Press, 2006.

Houck, Max M., and Jay A. Siegel. *Fundamentals of Forensic Science*. Burlington, Mass.: Elsevier Academic Press, 2006.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005.

Koppenhaver, Katherine M. *Forensic Document Examination: Principles and Practice*. Totowa, N.J.: Humana Press, 2007.

See also: Crime scene investigation; Document examination; Forensic photography; Imaging; Lindbergh baby kidnapping; Locard's exchange principle; Microspectrophotometry; Physical evidence; Questioned document analysis; Trace and transfer evidence; Writing instrument analysis.

Oklahoma City bombing

Date: April 19, 1995

The Event: The explosion of a bomb next to the Alfred P. Murrah Federal Building killed 168 people, injured more than 600 others, and launched a massive rescue effort.

Significance: Signaling a dramatic rise in the scale of domestic terrorism, the Oklahoma City bombing prompted one of the largest criminal investigations in U.S. history and prompted new legislation to fight terrorism.

Shortly after 9:00 A.M. on April 19, 1995, a bomb inside a rented van parked on the street next to the Alfred P. Murrah Federal Building in Oklahoma City exploded. Its blast struck the northern face of the office building, leaving one-third of the structure in ruins and much of downtown Oklahoma City devastated. The entire front of the nine-story building collapsed under the force of the blast, and the concussion was felt more than fifty miles away.

According to forensic engineers who reconstructed the blast, the federal office building collapsed easily because of its design. The engineers determined which of the building's support columns failed first and the approximate force with which the blast hit those columns. The blast was estimated to have been equivalent to that of about two tons of TNT. It damaged more than three hundred buildings, overturned nearby cars, and started numerous fires. About 5 percent of the bombing's death toll was caused by flying pieces of window glass alone.

The truck carrying the bomb was later determined to have contained about forty-eight hundred pounds of an explosive mixture of common ammonium nitrate fertilizer and diesel oil, packed into about twenty plastic drums. The mixture was the same compound that Arab terrorists had used in the bombing of the World Trade Center in New York, on February 26, 1993. The mode of delivery was also the same—a parked rental vehicle.

The Investigation

Similarities between the Oklahoma City and World Trade Center bombings made Arab terrorists prime suspects at first. This suspicion was reinforced by the fact that Oklahoma, a major oil-producing state, had strong ties to world oil markets and was well known to Middle Easterners. Early leads in the Oklahoma City investigation also developed in a fashion similar to those that led to the arrest of the Arabs responsible for the World Trade Center bombing. The vehicle carrying the explosives was quickly identified and tracked to the agency that had rented it.

Only one day after the blast, the Federal Bureau of Investigation (FBI) released composite sketches of two men who had rented the van; both were white Americans. Armed with these sketches, FBI agents acted quickly in what would develop into one of the most massive criminal investigations in U.S. history. Eventually, tens of thousands of persons were interviewed and millions of pieces of evidence were collected. One of the suspects identified by the composite drawings was eventually cleared of involvement in the bombing, but the second suspect, Timothy McVeigh, was soon arrested and charged.

As authorities reconstructed events, they determined that the planning of the attack had begun as early as the previous December, when McVeigh and an Army buddy, Michael Fortier, cased the federal building in Oklahoma City. Afterward, the two men raised the money needed to buy the fertilizer used in their bomb by selling firearms at gun shows. Meanwhile, Terry Lynn Nichols, another of McVeigh's Army buddies, apparently helped McVeigh make the bomb.

McVeigh was eventually convicted on eleven federal charges and was sentenced to death on

June 13, 1997; he was executed on June 11, 2001. Terry Nichols was convicted of manslaughter and of conspiracy to use a weapon of mass destruction but was found innocent on the count of actually using the weapon. He was sentenced to life in prison on June 4, 1998. In 2004, an Oklahoma state court found Nichols guilty on 160 counts of murder, but he was spared the death sentence because of a deadlocked jury. In a plea bargain, Fortier testified against both McVeigh and Nichols at their trials, and in 1998 he was sentenced to twelve years in prison and a fine of $200,000 for failing to alert authorities to the impending attack. He served only part of his sentence, however; he was released from prison in January, 2006.

Aftermath

As the Oklahoma City bombing investigation proceeded, there arose a national call for action against domestic and foreign terrorist threats. The bombing demonstrated the vulnerability to terrorism of an open society such as that of the United States. Both citizens and foreign visitors could travel freely throughout the United States and easily obtain the materials needed to make devastating bombs. Within weeks after the bombing, all federal buildings in major U.S. cities were fitted with prefabricated Jersey barriers to prevent similar attacks. Additionally, the federal government ruled that all new government buildings had to be constructed of stronger materials, with truck-resistant barriers, and set back from the street. The U.S. Congress then enacted a number of measures to prevent acts of terrorism, including the Antiterrorism and Effective Death Penalty Act of 1996.

Sheryl L. Van Horne

On the day after the Oklahoma City bombing, an FBI agent examines debris that the blast blew more than a block from the site of the explosion, the Alfred P. Murrah Federal Building. *(AP/Wide World Photos)*

McVeigh States His Reasons

The following is excerpted from a letter that Timothy McVeigh wrote to several media figures and news outlets on April 27, 2001, less than seven weeks before he was executed for his role in the bombing of the Alfred P. Murrah Federal Building.

I chose to bomb a federal building because such an action served more purposes than other options. Foremost, the bombing was a retaliatory strike; a counter attack, for the cumulative raids (and subsequent violence and damage) that federal agents had participated in over the preceding years (including, but not limited to, Waco). From the formation of such units as the FBI's "Hostage Rescue" and other assault teams amongst federal agencies during the '80's; culminating in the Waco incident, federal actions grew increasingly militaristic and violent, to the point where at Waco, our government—like the Chinese—was deploying tanks against its own citizens.

Knowledge of these multiple and ever-more aggressive raids across the country constituted an identifiable pattern of conduct within and by the federal government and amongst its various agencies. For all intents and purposes, federal agents had become "soldiers" . . . and they were escalating their behavior. Therefore, this bombing was also meant as a pre-emptive (or pro-active) strike against these forces and their command and control centers within the federal building. When an aggressor force continually launches attacks from a particular base of operation, it is sound military strategy to take the fight to the enemy.

Bombing the Murrah Federal Building was morally and strategically equivalent to the U.S. hitting a government building in Serbia, Iraq, or other nations. . . . From this perspective, what occurred in Oklahoma City was no different than what Americans rain on the heads of others all the time, and subsequently, my mindset was and is one of clinical detachment.

Further Reading

Brownell, Richard. *The Oklahoma City Bombing*. San Diego, Calif.: Lucent Books, 2007. Discusses the collection of evidence at the bombing site and the forensic techniques used to examine the evidence.

Hansen, Jon. *Oklahoma Rescue*. New York: Ballantine, 1995. Illustrated memoir of an assistant fire chief who was one of Oklahoma's City's pivotal rescue workers.

Hinman, Eve E., and David J. Hammond. *Lessons from the Oklahoma City Bombing: Defensive Design Techniques*. Washington, D.C.: American Society of Civil Engineers, 1996. Brief work addresses the physical characteristics of the Murrah Building that contributed to its becoming a target of a terrorist attack.

Kight, Marsha, comp. *Forever Changed: Remembering Oklahoma City, April 19, 1995*. Amherst, N.Y.: Prometheus Books, 1998. Collection of essays includes testimony of survivors of the bombing and recollections of friends and family members of those who died. Kight lost her twenty-three-year-old daughter in the bombing.

Linenthal, Edward T. *The Unfinished Bombing: Oklahoma City in American Memory*. New York: Oxford University Press, 2001. Examines the psychological impact on Americans of terrorist bombings and the effect of the Oklahoma City tragedy on the relatives of its victims.

Roleff, Tamara L., ed. *The Oklahoma City Bombing*. Detroit: Thomson/Gale, 2004. Collection of speeches, court documents, and interviews with eyewitnesses presents information on the planning, implementation, and aftereffects of the bombing.

Serrano, Richard A. *One of Ours: Timothy McVeigh and the Oklahoma City Bombing*. New York: W. W. Norton, 1998. Journalist's account focuses on McVeigh's background and role in the bombing.

See also: Blast seat; Bomb damage assessment; Bombings; Bureau of Alcohol, Tobacco, Firearms and Explosives; Driving injuries; Federal Bureau of Investigation; First responders; Improvised explosive devices; Structural analysis; Unabomber case; World Trade Center bombing.

Opioids

Definition: Natural substances derived from opium poppies and synthetic and semisynthetic substances that have properties similar to those derived from opium, generally used for pain relief in medical settings and also as drugs of abuse.

Significance: Opioids are important medicinal drugs for the management of pain, but they are also substances of abuse. Even when opioids are prescribed, users can develop problems such as drug dependence. Because of the addictive nature of opioids, these substances are widely bought and sold illegally.

"Opiate" is the term used to refer to naturally occurring compounds derived from the opium poppy, such as codeine, morphine, and opium. In contrast, "opioid" is a broader, more inclusive term used to describe both naturally occurring and synthetic or semisynthetic opiates. Examples of the latter include heroin, hydromorphone, and oxycodone.

Uses and Effects

Opioids are generally considered narcotics, both in name and legally. Functionally, narcotics are drugs that numb the senses, promote sleep, and elicit stupor. Clinically they are prescribed for analgesia—that is, to reduce pain. The ability of opioids to reduce pain is pronounced, so for individuals who need to manage chronic pain, these drugs can be of significant help. For individuals with careers that may expose them to chronic pain, such as athletes, opioids may also be akin to performance-enhancing drugs, such as steroids and stimulants. Similarly, for soldiers on the battlefield opioids may be a godsend, but if misused, these substances may be a source of danger to fellow soldiers and others. Given the potential dangers of these drugs, the forensic issues around opioids extend to the identification and regulation of their appropriate use in certain professional arenas, such as is achieved through drug testing.

In addition to analgesia, opioids may induce other changes, including initial warm flushing of the skin, a rush of feelings in the abdomen, and changes in mood. Other effects include constipation (as these drugs slow peristaltic muscle movement in the colon), decrease in rate of respiration, drowsiness, and euphoria. Opioids are also known to cause depression of the central nervous system and the heart (such as in overdoses).

Common routes of administration for these drugs are oral (ingested as pills), nasal (through snorting), inhalation (through smoking), and injection. Individuals may also take these drugs in other ways, such as subdermally and anally, but these are less common. Perhaps the greatest complications associated with these drugs are those that come with injection use among individuals using street drugs. For users who do

Opium poppies. *(© iStockphoto.com/Stephanie Horrocks)* not have access to clean means of injection, shared or improperly cleaned needles can lead to problems such as abscesses and the contraction of flesh-eating diseases, hepatitis C, and human immunodeficiency virus (HIV), which causes acquired immunodeficiency syndrome (AIDS). Other problems may result from overdose (using more of the drug than the body can tolerate) and from the use of drugs that are mixed with other substances that may not be good for the body (such as contaminants or materials used to dilute or artificially extend the perceived quantity of the drug).

Scope of Heroin Use

A 2005 research report from the National Institute on Drug Abuse (NIDA) provides this information on heroin use in the United States.

According to the 2003 National Survey on Drug Use and Health, which may actually underestimate illicit opiate (heroin) use, an estimated 3.7 million people had used heroin at some time in their lives, and over 119,000 of them reported using it within the month preceding the survey. An estimated 314,000 Americans used heroin in the past year, and the group that represented the highest number of those users were twenty-six or older. The survey reported that, from 1995 through 2002, the annual number of new heroin users ranged from 121,000 to 164,000. During this period, most new users were age eighteen or older (on average, 75 percent) and most were male. In 2003, 57.4 percent of past-year heroin users were classified with dependence on or abuse of heroin, and an estimated 281,000 persons received treatment for heroin abuse.

According to the Monitoring the Future survey, NIDA's nationwide annual survey of drug use among the nation's eighth-, tenth-, and twelfth-graders, heroin use remained stable from 2003 to 2004. Lifetime heroin use measured 1.6 percent among eighth-graders and 1.5 percent among tenth- and twelfth-graders.

The Drug Abuse Warning Network, which collects data on drug-related hospital emergency department (ED) episodes from twenty-one metropolitan areas, reported that in 2002, heroin-related ED episodes numbered 93,519.

Substance Abuse, Dependence, and Criminal Behavior

Opioids may cause the conditions of substance abuse and substance dependence. As defined in the *Diagnostic and Statistical Manual of Mental Disorders*, fourth edition, text revision (*DSM-IV-TR*), substance abuse is use of a substance to such a degree that it leads to repeated problems at work, home, or school; repeated legal problems; repeated use of the substance in dangerous situations; or repeated interpersonal problems related to the consequences of the substance use. In contrast, substance dependence is characterized by the following: the need to use more of the drug to get the same effect or getting less effect from the same amount of the drug (tolerance); the experience of symptoms when the user ceases or significantly cuts back on use of the drug (withdrawal); use of the drug more often or in greater quantities than intended; unsuccessful attempts to quit or persistent desire to quit; significant time spent obtaining, using, or recovering from the drug; reduction of other meaningful activities in order to use the drug; and the causing or exacerbation of other psychological or physical problems. These symptoms are significant and speak to the motivation that users of illicit or even prescribed opioids may feel to secure their drug supplies, whatever the means or consequences.

Those who use street opioids may also experience malnutrition and pronounced weight loss because the drugs tend to be so powerful that users fail to pay attention to hunger or to be motivated enough to eat. Often, chronic users of opioids ignore all other activities except what they need to do to obtain and use the drugs. In some cases, they engage in criminal behavior to secure the drugs. This may range from dealing drugs, so that they can maintain access to an adequate supply, to theft and other crimes (including prostitution) that can provide them with resources to buy drugs.

Opioid dependency can also occur among persons who begin using the drugs under their doctors' care. Sometimes such users will work very hard to build up networks of doctors and other outlets where they can gain access to the drugs. Some may spend entire days going from doctor to doctor to procure the supplies of drugs they need. This may lead them to commit fraud and misrepresentation to doctors, prescription forgery, and theft and other crimes to secure the drugs. In some cases, prescribing doctors may be involved in significant violations of the law related to drug diversion.

Dangers and the Drug Trade

When opioid-dependent users cannot get enough of their preferred drugs, they frequently mix these substances with alcohol, other prescription or illicit drugs, and even herbal remedies and over-the-counter drugs. This practice can be very dangerous, as mixing opioids with barbiturates, alcohol, and other drugs that act as depressants on the body can cause synergistic effects that can detrimentally affect the body's basic ability to function. Synergistic effects make the impact of the drugs together greater than the impact any of the drugs would have individually. With opioids, this can often lead to respiratory distress or cardiac distress. These reactions may be magnified in persons whose health is compromised by other problems.

Given the broad medical value of opioids and the abuse potential of these substances, it is no surprise that a significant black market exists for their manufacture, distribution, and sale. The illicit trade in opioids ranges from the manufacture of illegal, unregulated supplies in small clandestine laboratories to the large-scale manufacture of look-alike drugs (some of which may fall into the hands of non-substance-abusing consumers), to the theft or diversion of legal drug supplies from their intended points of distribution. The legal and illegal uses of opioids thus pose significant challenges for government authorities, who must balance the protection of appropriate medical uses of these substances against the need to address drug-related crimes such as theft, prostitution, forgery, fraud, assault, and murder.

Nancy A. Piotrowski

Further Reading

Harris, Nancy, ed. *The History of Drugs: Opiates*. Farmington Hills, Mich.: Greenhaven Press, 2005. Provides a historical perspective on opioids, including how they have been used and the political and social issues they have stirred over time.

Julien, Robert M. *A Primer of Drug Action: A Comprehensive Guide to the Actions, Uses, and Side Effects of Psychoactive Drugs*. 10th ed. New York: Worth, 2005. Reliable, longstanding text presents information regarding how these drugs affect individuals at various stages of the life span, from youth to old age.

Moraes, Debra, and Francis Moraes. *The Little Book of Opium*. Oakland, Calif.: Ronin, 2003. Easy-to-read book provides a hodgepodge of information about myths and facts related to opium, its history, chemistry, and effects.

Robbins, David. *Heavy Traffic: Thirty Years of Headlines and Major Ops from the Case Files of the DEA*. New York: Chamberlain Bros., 2005. Chronicles the varied activities of the U.S. Drug Enforcement Administration.

Strain, Eric C., and Maxine L. Stitzer. *The Treatment of Opioid Dependence*. 2d ed. Baltimore: The Johns Hopkins University Press, 2005. Presents a well-informed perspective on how to treat opioid dependence. Suitable for a broad audience, including students, family members of opioid-dependent drug users, and practitioners.

Weil, Andrew, and Winifred Rosen. *From Chocolate to Morphine: Everything You Need to Know About Mind-Altering Drugs*. Rev. ed. Boston: Houghton Mifflin, 2004. Presents a down-to-earth discussion of drugs that affect the mind. Easy to read.

See also: Antianxiety agents; Barbiturates; *Diagnostic and Statistical Manual of Mental Disorders*; Drug abuse and dependence; Drug classification; Illicit substances; Narcotics; Performance-enhancing drugs; Psychotropic drugs.

Oral autopsy

Definition: Examination of the mouth and teeth of a deceased person, usually for the purpose of establishing the person's identity.

Significance: In cases of multiple deaths in disasters such as hurricanes or airplane crashes, oral autopsies are important for establishing the identities of the deceased. This procedure is also used in individual cases when bodies are so decomposed or badly burned that little remains except bones and teeth.

Comparison of the dental characteristics of a deceased person with antemortem (before death) dental records of a known person is an accepted method of identification when it is not possible for investigators to rely on other methods, such as identification by a person familiar with the deceased, fingerprinting, or DNA (deoxyribonucleic acid) analysis. Oral autopsies serve as the primary means of identification in three general kinds of situations: when a body is burned beyond recognition, when a body is severely decomposed or skeletonized, and when multiple bodies must be identified following mass disasters in which people died violently.

Dentists trained in forensic pathology perform oral autopsies. This field is also called forensic odontology. In the United States, the American Board of Forensic Odontology has established guidelines to standardize the procedures of the oral autopsy and to ensure that oral autopsies yield the maximum possible amount of information and properly preserved evidence.

Procedure

The oral autopsy is usually performed after any standard autopsy procedures have been completed, because the oral autopsy destroys facial tissue. The first steps in an oral autopsy are visual examination, photographing, and X-raying of the exterior jaw and mouth area. Next, the mouth is opened. In some cases, the forensic dentist can open the mouth manually, but in many cases, rigor mortis, carbonization (burning), or fragmentation of the body makes it necessary to gain access to the oral cavity by dissection. The jaw may be broken with a mallet and chisel or cut with pruning shears or a bone saw, or the dentist may expose the interior of the mouth by dissecting away the facial muscles. Interior photographs and X rays are then taken.

The forensic dentist next makes a dental chart, using a numbering system to record the presence or absence of each of the thirty-two teeth an adult usually has; the dentist notes whether each tooth is a primary (baby) tooth or a permanent tooth. For each tooth, any unusual features (such as chips) and dental work (such as fillings and crowns) are noted. The presence of dental prostheses (such as bridges) or orthodontic appliances (such as braces) is also recorded. If the body is not badly damaged, the dentist also records information about the soft tissue of the mouth. The dental chart is supplemented with a narrative record of what the dentist sees. Depending on the condition of the body, the dentist may also make a permanent cast of the teeth using a material called dental stone.

From the condition of the teeth, it is possible to estimate the age of the deceased. The types of materials used in crowns and fillings and the styles of such dental work provide clues to the country or region where the deceased lived when the dental work was done and may possibly also indicate socioeconomic status. This gives law-enforcement investigators some guidance regarding the best places to look for antemortem dental records for the individual. In the United States, investigators might seek dental records from a number of sources, including personal dentists, dental schools and clinics, dental insurance companies, the National Crime Information Center (a database maintained by the Federal Bureau of Investigation), and the Military Personnel Records Center.

After antemortem records are found for the person suspected to be the deceased, the forensic dentist compares the information gathered in the oral autopsy with the dental work detailed in the antemortem records. Based on this comparison, the records are declared a positive match, a possible match, or a definite nonmatch to the deceased, or the dentist states that too little information is available on which to base a conclusion.

It may be weeks or months following the oral autopsy before dental records are found for comparison. For this reason, the forensic dentist must make excellent notes and casts, because the body may no longer be available for examination by the time antemortem dental records are in hand.

Possible Complications

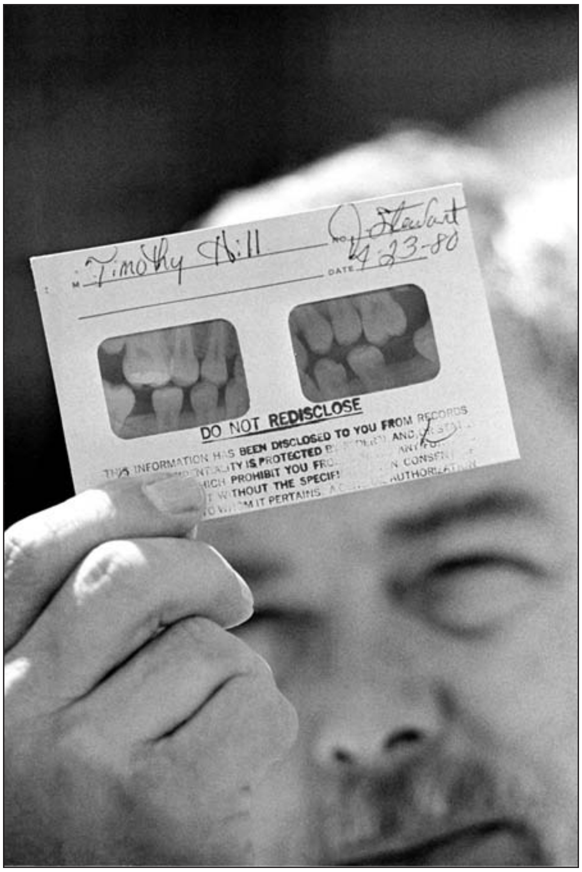
The teeth tend to withstand burning and trauma better than many other parts of the body. Nevertheless, some situations can complicate identification by oral autopsy. When a body is burned beyond recognition (carbonized), the teeth may remain intact but become very fragile. In addition, before the dentist can complete a dental chart and cast, the teeth must be cleaned with an enzyme solution, which is likely to make them even more fragile.

In mass disasters such as airplane crashes and bombings, the bodies of victims are apt to be fragmented. During the oral autopsy, the dentist may have to work with incomplete or misleading information. For example, if the jaw is splintered at the time of death, teeth may be missing that were present during life. The forensic team must collect all body fragments and determine to which set of remains each fragment belongs if complete dental records are to be made for individual victims.

Another kind of complication can arise because multiple systems are used worldwide to number teeth. When forensic dentists in the United States are working with dental records from other countries, they must be familiar with those countries' numbering and nomenclature systems to make valid comparisons.

Sometimes antemortem dental records are simply unavailable, and sometimes those that do exist are incomplete or indecipherable. One advantage of an oral autopsy is that dental casts and notes can be stored easily and do not decompose. They remain readily available should a possible match in dental records turn up years later.

Martiscia Davidson



An associate medical examiner in Fulton County, Georgia, displays a set of dental X rays used to help identify the body of a child as that of a thirteen-year-old boy who had gone missing a few weeks earlier. The boy was one of the victims in what became known as the Atlanta child murders. *(AP/Wide World Photos)*

Further Reading

Bowers, C. Michael. *Forensic Dental Evidence: An Investigator's Handbook*. San Diego, Calif.: Elsevier Academic Press, 2004. Outlines the basics of forensic dentistry for law-enforcement personnel and others who must handle and understand dental evidence but who are not dentists.

Fairgrieve, Scott I. *Forensic Cremation: Recovery and Analysis*. Boca Raton, Fla.: CRC Press, 2008. Examines the effects of fire on human tissue, paying special attention to the use of DNA and dental remains as means of reconstructing crimes and making identifications.

Redsicker, David R., and John J. O'Connor. *Practical Fire and Arson Investigation*. 2d ed. Boca Raton, Fla.: CRC Press, 1997. Thoroughly covers all aspects of fire investigations, with an emphasis on fires that cause deaths.

Saferstein, Richard. *Forensic Science: An Introduction*. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007. Provides a general introduction to forensic laboratory work.

See also: Autopsies; Bite-mark analysis; Decomposition of bodies; Forensic odontology; Mass graves; Saliva; September 11, 2001, victim identification.

Orthotolidine

Definition: Chemical used in presumptive tests for blood at crime scenes.

Significance: A positive reaction to orthotolidine of a stain found at a crime scene suggests that the stain is probably blood; such information can facilitate an initial reconstruction of a crime and prompt follow-up.

In the presence of heme iron and hydrogen peroxide, orthotolidine, clear in the reduced state, is converted to an oxidized state, which is blue. Because heme iron is present in hemoglobin, the protein that carries oxygen in red blood cells, a positive test can indicate the presence of blood. Such a test does not distinguish between human blood and animal blood, however; further testing is necessary to make that distinction and, if the blood is human, to determine whose blood it is. In addition, constituents of some plants, such as potatoes and horseradish, as well as oxidizing agents found in some cleansers, can catalyze the reaction. Accordingly, an orthotolidine test is only presumptive for blood; a positive result must be confirmed by laboratory tests.

Typically, a forensic investigator performs the test by moistening a cotton swab with deionized water and rubbing the swab on the suspect stain, adding a drop of orthotolidine solution to the swab, waiting thirty seconds, and then adding a drop of 3 percent hydrogen peroxide to the swab. A positive reaction will turn the swab an intense blue color within fifteen seconds. Often, a swab taken near the stain of interest is used as a control. If the swab turns pinkish before the hydrogen peroxide is added, the test is invalid. To ensure that the reagents have not deteriorated before use, the investigator validates the test using a known blood standard.

First introduced in 1912, orthotolidine, also known as o-tolidine, became almost as widely used as benzidine for testing suspected blood. It has a high sensitivity and is quite specific. It is less carcinogenic than benzidine but more so than phenolphthalein (also used for testing suspected blood), and it poses some risk to users. This risk has been minimized with the introduction of a product marketed as Hemastix: orthotolidine-impregnated sticks designed for use by medical professionals who need to identify the presence of blood in urine. Hemastix can also be used at crime scenes: A drop of deionized water is placed on the stain to be tested, and that drop is transferred to the stick. A resulting blue color suggests the presence of blood. Aside from the convenience this product offers, it allows the investigator to avoid direct contact with orthotolidine. However, whereas the standard orthotolidine test does not interfere with subsequent blood typing and DNA typing, the results of one study suggest that samples collected using Hemastix may interfere with some automated DNA testing procedures.

James L. Robinson

Further Reading

Geberth, Vernon J. *Practical Homicide Investigation: Tactics, Procedures, and Forensic Techniques*. 4th ed. Boca Raton, Fla.: CRC Press, 2006.

Lee, Henry C., Timothy Palmbach, and Marilyn T. Miller. *Henry Lee's Crime Scene Handbook*. San Diego, Calif.: Academic Press, 2001.

Nickell, Joe, and John F. Fischer. *Crime Science: Methods of Forensic Detection*. Lexington: University Press of Kentucky, 1999.

See also: Benzidine; DNA typing; Luminol; Phenolphthalein; Presumptive tests for blood; Reagents; Serology.

Osteology and skeletal radiology

Definition: Subdiscipline of physical anthropology specializing in the scientific study of bone and bony anatomy.

Significance: When remains are discovered that are decomposed, skeletonized, or otherwise unrecognizable, osteology and radiology are used to determine whether the remains are human and how many individuals are represented. Osteological examination may further enable identification of the person or persons and the possible manner of death.

Bone is connective tissue that comprises both organic (living bone cells) and inorganic (mineral) components. Bones provide support for the body's locomotion and other movement, protection of the vital organs, and regulation of bodily substances (such as calcium). Osteologists study the growth, development, morphology, and functions of bone, as well as the pathologies that affect it, in order to understand the human skeletal system.

Origins of the Field

In 1897, George A. Dorsey became the first anthropologist to apply a knowledge of osteology toward expert testimony in a criminal trial—the infamous Luetgert sausage factory trial in Chicago. Dorsey testified that he had identified four small fragments of human bone (believed to be the bones of the wife of factory owner Adolph Luetgert) found in a sausage vat in Luetgert's factory. Luetgert was convicted of the murder of his wife and sentenced to prison, where he died shortly thereafter.

Forensic anthropologist Wilton Marion Krogman illustrated the importance of osteology to law enforcement in his seminal 1939 work "A Guide to the Identification of Human Skeletal Material," which appeared in the *FBI Law Enforcement Bulletin*. World War II, the Korean War, and the Vietnam War saw the regular application of osteology toward the identification and repatriation of the remains of U.S. soldiers. In the twenty-first century, forensic anthropologists routinely use osteology and radiology in the identification of decomposed or unrecognizable human remains and the interpretation of the events preceding, surrounding, and postdating deaths in situations involving both individual and multiple fatalities.

Identifying Human Bones

The first question in a forensic investigation of decomposed, skeletonized, or otherwise unrecognizable animal remains is whether the remains are human. Osteologists answer this question by applying their detailed knowledge of human bony fragments. Such an assessment can often be made visually through comparison of the remains with known human ones in terms of size, shape, density, and significant bony features. Radiographic and microscopic comparisons may be needed, focusing on bone density, trabecular (spongy) bone patterns, and microscopic structures of human versus animal bone.

After remains are confirmed as human, osteologists assess the number of individuals represented by the remains. This can be accomplished through a variety of methods, one of which is the principle known as the minimum number of individuals (MNI), a conservative estimate of the smallest number of persons the remains could represent. MNI is assessed through the documentation of duplication of bony elements (for example, the presence of two right femurs, or thighbones, equals the presence of at least two individuals) as well as differences in age, sex, ancestry, stature, size, shape, coloration, and overall morphology of the bony fragments.

Individuating Remains

The primary applications of osteology and skeletal radiology to forensic science are toward individuation of human remains and reconstruction of perimortem events—that is, the events around the time of death. Individuation is ac-

Dr. Heather Walsh-Haney (far right), a forensic anthropologist, teaches a class in human osteology at Florida Gulf Coast University in August, 2007. *(Ronna Gradus/MCT/Landov)*

complished in a variety of ways, the most basic of which is determination of a biological profile for the remains. Such a profile, which is derived from detailed analysis of the recovered remains, comprises the individual's age at death, sex, ancestry, and stature. For example, age at death for a child may be determined through analysis of the growth of long bones and dental eruption, whereas for an adult the osteologist may consider dental wear and degeneration of significant bony regions (such as pubic symphysis) and joints (osteoarthritis). Sex of the remains is established through consideration of the morphology and metrics of major long bones, pelvis, and cranium, if present, and stature is mathematically derived from the maximum length of a long bone. Ancestry is suggested by morphological and metric features of the mid and lower face.

Tentative identification may be based on a comparison of the biological profile of a set of remains with the biological profile of a missing individual or potential victim. A more confident (in some cases, positive) identification can be derived from a comparison of unique antemortem (before death) anomalies and pathologies observed on the remains to those from a suspected identity. These might include prior healed fractures, unique anomalies, or identifying pathological conditions.

Discovery of such anomalies and pathologies is often accelerated through the use of forensic radiology—that is, the application of radiological imaging to a legal context. This can involve traditional radiology (X rays), computed tomography (CT or CAT scans), or magnetic resonance imaging (MRI). One of the most common methods of obtaining positive identifications of remains involves antemortem and postmortem comparisons of radiographic images of teeth; forensic odontologists focus on patterns of missing and filled teeth as well as unique dental traits in applying this method.

In the absence of dental comparisons, frontal sinus patterns can be used. Frontal sinus patterns are believed to be similar to human fingerprints in that each person's sinus "print" is unique. Radiographic comparisons of antemortem and postmortem frontal sinus morphology—including area size, bilateral symmetry, and superior margin outline—have been admissible in court cases to confirm identification. Comparisons of other sinuses (of the maxilla, ethmoid, sphenoid, and mastoid process) have also been used.

Remains may also be identified based on the exact placement of orthopedic and other surgical devices (such as surgical plates, screws, rods); in addition, such devices sometimes carry identifying serial numbers. The presence of pathological (disease) states (such as osteoporosis or osteoarthritis) can be helpful for identification in terms of their level of severity and location within the body, if medically documented. Morphology of trabecular bone patterns within the postcranium has also been used in identification. Trabecular bone is found in the ends of long bones and is characterized by a complex crisscross pattern that may be unique for every individual. Finally, comparisons of multiple and unique concordant bony anomalies (such as an extra rib) may offer supportive evidence for a positive identification.

Interpreting Trauma at Time of Death

A second important application of forensic osteology and skeletal radiology is the interpretation of perimortem trauma. Evidence for blunt force, sharp force, and gunshot wound trauma is often (but not always) visible in characteristic signatures on bone. Such signatures include gunshot entrance and exit defects, impact fractures, radiating and concentric fractures, and cut marks. Osteologists can assess the number of traumatic events (such as gunshot, blunt force, or sharp force wounds), the directionality and trajectories of the events, and sometimes the sequence of impacts (if multiple), often with the help of forensic radiology. These interpretations can be applied toward assessment of the individual's manner of death.

Osteologists must be cautious when interpreting and comparing antemortem and postmortem radiographs to avoid possible sources of error. For example, the body positions of postmortem radiographs must match those from antemortem sources. Other technical difficulties may arise from the level of detail captured in the radiographs as well as the level of skill of the technician in reading them. Bone remodeling over many years may eliminate many potentially concordant details (for example, evidence of healed fractures may fade over several decades and may not be visible on radiographs). Finally, locating antemortem radiographs may be difficult—without comparative antemortem radiographs of appropriate bony regions, a positive identification based on forensic osteology and radiology may not be possible.

Donna C. Boyd

Further Reading

Bass, William M. *Human Osteology: A Laboratory and Field Manual*. 5th ed. Columbia: Missouri Archaeological Society, 2005. Classic guide to human osteology discusses bone identification and completion of a biological profile for skeletonized remains.

Brogdon, B. G., ed. *Forensic Radiology*. Boca Raton, Fla.: CRC Press, 1998. Focuses on the interpretation of radiographic images in courts of law and the applications of radiology in forensic science.

Klepinger, Linda L. *Fundamentals of Forensic Anthropology*. Hoboken, N.J.: John Wiley & Sons, 2006. Introduces methods of estimating age, sex, ancestry, and stature based on skeletal remains and discusses skeletal markers of activity and life history.

Komar, Debra A., and Jane E. Buikstra. *Forensic Anthropology: Contemporary Theory and Practice*. New York: Oxford University Press, 2008. Basic forensic anthropology text includes a section on personal identification through radiological as well as other means.

Matshes, Evan, et al. *Human Osteology and Skeletal Radiology: An Atlas and Guide*. Boca Raton, Fla.: CRC Press, 2005. User-friendly volume intended as a field guide presents comparative images of bones in photographic and radiographic form and addresses the differences among adult, juvenile, and fetal bones.

Schwartz, Jeffrey H. *Skeleton Keys: An Introduction to Human Skeletal Morphology, Development, and Analysis*. 2d ed. New York: Oxford University Press, 2007. Osteology text focuses on human development and individual variation.

White, Tim D., and Pieter A. Folkens. *The Human Bone Manual*. Burlington, Mass.: Elsevier Academic Press, 2005. Handy and portable osteology manual provides detailed photographs of human bony anatomy. Designed for use in the field by anthropologists, forensic scientists, and researchers.

_______. *Human Osteology*. 2d ed. San Diego, Calif.: Academic Press, 2000. Textbook presents detailed discussion of human bony anatomy accompanied by hundreds of high-quality photographs.

See also: Anthropometry; Body farms; Forensic anthropology; Forensic archaeology; Forensic pathology; Forensic sculpture; Imaging; Sex determination of remains; Sinus prints; Skeletal analysis.

P

Paint

Definition: Substance that is spread over surfaces and dries to leave a thin decorative or protective coating.

Significance: Paint is present on a multitude of surfaces in many environments. If a painted surface is damaged during the commission of a crime, paint may be transferred from that surface onto the victim, the offender, or other persons or objects present. Forensic scientists most commonly encounter paint evidence in motor vehicle hit-and-run cases and in burglary cases.

The quantity of paint that is transferred in any particular incident in which a painted surface is damaged depends on the force of contact, the area of contact, and the paint's characteristics, such as its softness and state of deterioration. In hit-and-run cases, where a vehicle has struck a person or another vehicle, a large amount of paint may be transferred, especially if a number of the striking vehicle's panels have been damaged. In contrast, only a small amount of paint is likely to be transferred to a tool when it is used to pry open a window during a burglary.

Composition and Types

Different kinds of paint consist of mixtures of a number of different chemical compounds. Paint can broadly be described as being composed of pigment, binder (also called vehicle or resin), solvent, and other additives. The pigment imparts the color and opacity (hiding power) to the paint. The binder, usually a polymeric compound, provides the medium to spread the pigment across surfaces. The solvent, which may be either organic or water-based, is designed to evaporate after the paint has been applied to the surface, leaving the dried paint film. A range of additives can be included in the formulation of paints, depending on the paints' intended uses; these can include plasticizers, driers, and mildew-resistant agents.

Most of the work of forensic scientists in relation to paint evidence involves the comparison of either automotive paint or architectural paint, although other types of specialized paint, such as marine paint or art paint, are sometimes encountered. When an automobile is manufactured, its finishing system usually consists of four layers of paint, called the original manufacturer's paint. First, the electrocoat primer layer is applied directly to the metal of the car body to provide corrosion resistance. This layer is usually black or gray. The primer layer is then applied. The purpose of this layer is to provide a smooth surface for the base-coat application. The base-coat layer imparts the color and appearance to the final product and provides resistance to environmental conditions, such as weather and ultraviolet radiation. The base coat may contain additives to affect the final look of the paint; for example, aluminum flakes give a metallic finish, and mica pigments coated with metal oxide produce interference colors. Finally, a clear-coat layer is applied to protect the base-coat layer and add a glossy appearance to the paint.

In contrast to automotive paint, architectural paint is not applied in any set sequence of paint layers. The choices of paints used on building interiors and exteriors are usually made by individuals and may include varying numbers of base- and top-coat layers. The walls of older buildings may be coated with large numbers of paint layers, reflecting the many times they have been repainted.

Depending on the cost and availability of individual components, paint manufacturers may alter the ingredients they add to their products at different times while still ensuring that the paint meets strict quality-control requirements. Such differences in batch formulation can provide forensic scientists with additional points of discrimination as they make paint comparisons.

Comparison of Paint Samples

The first step in the forensic examination of any paint evidence is a visual comparison between the paint sample recovered from the crime scene and a control sample. This comparison, often aided by a microscope, involves analysis of the color and texture of each layer of paint. Inspection of the sequence of paint layers present is extremely important for evaluating the evidential significance of any match.

For automotive paints, the examiner should be able to establish whether the paint is the original manufacturer's paint or whether additional layers of paint have subsequently been added. The presence of additional paint layers means that the sample of paint, and therefore the vehicle from which it came, is likely to be distinguishable from other vehicles of the same model made by the same manufacturer.

For architectural paints, an assessment of the commonness of the color and type of paint present is required. Thousands of different paint colors are available, and new colors are continually being marketed as fashions change. No set number of paint layers must be matched between samples for the examiner to determine a conclusive match, but matches that include the presence of uncommon paint colors or large numbers of corresponding layers are considered to be of higher evidential value.

The comparison of the visual appearance of paint samples can be complicated if the recovered sample is present only as a paint smear. Smears are frequently encountered on the clothing of hit-and-run victims and on tools used to pry open painted windows or doors during the commission of burglaries. The color of a paint smear may be altered slightly because of the influence of the substrate color or because a number of different paint layers have been crushed together.

If two samples of paint cannot be differentiated after a visual examination, the examiner's next step is to compare the chemical compositions of the paint layers. As most paints contain mixtures of organic and inorganic compounds, the instrumental techniques used must be able to detect the full range of compounds present. In addition, each layer should be analyzed separately, if possible. For some techniques, this means that the examiner must section the paint, either by hand or using a microtome.

Pyrolysis gas chromatography (PyGC) is frequently used to compare the organic compounds present in the paint layers. This technique is particularly suited to the analysis of polymers, as the heat present in the pyrolyzer decomposes the polymer into smaller oligomers that are able to be chromatographed. Fourier transform infrared (FTIR) spectroscopy can also be used to compare the major organic compounds present and some of the inorganic compounds present (such as titanium dioxide).

The examiner may use a variety of techniques to compare the inorganic compounds present in each paint layer, such as X-ray fluorescence (XRF) and scanning electron microscopy with energy-dispersive spectroscopy (SEM-EDS). SEM-EDS has the added advantage of allowing a visual examination of each layer at a very high magnification. This can reveal the presence of additives such as aluminum flakes.

The PDQ Database

The Forensic Laboratory Services of the Royal Canadian Mounted Police maintains one of the world's largest databases of information on the colors and chemical compositions of the paints used by automobile manufacturers, the International Forensic Automotive Paint Data Query (PDQ) database. By using the PDQ, law-enforcement agencies can identify the makes and models of many vehicles from samples of their paint; often, even the assembly plant in which a vehicle was made can be determined.

Through collaborative efforts involving automakers and law-enforcement agencies in Canada and around the world, the PDQ has accumulated a library of more than fifty thousand layers of paint. Samples of paint included in the database come from forensic laboratories as well as from automobile manufacturers. In return for contributing sixty new samples of automotive paint to expand the database each year, accredited users receive a copy of the PDQ. Users include law-enforcement agencies in the United States, the European Union, Australia, New Zealand, Japan, and Singapore.

A forensic scientist for the Michigan State Police testifies about the similarity between paint samples collected from the defendant's shoes and paint samples collected from the suspected scene of a murder in a 2006 trial. *(AP/Wide World Photos)*

Evaluation of Paint Evidence

If the paint layers present in the recovered and control samples cannot be distinguished by their physical appearance and chemical composition, the next step is the assessment of the evidential value of these findings. This is usually a subjective exercise based on the experience of the analyst, who takes into consideration the number of corresponding paint layers and the commonness of the types of paint present. For automotive paint, it is important to establish whether the paint layers are the original manufacturer's paint or whether additional layers of paint have been added.

The finding of a number of corresponding paint layers usually provides strong evidence to link the two samples of paint. For cases involving the collision of two vehicles, the finding of two-way paint transfer can provide very strong evidence, and in some cases a conclusive finding may be made. A conclusive match can also be reported when the analyst considers that the combination of corresponding paint layers is unique and therefore no alternative sources are possible.

Forensic scientists are also sometimes asked to identify the makes and models of automobiles from paint layers present in samples recovered from crime scenes. Such requests are commonly made to provide investigative evidence on the specific kinds of vehicles that were present at the scenes, whether hit-and-run or other kinds of crime scenes. To make such identifications, the scientists consult databases containing extensive information on the paints used by automobile manufacturers, such as the International Forensic Automotive Paint Data Query (PDQ) database established by the Forensic Laboratory Services of the Royal Canadian Mounted Police.

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Further Reading

Caddy, Brian, ed. *Forensic Examination of Glass and Paint: Analysis and Interpretation*. New York: Taylor & Francis, 2001. Detailed text provides thorough discussion of all aspects of forensic paint examination.

Challinor, John. "Paint Examination." In *Expert Evidence*, edited by Ian Freckelton and Hugh Selby. North Ryde, N.S.W.: Lawbook, 1993. Presents an overview discussion of paint evidence and comparative techniques. Intended for members of the legal community.

Houck, Max M., and Jay A. Siegel. *Fundamentals of Forensic Science*. Burlington, Mass.: Elsevier Academic Press, 2006. Good general textbook includes a section on paint examination and analysis.

Inman, Keith, and Norah Rudin. *Principles and Practice of Criminalistics: The Profession of Forensic Science*. Boca Raton, Fla.: CRC Press, 2001. Discusses the interpretation of various kinds of forensic evidence, including paint evidence.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007. Standard textbook includes discussion of the general points of forensic paint examination. Presents examples of cases in which paint evidence was used.

See also: Arsenic; Art forgery; Chromatography; Fourier transform infrared spectrophotometer; Gas chromatography; Hit-and-run vehicle offenses; Lead; Mass spectrometry; Micro-Fourier transform infrared spectrometry; Microspectrophotometry; Spectroscopy.

Paper

Definition: Flexible sheets of compressed wood pulp, or similar substrates made of other materials, used chiefly for written and printed documents but also for disposable containers.

Significance: Paper figures most commonly as evidence in civil forgery cases. Many of the tools that forensic scientists use to analyze inks and toners can also be applied to the paper on which these substances appear. Questioned document analysts focus more attention on ink and handwriting than on paper, because the writing itself usually provides more definitive clues than the substrate. Analysis of paper, however, can be crucial to proving forgery or the authenticity of works of art and historical documents. In addition, fragments of paper found at crime scenes may provide evidence that can link suspects to crimes.

A piece of paper, independent of any writing or printing that may appear on it, conveys a wealth of information. By examining it closely, an expert can often tell where and when it was manufactured. Telltale signs of its subsequent history—how it was stored and whether it was treated in any way—may be discernible as well. Forensic scientists may also be able to match paper fragments that have been torn or cut from larger original pieces to those original pieces in a process known as fracture matching.

Differing Characteristics

Paper manufacture originated in the Orient and was imported into Europe in the late Middle Ages. Paper is basically a felt made of plant fibers, compressed to form a thin, tough sheet. Certain characteristics imparted by the papermaking process are visible in the finished product. These include the species of plant from which the fibers were derived, the chemical and mechanical means used to extract and treat the fibers to make them suitable for papermaking, bleaching agents and dyes, density, surface texture imparted by rollers, watermarks, fillers, and substances used for coating.

The older the paper, the more likely the species of plant used in its manufacture is to be diagnostic. In the twenty-first century, wood chips used in pulping are shipped all over the world. In contrast to new paper from large international conglomerates, which varies little in its species composition, recycled paper can be highly diagnostic, because the species mix changes so much from batch to batch.

Because visible surface features of documents can be photocopied, many firms and government agencies print their most sensitive documents on security paper that is manufactured for specific purposes. Such paper incorporates fibers, watermarks, invisible reactive inks, and other features that forgers and counterfeiters cannot reproduce without access to the original, tightly controlled paper stock.

Analysis Techniques

Document analysts use radiocarbon dating as well as the analysis of paper manufacturing techniques to determine the ages of old documents and drawings. Serious forgers of purportedly old documents attempt to avoid discovery by using antique paper. In initial authentication of the Vinland map, which was claimed to be a fifteenth century copy of a thirteenth century map proving Viking settlement in the New World, investigators concluded that the map was genuine because it was drawn on fifteenth century parchment. A supposed center fold, however, turned out to be a seam where two leaves were joined before the map itself was drawn. Through microscopic examination, forensic document examiners can readily determine whether folds or mechanical damage on a piece of paper occurred before or after the paper was written on. Something written after the paper was damaged raises suspicion of forgery.

The origins of the fibers used in paper can be determined through examination of the morphology of individual fibers with either transmitted light or scanning electron microscopy (SEM). Forensic scientists use the same spectrographic methods they apply to analyzing ink in analyzing paper. SEM produces a high-resolution image of surface features, and a laser scanning confocal microscope produces a three-dimensional image. As an adjunct to SEM, energy-dispersive spectroscopy (EDS; also known as energy-dispersive X-ray spectroscopy, or EDX) measures the X-ray emission spectra of compounds bombarded by electrons. An EDS reading indicates which atomic elements are present in a sample and in what proportions.

Infrared absorption spectrometry detects specific types of chemical bonds in organic molecules. This technique is useful for detecting coating agents on paper and for tracing plastics used in place of paper. Photographic papers of-

Paper and Forgery

One of the most skilled document forgers in modern history, Mark Hofmann was a disaffected Mormon who specialized in faking key documents in his church's history. A major reason for his success in fooling church officials, collectors, historians, and forensic experts was the care he took in producing his forgeries on paper manufactured during the periods in which his documents were supposedly written. He was also skilled in making inks that chemically matched those in authentic historical documents. Two decades after his criminal career ended, his forgeries were still giving headaches to scholars, archivists, and document collectors. Hofmann's downfall came after mounting financial difficulties moved him to launch a bombing campaign against his clients in Salt Lake City that led to his conviction for murder and a life sentence in Utah State Prison. Pictured here during his 1986 trial, he is seated in a wheelchair because he was severely injured by one of his own bombs.

(AP/Wide World Photos)

ten have distinctive chemical signatures and surface characteristics. Trace-element analysis using plasma mass spectrometry has been used to identify batches of recycled paper. Examination under ultraviolet light reveals erasures and stains, and raking (low-angle) light shows buckling and watermarks.

A discarded paper match found at an arson scene or at another kind of crime scene can be a valuable piece of evidence. If investigators identify a suspect and find in that person's possession the matchbook from which the discarded match came, the torn end of the match will correspond to the stub in the matchbook. Also, because paper matches are made from recycled cardboard, the lot number and its distribution pattern can be determined from the fiber content of the match. This information can provide investigators with a range of places the suspect might have been seen immediately prior to the commission of the crime.

Although paper analysis has entered into a number of high-profile historical criminal cases, notably in the analysis of the ransom notes in the 1932 kidnapping of Charles A. Lindbergh's infant son, the findings of paper analysis are rarely definitive. An exception is the hoax involving diaries purportedly written by Adolf Hitler, in which the handwriting, writing style, and supposed origin of the documents were plausible, but analysts determined that the paper itself could not have been manufactured before 1950.

Martha Sherwood

Further Reading

Conners, Terrance E., and Sujit Banerjee, eds. *Surface Analysis of Paper*. Boca Raton, Fla.: CRC Press, 1995. Technically oriented volume provides detailed information on paper surfaces. Intended mainly for use in quality-control applications in the paper industry.

Dines, Jess E. *Document Examiner Textbook*. Irvine, Calif.: Pantex International, 1998. Practical manual for forensic document examiners includes good coverage on watermarks.

Eckert, William G., ed. *Introduction to Forensic Sciences*. 2d ed. Boca Raton, Fla.: CRC Press, 1997. Text aimed at students considering careers in forensic sciences offers useful tips on identifying types of paper.

Houck, Max M. *Forensic Science: Modern Methods of Solving Crime*. Westport, Conn.: Praeger, 2007. Highly readable volume provides a rigorous overview of many aspects of forensic science, with numerous examples. Includes brief coverage of document analysis.

Kaye, Brian H. *Science and the Detective. Selected Reading in Forensic Science*. New York: VCH, 1995. Presents clear descriptions of the manufacturing processes used in the paper industry and discusses how to detect the differences among types of paper.

Spencer, Ronald D. *The Expert Versus the Object: Judging Fakes and False Attributions in the Visual Arts*. New York: Oxford University Press, 2004. Describes scientific methods for the authentication of art, including radiocarbon dating and analysis of historic paper-making techniques.

White, Peter, ed. *Crime Scene to Court: The Essentials of Forensic Science*. 2d ed. Cambridge, England: Royal Society of Chemistry, 2004. Contains a lengthy discussion of questioned document analysis.

See also: Art forgery; Counterfeit-detection pens; Counterfeiting; Document examination; Energy-dispersive spectroscopy; Forgery; Fracture matching; Hitler diaries hoax; Lindbergh baby kidnapping; Questioned document analysis; Scanning electron microscopy; Writing instrument analysis.

Parasitology

Definition: Study of a class of debilitating organisms that feed on other organisms.

Significance: In some death investigations, parasites observed in corpses during autopsy may provide important information. Specific parasites have unique life histories and distribution patterns, and the presence of certain parasites can indicate when a corpse was subjected to particular conditions. This information may be useful to investigators in determining the sequence of events leading to the death. Forensic examination of parasites is also sometimes important in liability cases involving the contamination of food, water, medicines, or building systems such as air conditioning.

Parasitologists study the ecological and evolutionary adaptations and relationships between parasites and their host organisms, the impacts of parasites and hosts on each other, and the populations and distributions of parasites. Virtually every species of animal and plant hosts at least one variety of parasite that is specific to that species. Some parasites are affiliated with multiple host types during their life histories. The modern study of parasitology combines information from the disciplines of biology, ecology, biochemistry, cell and molecular biology, microbiology, and immunology.

Types and Impacts of Parasites

Parasitism occurs when one organism (the parasite) benefits from a relationship in which it feeds on another organism (the host) and, in so doing, harms that organism in some way. (A relationship between organisms that does not harm either is referred to as mutualistic rather than parasitic.) Parasites may use host organisms for refuge or as platforms for reproduction. Typically, parasites are much smaller in size than their hosts, and they are usually much more numerous as well.

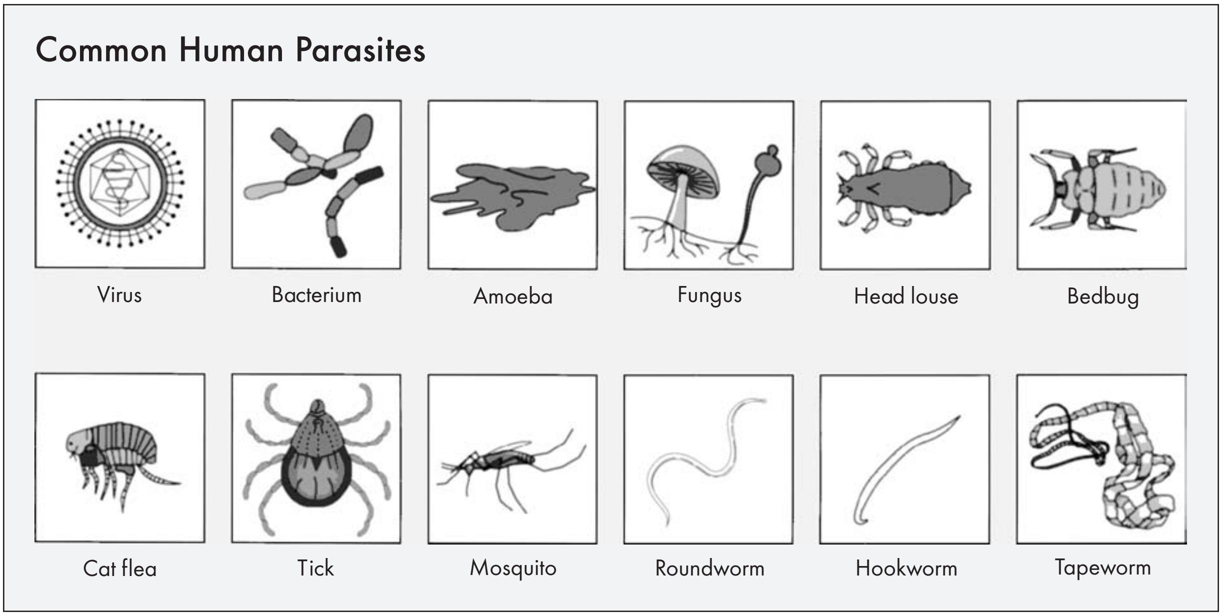
Two basic types of parasites are endoparasites, which live inside the body (such as tapeworms, flukes, and amoeboid parasites of body fluids), and ectoparasites, which live on the skin or among hairs (such as fleas, ticks, and lice). A familiar example of a parasite-host relationship is the presence of fleas on a dog or cat. Fleas obtain food, a safe and sheltered living habitat in the animal's fur, and transportation that allows them to infect other cats and dogs, thus increasing their distribution across a landscape. The impacts of parasites on their hosts include neurological, physical, and behavioral changes that collectively can diminish the ability of the hosts to survive and reproduce. Fleas, for example, can cause skin irritations, infections, and even life-threatening anemia in their animal hosts.

Human Parasitology

An important branch of medicine is devoted to the prevention and cure of diseases caused by parasites in humans. A wide range of organisms have parasitic relationships with humans; among the most common of these are bacteria, viruses, protozoans, and helminths (worms). In humans, parasite-induced diseases arise when parasites deprive the body of nutrients, destroy tissues, and release or create toxic wastes that disrupt the functioning of tissues, organs, and systems such as the nervous system.

Humans are often affected by protozoan (single-celled) parasites, amoebae, flukes, and helminths. An example of a pathogenic amoeba is *Entamoeba histolytica*, which causes amoebic dysentery and can penetrate the digestive wall and spread to other tissues of the body. This organism is introduced into the body most often

One of the most common ectoparasites that afflicts human beings is the tick, a biting insect that helps to spread hemorrhagic fevers and tularemia. *(© iStockphoto.com/Eric Delmar)*



Any organism that, temporarily or permanently, lives on or in another organism for the purpose of procuring food is considered a parasite; these parasites may cause infection in human hosts.

through drinking water that has been contaminated with fecal products. Infections of amoebic dysentery, which causes severe diarrhea and bleeding of the digestive tract, can result in death if untreated or treated too late.

Forensic Applications

In criminal cases involving deaths or illnesses, pathologists and other forensic scientists usually take complete inventories of both ectoparasites and endoparasites found on or in the bodies of the deceased or ill victims. They are especially concerned with identifying organisms that can cause death or may be factors leading to death. They also note the presence of any parasites that may provide clues regarding certain aspects of the life histories of the victims, such as health issues. An autopsy of someone who has died from parasitic infection reveals the causal parasites through their chemical traces or by-products and through their typical destructive pattern in tissues and organs.

When the body of a possible crime victim is discovered, forensic parasitology can sometimes provide law-enforcement investigators with important information concerning the circumstances, location, and time of death. By examining the body for parasites that can survive in and feed on dead hosts, a parasitologist may be able to determine, for example, whether or not the body was moved from the location where the person died. Also, when living parasites are found on a corpse, this is a strong indication that the individual died within a short period before the body was found.

Forensic scientists may also be involved in examining the relationship between outbreaks of illness caused by parasites and the likely sources of the parasites. Deaths and illnesses related to parasites are on the rise in the United States and in many other countries, in part owing to the ever-increasing mobility of the global population. International travelers may unintentionally transport parasites and their eggs or larvae on their clothing, shoes, or skin, and the introduction of parasites to new areas may not be detected immediately. When lawsuits arise as the result of parasitic infections caused by contaminated food, water, or other products or facilities, forensic parasitologists are called upon to identify and clarify the transmission modes of the parasites and the most likely sources of the contamination.

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Further Reading

Ash, Lawrence R., and Thomas C. Orihel. *Atlas of Human Parasitology*. 5th ed. Chicago: American Society for Clinical Pathology Press, 2007. Useful reference work provides identification methods for the parasites seen most often in human beings in forensic science applications. Includes more than eight hundred color photographs of parasites.

Bogitsh, Burton J., Clint E. Carter, and Thomas N. Oeltmann. *Human Parasitology*. 3d ed. Burlington, Mass.: Elsevier Academic Press, 2005. Discusses the full range of parasites found in humans. Intended for students in the health professions.

Breeze, Roger G., Bruce Budowle, and Steven E. Schutzer, eds. *Microbial Forensics*. Burlington, Mass.: Elsevier Academic Press, 2005. Collection focuses on the relationship between forensic science and microbe physiology. Includes some discussion of parasites.

Mahon, Connie R., Donald C. Lehman, and George Manuselis, eds. *Textbook of Diagnostic Microbiology*. 3d ed. St. Louis: Saunders Elsevier, 2007. Well-illustrated, comprehensive volume covers all aspects of microbiology.

See also: Air and water purity; Antibiotics; Biological terrorism; Biological warfare diagnosis; Biological weapon identification; Bubonic plague; Centers for Disease Control and Prevention; Pathogen genomic sequencing; Pathogen transmission.

Parental alienation syndrome

Definition: Set of symptoms in which a child is obsessively preoccupied with unjustified or exaggerated deprecation or criticism of a parent (the target parent) owing to the influence of the favored parent (the alienating parent) combined with the child's own contributions.

Significance: Forensic psychiatrists and psychologists testifying as expert witnesses in child-custody cases sometimes discuss parental alienation syndrome. Attorneys seek to have such testimony admitted into evidence to establish that the alienating parent has created a psychological disorder in the child. Controversy exists about the scientific basis for parental alienation syndrome, however, because it is not a diagnostic syndrome recognized by the American Psychiatric Association's *Diagnostic and Statistical Manual of Mental Disorders*.

Richard A. Gardner, a child psychiatrist, coined the term "parental alienation syndrome" (PAS) in 1985 to describe a set of symptoms indicative of intense rejection of a parent by a child following parental divorce or separation. When a child's parents separate, the child may resist contact with one of the parents for a variety of normal reasons, including reasons having to do with the child's stage of development. The alienated child described by Gardner, however, persistently refuses and rejects contact with a parent because of unreasonable negative views and feelings toward that parent.

Gardner described the child exhibiting PAS as obsessed with hatred of the target parent. This hatred is irrational and stems from the influence of the alienating parent on the child's feelings toward the target parent. According to Gardner, the alienating parent is unable to tolerate separation from the child and so engages in a campaign to program the child to denigrate the target parent. In this way, the alienating parent uses the child to meet the alienating parent's own emotional needs. Gardner's account of PAS captured the attention of both mental health professionals and the legal community in the United States and stimulated research on the syndrome's conceptualization, identification, diagnosis, and treatment.

Conceptualization of PAS

Gardner posited three essential elements as necessary for a diagnosis of PAS. First is the child's denigration of the target parent, which is persistent and reaches the level of a campaign. This persistent denigration has a rehearsed quality, and it often includes phraseology not typically used by a child. Second, the denigration and rejection of the target parent are irrational, not reasonable responses to any behavior on the part of the target parent. Child abuse, child neglect, the child's witnessing of episodes of domestic violence, or other dysfunctional factors are not present. Third, the denigration is the result of the influence of the alienating parent as well as the self-created contributions by the child in support of the alienating parent's campaign to denigrate the target parent. The child contributes to the alienating parent's campaign because the child fears the loss of the love of the alienating parent. Hatred of the target parent often extends to include members of the target parent's extended family.

In presenting his conceptualization, Gardner wanted to distinguish PAS from situations in which a child prefers one parent but still maintains a relationship with the other parent. In addition, he distinguished situations in which a child resists spending time with a parent after divorce or separation but that resistance is short-lived; in such cases, the child is not alienated and is not under the influence of an alienating parent.

Legal and Therapeutic Interventions

A mental health clinician makes a diagnosis of PAS and may testify in court as an expert witness in a child-custody or visitation case. Gardner has recommended that any legal intervention in a given case should be based on whether a behavioral science expert has assessed the case as mild, moderate, or extreme parental alienation. In mild parental alienation cases, the alienating parent does not have any severe emotional problems. A court order for visitation is the only intervention necessary in such a case, because a clear court order will alleviate the child's guilt about contact with the target parent and should lower the conflict between the parents.

In moderate parental alienation cases, Gardner has recommended a combination of court orders for visitation and for therapy. Therapy is necessary because the alienating parent is giving verbal and nonverbal cues to the child, encouraging the child to denigrate the target parent. The goals of the therapy are to structure the visitation between the child and the target parent by deprogramming the child and confronting the tactics of the alienating parent.

In severe parental alienation cases, a change in custody is likely to be necessary, because typically the alienating parent has severe psychopathology that is also affecting other aspects of his or her parenting. The vast majority of PAS cases that are seen in therapeutic settings fall within the category of moderate parental alienation.

Limitations

PAS is a controversial concept within the mental health and legal communities. Proponents of the concept claim that it helps attorneys and judges to understand and address a phenomenon long recognized by the mental health community. They assert that expert testimony on PAS can be useful to the court in that it can shed light on a child's refusal to see a parent and can help the court determine how much weight to give to the child's preferences regarding custody.

Critics charge that PAS lacks an adequate scientific foundation for recognition as a diagnostic syndrome and that, therefore, expert testimony regarding its diagnosis and treatment should be inadmissible. They point to the fact that little research exists concerning the scientific reliability of a diagnosis of PAS—that is, the degree to which different clinicians examining the same children reach a high rate of agreement on which children do or do not have the syndrome. Critics also emphasize the lack of empirical research substantiating whether PAS accurately describes a disturbance suffered by some children. The accurate description of such a disturbance requires empirical research to identify what kinds and how many symptoms are necessary for a diagnosis of PAS. This research should include the examination of the prevalence of PAS and its long-term effects on children. In addition, critics assert that the use of the medical designation "syndrome" may convey a legitimacy to testimony on PAS that is not warranted given the lack of empirical research. Further research is necessary to resolve these controversies.

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Further Reading

Gardner, Richard A. *The Parental Alienation Syndrome*. 2d ed. Creskill, N.J.: Creative Therapeutics, 1998. Presents a comprehensive discussion of PAS in the context of the American adversarial legal system.

Gardner, Richard A., Richard S. Sauber, and Demosthenes Lorandos, eds. *The International Handbook of Parental Alienation Syndrome: Conceptual, Clinical, and Legal Considerations*. Springfield, Ill.: Charles C Thomas, 2006. Collection of articles provides information useful for understanding research findings concerning PAS.

Warshak, Richard A. "Current Controversies Regarding Parental Alienation Syndrome." *American Journal of Forensic Psychology* 19 (2001): 29-59. Presents a clearly written discussion of the controversies that surround the use of the diagnosis of PAS in the courtroom.

See also: Borderline personality disorder; Child abuse; *Daubert v. Merrell Dow Pharmaceuticals*; Expert witnesses; False memories; Forensic psychiatry; Forensic psychology; Minnesota Multiphasic Personality Inventory; Paternity evidence.

Paternity evidence

Definition: Evidence used to determine whether a person is the father of a specific child.

Significance: Information on paternity can be important for a number of legal reasons, from issues of inheritance to cases involving rape. Most often, tests for paternity are conducted using DNA evidence. Forensic scientists compare the DNA of an alleged father to a child's DNA to determine whether there is evidence of paternity based on the fact that the man cannot be excluded as the father of the child.

Before forensic experts began to analyze DNA (deoxyribonucleic acid), the evidence used in paternity cases was far from conclusive. Courts in the United States applied a common-law "presumption of paternity" after a mother named a particular person as the father of her child. The alleged father might rebut the presumption by producing evidence such as sterility or impotence or evidence showing that he was not present in the same location as the mother at the time of conception. Because of the lack of definitive evidence, however, many cases of paternity fraud were perpetrated, as most U.S. states did not require mothers to disclose the names of all potential fathers of their children.

Although modern methods of examining DNA evidence may exclude a person as the fraternal parent of a child with almost 100 percent accuracy, scientists have not yet been able to use DNA to prove positively that a specific person is the father. In addition, paternity fraud still exists in those courts that are slow to accept some of the newer technologies used by forensic scientists to establish paternity. After paternity has been established, the person designated as the father may find it difficult to obtain rescission of the paternity court order, even if more sophisticated evidence is produced at a later date.

Reasons for Establishing Paternity

Establishing paternity serves several purposes. One of the largest demands for paternity testing relates to child support. The government wants to make sure that parents pay to support their children rather than have taxpayers fund child support through public assistance. In fact, U.S. law requires a woman to name possible fathers in order to obtain public assistance for her children.

Paternity must also be established before children and fathers are able to inherit from each other under state intestacy laws that require a biological relationship. Insurance companies and the government may also require a father-child determination before paying insurance or Social Security benefits. Children may want to know the identities of their biological fathers for personal, medical, and emotional reasons. Finally, it is important to identify fathers for purposes of prosecution in criminal paternity cases such as rape, sexual abuse of a child, and incest.

Blood and DNA Heredity Evidence

In some paternity cases, forensic serologists may still use blood typing. Using blood as the only evidence to establish paternity, however, has limitations, not the least of which is the amount of blood evidence needed to run such tests and the lack of genetic information generated from blood typing.

DNA provides better evidence of paternity, as it is unique and the hereditary factors found in DNA work well to exclude people as biological parents of a child. Half of a person's DNA is contributed by the mother and the other half by the father. By comparing the specific short tandem repeats (STRs) of a child's DNA to the DNA of possible parents of the child, forensic scientists are able to identify people who could not be the mother and father based on dissimilarities in their DNA (assuming a genetic mutation did not result in a false exclusion). To determine the most likely father, forensic scientists use probability calculations after finding consistent genetic patterns between the DNA of the alleged father and the child.

Sources of DNA Evidence

The most credible way to test for paternity is by comparing samples of DNA extracted from body fluids (such as saliva, semen, or blood) collected directly from the purported father and the child. Noninvasive buccal samples—collected by scraping the inside of the mouth with a foam applicator or cotton swab—may also be used; this method is especially useful for collecting DNA from infants. When an individual of interest is not available, scientists must collect DNA evidence from some other source that person has left behind. For example, paternity testing can be conducted with a small DNA sample obtained from a hair (with root intact) left in a hairbrush or from saliva on a toothbrush, envelope flap, or cigarette butt. The blood in the umbilical cord of a newborn or cells from a fetus also provide sufficient DNA for testing.

In some cases, the purported father or child is deceased, and DNA samples are collected during autopsy or from the body at the funeral home; if a case requires DNA from a body after burial, a court-ordered exhumation may take place so that a specimen can be collected. For children, DNA exemplars may be available from dried blood samples stored on so-called Guthrie cards, which many U.S. states use to screen for genetic diseases at the time of birth. In criminal paternity cases involving fetuses aborted before full term, DNA from the fetuses can be compared with the DNA of the alleged fathers.

Carol A. Rolf

Larry Birkhead emerges from a court hearing in Nassau, Bahamas, in April, 2007. Citing expert testimony based on DNA evidence, the court ruled that Birkhead is the father of the infant daughter of former Playboy Playmate Anna Nicole Smith, a legal resident of the Bahamas who had died two months earlier. Smith died while in the midst of a prolonged lawsuit over the estate of her billionaire husband, an octogenarian who had died in 1995. As Smith's only surviving child, the daughter stood to inherit an immense fortune. After Smith died, Birkhead was one of several men who stepped forward to claim paternity of the daughter. *(AP/Wide World Photos)*

Further Reading

Buckleton, John, Christopher M. Triggs, and Simon J. Walsh, eds. *Forensic DNA Evidence Interpretation*. Boca Raton, Fla.: CRC Press, 2005. Provides good explanations regarding biology and DNA analysis, including the interpretation of DNA in paternity identification.

Butler, John M. *Forensic DNA Typing: Biology, Technology, and Genetics of STR Markers*. 2d ed. Burlington, Mass.: Elsevier Academic Press, 2005. Readable text includes discussion of the use of short random repeats in the genome, which provides useful evidence in determining paternity.

Coleman, Howard, and Eric Swenson. *DNA in the Courtroom: A Trial Watcher's Guide*. Seattle: GeneLex, 1994. Discusses in simple terms the comparison of DNA evidence for use in court trials.

Evett, Ian W., and Bruce S. Weir. *Interpreting DNA Evidence: Statistical Genetics for Forensic Scientists*. Sunderland, Mass: Sinauer Associates, 1998. Addresses the basics of the mathematical analysis of DNA evidence, including the determination of statistical probability in paternity cases.

Kobilinsky, Lawrence F., Thomas F. Liotti, and Jamel Oeser-Sweat. *DNA: Forensic and Legal Applications*. Hoboken, N.J.: Wiley-Interscience, 2005. Presents a comprehensive overview of the uses of DNA analysis in American legal proceedings, including paternity cases.

See also: DNA analysis; DNA database controversies; DNA fingerprinting; DNA isolation methods; DNA profiling; DNA sequencing; DNA typing; Jefferson paternity dispute; Parental alienation syndrome; Paternity testing; Polymerase chain reaction; Y chromosome analysis.

Paternity testing

Definition: Use of DNA profiling or examination of blood proteins to determine whether specific men are the biological fathers of particular children.

Significance: Forensic paternity testing may be used for a variety of reasons, including in legal cases regarding inheritance rights or child support. The ability to answer questions of paternity is also sometimes important in criminal cases involving pregnancies, such as rape and incest cases.

During the 1920's, paternity testing was done using the ABO blood group types. This test could exclude a man as the father of another person, but it could not prove that a man was the father. The ABO blood group types are caused by the particular modification of a specific red blood cell surface protein called H antigen. The A and B genes code for enzymes that put specific sugars on the H antigen, and the O gene does not modify the H antigen. The human blood types are A, B, AB, and O; A and B are codominant, and O is recessive. A person has two ABO blood group genes, one from each parent. Based on the father's and mother's blood types, the blood type of the offspring can be determined. If a man has AB blood, he cannot have children with blood type O; a man with blood type AB thus would be excluded as the father of a blood type O child. By the 1930's, paternity testing also began to take into account other red blood cell surface proteins, such as Rh, Kell, and Duffy blood groups.

During the 1970's, human leukocyte antigens (HLAs) were used for paternity testing as well as for typing for organ transplants. HLAs are abundant in white blood cells, are in all cells of the body except red blood cells, and are used by the immune system to detect foreign cells. Each person has a unique set of HLA proteins inherited from parents. The usefulness of HLA type to determine paternity depends on how unusual (rare) a man's HLA type is in the population. Also, related men may share the same HLAs and cannot be distinguished from each other by the HLA typing test.

DNA Tests for Paternity

During the 1980's, DNA (deoxyribonucleic acid) profiling was developed. DNA analysis can be used to determine paternity conclusively, but this procedure requires large amounts of intact DNA. English geneticist Alec Jeffreys and his colleagues studied minisatellites made of a DNA sequence that is tandemly (end-to-end) repeated hundreds of times. These are called restriction fragment length polymorphisms (RFLPs) or variable number of tandem repeats (VNTRs). Individuals vary in the numbers of tandem repeats of the DNA sequence in their genomes. To detect these RFLPs, analysts isolate DNA and

Members of the polygamist Fundamentalist Church of Jesus Christ of Latter-day Saints walk past sheriff's deputies on their way to submit DNA samples in Eldorado, Texas, in April, 2008. Texas authorities sought the samples in order to determine the familial relationships among the group's adult and child members after allegations of child abuse led the state to remove the children from the group's custody. *(AP/ Wide World Photos)*

add a restriction enzyme (which makes sequence-specific cuts in DNA) to make cuts outside the repeating sequence. Gel electrophoresis is used to separate the DNA based on size. The DNA fragments are transferred from the gel to a membrane called a Southern blot, and a single-stranded, labeled DNA probe that is complementary to the repeating sequence is hybridized with the DNA on the membrane. This labeled probe allows the VNTR regions to be detected among all the DNA in the genome. The size of the fragment detected varies depending on the number of tandem repeats the individual has. This is length polymorphism—length variation from individual to individual.

During the 1990's, polymerase chain reaction (PCR) became available to analyze DNA. Using sequence-specific primers, specific segments of DNA are amplified. Small quantities of a sample are readily amplified to give large amounts of DNA for analysis. The polymorphic sequences—those sequences that vary greatly from person to person—that are used for paternity testing include single nucleotide polymorphisms (SNPs) and short tandem repeats (STRs) that occur in the genome. In multiplex PCR, thirteen core loci that show large variability in the population are copied at the same time. Gel electrophoresis is used to separate the DNA fragments by size, and a DNA profile is created. In paternity testing, the DNA profile of the child is compared with the profiles of potential fathers. This analysis is rapid to perform and can determine paternity conclusively.

Susan J. Karcher

Further Reading

Brinkmann, B. "Is the Amelogenin Sex Test Valid?" *International Journal of Legal Medicine* 116, no. 2 (2001): 63. Brief article addresses the use of the amelogenin gene for sex determination.

Cho, Mildred K., and Pamela Sankar. "Forensic Genetics and Ethical, Legal, and Social Implications Beyond the Clinic." *Nature Genetics* 36 (2004): S8-S12. Discusses the ethical considerations related to DNA and genetic analysis.

Dawid, A. Philip, Julia Mortera, and Vincenzo L. Pascali. "Non-fatherhood or Mutation? A Probabilistic Approach to Parental Exclusion in Paternity Testing." *Forensic Science International* 124, no. 1 (2001): 55-61. Addresses the effects of mutations on paternity tests.

Fisher, Barry A. J. *Techniques of Crime Scene Investigation*. 7th ed. Boca Raton, Fla.: CRC Press, 2004. Provides a broad overview of many areas of forensics, including DNA and RFLP typing.

Kobilinsky, Lawrence F., Thomas F. Liotti, and Jamel Oeser-Sweat. *DNA: Forensic and Legal Applications*. Hoboken, N.J.: Wiley-Interscience, 2005. Presents a general overview of the uses of DNA analysis.

Petkovski, Elizabet, Christine Keyser-Tracqui, Rémi Hienne, and Bertrand Ludes. "SNPs and MALDI-TOF MS: Tools for DNA Typing in Forensic Paternity Testing and Anthropology." *Journal of Forensic Sciences* 50, no. 3 (2005): 535-541. Provides details regarding single nucleotide polymorphisms.

Ruitberg, Christian M., Dennis J. Reeder, and John M. Butler. "STRBase: A Short Tandem Repeat DNA Database for the Human Identity Testing Community." *Nucleic Acids Research* 29, no. 1 (2001): 320-322. Describes the database of short tandem repeats.

See also: Argentine disappeared children; CODIS; DNA database controversies; DNA profiling; Ethics of DNA analysis; Jefferson paternity dispute; Paternity evidence; Polymerase chain reaction; Semen and sperm.

Pathogen genomic sequencing

Definition: Techniques used to determine the linear order of monomers (small molecules such as nucleotides) that can be linked together to form polymers, mainly nucleic acids, found in the genomes of disease-causing microbes such as certain viruses, bacteria, and fungi.

Significance: Microbial forensics, the branch of forensic science that deals with microorganisms, extends the scope of epidemiology by going into greater detail to characterize pathogens for use as possible evidence in legal proceedings. The sequencing of pathogens is an especially important technique in forensic science as it pertains to increasingly dangerous global scourges of infectious emerging diseases.

Using a triad of techniques—polymerase chain reaction (PCR) and genomic sequencing followed by phylogenetic studies, which infer relationships among microbial strains—forensic scientists have the ability to determine the origin of a disease-causing agent, or pathogen, used in a biocrime and to determine who or what organization was responsible for its dissemination. In 2000, the human genome was characterized through sequencing techniques; this accomplishment revolutionized molecular biology. The comparatively small viral genomes of human immunodeficiency virus (HIV), hantaviruses, and *Haemophilus influenzae* have been elucidated through sequencing, as have the larger genomes of bacteria including *Mycobacterium tuberculosis* (TB) and its drug-resistant strains, *Yersinia pestis* (plague), *Mycobacterium leprae* (leprosy or Hansen's disease), *Salmonella typhi* (typhus), *Bacillus anthracis* (anthrax), and *Neisseria meningitidis* (meningitis). All of these pathogens are considered threats to global health.

The techniques used by forensic scientists in the collection, handling, shipping, and preservation of potential pathogens are different from those employed for nonpathogenic samples.

Forensic microbial analysis is based on a technique that identifies tandemly repeated sequences within the pathogen's genome. (Tandem repeats are repetitive sequences consisting of two or more nucleotides that serve as genetic markers and are frequently used to establish attribution—the source of a pathogen—in legal proceedings.)

After an unknown attacker sent letters containing *B. anthracis* to addresses in New York City, Washington, D.C., and Boca Raton, Florida, in the fall of 2001, careful preservation of initial and follow-up samples of the contents of the envelopes allowed forensic scientists to identify the Ames strain of *B. anthracis* as the specific pathogen used in the attacks. Before the entire genome was sequenced, the sample in question was compared with natural strains of *B. anthracis*; this comparison narrowed the possible source to a human-made strain of anthrax as opposed to one that might be found in nature. Further comparison to attribute the Ames strain to this biocrime was possible because the first strain, isolated from a victim in Florida (the index case), and the strains isolated from other victims as well as those found in anthrax spores recovered in the letters had previously been collected and preserved according to microbial forensic guidelines.

Specialized facilities, such as the J. Craig Venter Institute (JCVI), have been established to enable microbial forensic analysts to ascertain the entire genomic sequences of about five million bases of *B. anthracis* so as to identify polymorphisms (variations in DNA sequences) that serve as genomic signatures. In late 2007, the National Institute of Allergy and Infectious Diseases announced that twenty-eight hundred human and avian isolates had been completely sequenced and were publicly accessible.

Cynthia Racer

Further Reading

Binnewies, Tim T., et al. "Ten Years of Bacterial Genome Sequencing: Comparative-Genomics-Based Discoveries." *Functional and Integrative Genomics* 6 (July, 2006): 165-185.

Breeze, Roger G., Bruce Budowle, and Steven E. Schutzer, eds. *Microbial Forensics*. Burlington, Mass.: Elsevier Academic Press, 2005.

Budowle, Bruce, et al. "Genetic Analysis and Attribution of Forensic Evidence." *Critical Review of Microbiology* 31 (October, 2005): 233-254.

_______. "Quality Sample Collection, Handling, and Preservation for an Effective Microbial Forensics Program." *Applied and Environmental Microbiology* 72 (October, 2006): 6431-6438.

Cole, Leonard A. *The Anthrax Letters: A Medical Detective Story*. Washington, D.C.: Joseph Henry Press, 2003.

See also: Anthrax; Anthrax letter attacks; Biodetectors; Biological warfare diagnosis; Biological weapon identification; *Escherichia coli*; Parasitology; Pathogen transmission; Viral biology.

Pathogen transmission

Definition: Manner in which a disease-causing organism moves through the environment to infect plants or animals, including human beings.

Significance: Forensic scientists need to understand how microorganisms can inflict disease on humans directly or through contamination of food, water, animals, or plants. Their concerns include both how such pathogens affect the primary victims and whether and how the pathogens can be transmitted from primary victims to other healthy individuals.

Bacteria, protozoa, fungi, and viruses can all act as natural pathogens. Transmission occurs either directly, through contact with a host, or indirectly, through contact with a contaminated object (a fomite) or with a vehicle carrying the pathogen, such as air, water, or food. Living vectors, such as insects or animals, can also transmit various pathogens. Each pathogen has a specific way it gains entry to a host to cause disease and a specific manner by which it is released from the initial host to find a new host.

Criminals employing pathogens as weapons can use any of the natural transfer mechanisms to inflict damage or death, or they can artificially cause transfer, introducing pathogens or their parts (such as spores or toxins) by routes that the natural organisms would not or could not use. For example, consider the toxin produced by the bacterium *Clostridium botulinum*. This organism is normally found in the soil and infects improperly prepared foods. A malefactor, however, might affect a single individual by putting the bacterium in the target's food or injecting it into the person; alternatively, terrorists might contaminate a city's water supply with *C. botulinum*, potentially affecting millions of people.

A sales representative for a technology company shows off a kit for identifying biological agents that uses freeze-dried reagents to test for traces of pathogens such as anthrax. *(AP/Wide World Photos)*

Investigators working to solve cases involving pathogen transmission typically use techniques of epidemiology, the science of understanding how diseases behave in populations. These techniques include detecting organisms using their DNA (deoxyribonucleic acid)—that is, through genomic sequencing. The process starts with the examination of affected individuals, living or dead, to determine the organism that caused the disease by noting symptoms and taking samples from appropriate body locations. Investigators determine the manner in which the victims were infected by looking for the presence of the organism in the surrounding environment and identifying how the victims were exposed to the organism.

It is critical for investigators to understand how pathogens are transmitted, as they must determine not only the nature of specific crimes to individual victims but also the degree of danger to the rest of the healthy population. Of particular concern are organisms that cause life-threatening contagious diseases, such as smallpox, that can be transmitted from infected individuals to large numbers of other people. Containing human-to-human contagion in an unprotected population is much more difficult than dealing with the effects of an agent such as anthrax, which causes people and animals to become sick but is not transmitted directly from infected persons to others. This was illustrated in 2001, when envelopes with anthrax spores were sent through the mail to different cities in the United States. A few individuals were infected, but none of them (even those who contracted pulmonary anthrax) directly transmitted the pathogen to other people; the outbreaks thus remained small.

Steven A. Kuhl

Further Reading

Henderson, Donald A., and Thomas V. Inglesby. *Bioterrorism: Guidelines for Medical and Public Health Management*. Chicago: American Medical Association, 2002.

Loue, Sana. *Case Studies in Forensic Epidemiology*. New York: Springer, 2002.

Wheelis, Mark, Lajos Rózsa, and Malcolm Dando, eds. *Deadly Cultures: Biological Weapons Since 1945*. Cambridge, Mass.: Harvard University Press, 2006.

See also: Air and water purity; Anthrax; Anthrax letter attacks; Biodetectors; Biological terrorism; Biotoxins; Botulinum toxin; Bubonic plague; Ebola virus; Epidemiology; Hantavirus; Mad cow disease investigation; Parasitology; Pathogen genomic sequencing; Smallpox.

Pathology. *See* Forensic pathology

PCR. *See* Polymerase chain reaction

People v. Lee

Date: Ruling issued on May 8, 2001
Court: New York Court of Appeals
Significance: In the case of *People v. Lee*, the New York Court of Appeals held that the decision regarding whether or not to admit expert testimony at trial regarding the reliability of eyewitness identification is at the discretion of the trial court judge.

The court case *People v. Lee* focused on eyewitness testimony and the issue of whether the defense can introduce the testimony of expert witnesses during trial to raise doubt about a witness's reliability. The court exercised its discretion in determining that this testimony was not necessary to assist the jury in reaching a verdict. Key factors relating to the court's decision were the lack of any taint regarding the victim's out-of-court identification and the existence of corroborating evidence.

The case involved the theft of a motor vehicle at gunpoint, in a lighted area, where the defendant was about four feet from the victim. Two months after the theft, the defendant was arrested after committing a traffic violation; at that time, he was in possession of the victim's vehicle. About six months after the arrest, the police presented the victim with a photo array from which he identified the defendant. Ten days later, the victim also identified the defendant in a lineup.

During a pretrial hearing, the defendant sought to introduce at trial a psychology expert who would testify regarding factors that could influence perception, memory, and the accuracy of victims' identification of their assailants. The hearing court denied the defense motion to present this evidence at trial. After the trial began, the defendant renewed his request, and the request was again denied.

The New York Court of Appeals affirmed that it is up to the discretion of the trial judge whether this type of testimony is appropriate. The appellate court indicated that the trial court is in the best position to "weigh the request against other relevant factors, such as . . . the existence of corroborating evidence." The defendant had an opportunity to cross-examine the victim (witness) during the trial to question and to place before the jury any facts relevant to the identification of the defendant.

In two earlier cases, the New York Court of Appeals addressed issues relating to the admissibility of expert testimony regarding eyewitness identification. In *People v. Cronin* (1983), the court indicated that "it is for the trial court in the first instance to determine when jurors are able to draw conclusions from the evidence based on their day-to-day experience, their common observation and their knowledge, and when they would be benefited by the specialized knowledge of an expert witness." The decision in this case is consistent with the court's holding in *People v. Mooney* (1990); however, it was the dissent that stated that "the emerging trend today is to find expert psychological testimony on eyewitness identification sufficiently reliable to be admitted, and the vast majority of academic commentators have urged its acceptance."

In a later case, *People v. Young* (2006), the court noted that several factors could affect an eyewitness's identification, such as race, stress, experience, opportunity to observe, and the weapon used during commission of the crime (often, crime victims focus more closely on the weapons used against them than on the persons committing the crimes). The appellate court acknowledged that an expert witness could provide information to jurors that they may not know but determined that the court appropriately exercised its discretion to exclude the testimony of an expert witness as requested by the defense. In this case, as in *People v. Lee*, in addition to the victim's identification of the defendant, corroborating evidence was presented to the jury for evaluation.

Keith G. Logan

Further Reading

Brewer, Neil, and Kipling D. Williams, eds. *Psychology and Law: An Empirical Perspective*. New York: Guilford Press, 2005.

Technical Working Group on Eyewitness Evidence. *Eyewitness Evidence: A Guide for Law Enforcement*. Washington, D.C.: National Institute of Justice, 1999.

Wells, Gary L., and Elizabeth F. Loftus. "Eyewitness Memory for People and Events." In *Forensic Psychology*, edited by Alan M. Goldstein. Vol. 11 in *Handbook of Psychology*, edited by Irving B. Weiner. Hoboken, N.J.: John Wiley & Sons, 2003.

See also: Cognitive interview techniques; Courts and forensic evidence; Expert witnesses; Eyewitness testimony; False memories; Trial consultants.

Performance-enhancing drugs

Definition: Substances taken by persons seeking to improve their athletic performance or their physical work capacity.

Significance: As the level of athletic competition continues to rise throughout the world, athletes are always looking for ways to get a competitive edge. Superior nutrition and training programs are not enough for some athletes; many choose to use performance-enhancing drugs even though such substances are banned by sports federations and illegal unless prescribed for medical purposes. Law-enforcement agencies expend significant resources in efforts to address the illegal sale and use of such drugs.

Athletes' use of particular substances to improve their physical performance dates back to ancient Greece. Competitors in the ancient Olympics took stimulants such as strychnine, hashish, and extracts from cola plants, cacti, and fungi to improve their performance. Although the beneficial effects of these substances are questionable, many believe that their widespread use was one of the elements that led to the termination of the Olympic Games and other sporting competitions in about 400 C.E.

Competitive sports did not gain great popularity again until the time of the second phase of the Industrial Revolution, around 1850. With competition, the use of performance-enhancing drugs also returned. In particular, competitive swimmers, runners, and cyclists used caffeine, strychnine, codeine, cocaine, heroin, and nitroglycerin to stimulate their bodies to perform. Numerous athletes died from taking these drugs, but their deaths did deter many others from using such drugs. After World War II and throughout the Cold War period, the use of performance-enhancing drugs escalated, particularly the use of anabolic steroids.

Bodybuilding Supplements

The most widely known class of performance-enhancing drugs used since the 1930's is that of anabolic steroids (also known as anabolic-androgenic steroids). These are testosterone-like substances that augment male sex characteristics and the building of muscle. Anabolic steroids were first developed in Nazi Germany, where they were used to increase the aggressiveness of troops in battle.

Many studies have shown that anabolic steroids increase muscle mass and strength, which has made them popular among many different kinds of athletes, from football players to track-and-field athletes who participate in throwing events. Two strategies that athletes use to maximize strength and muscle mass with anabolic steroids are known as stacking and pyramiding. Stacking is the blending of different types of the drug in oral and injectable forms to maximize effect. Pyramiding is the continual increase in dosage over time to maximize benefit. Taking large doses of anabolic steroids comes with many dangerous side effects, however. Because the liver is responsible for breaking down and removing excess chemicals from the body, anabolic steroids can cause severe liver damage. These substances have also been linked to high blood pressure, adult-onset diabetes mellitus, increased blood clotting factors, and decreased high-density lipoproteins (good cholesterol) in the blood, all of which increase the risk of cardiovascular disease.

Another substance that has been reported to increase muscle mass and strength is human growth hormone (HGH). With the advances made in the field of genetic engineering during the 1980's, HGH became increasingly widely available and hit the black market, where athletes could get access to it. Research on the effects of HGH has been very limited, however, and any actual benefits of the substance for athletes have not been identified conclusively.

Two other substances that have been promoted as useful in increasing muscle mass and strength are dehydroepiandrosterone (DHEA) and androstenedione. Both are precursors to testosterone that are converted to testosterone by the body. Research has not found either substance to be effective for the enhancement of athletic abilities, and both decrease the high-density lipoproteins in the blood, which increases the risk of cardiovascular disease.

One supplement that has been shown to be effective in improving performance in high-intensity exercise is creatine. Research indicates that the ingestion of creatine in high doses helps the muscles to work harder and increases the body's ability to gain muscle and strength. Although creatine is not regulated by the U.S. Food and Drug Administration (FDA), it is banned by most sports federations. The long-term side effects of this substance have not been clearly identified.

Marion Jones celebrates after winning a gold medal in the women's 100-meter run during the Summer Olympic Games in Sydney, Australia, in 2000. Later accused of having used steroids to enhance her Olympic performance, Jones finally admitted, in 2007, that she had done so. Shortly afterward, she returned all her Olympic medals. Convicted of lying to investigators, she was sentenced to a term in a federal prison in early 2008. *(AP/Wide World Photos)*

Stimulants

The primary stimulant substances used by athletes for much of recent history are amphetamines. Athletes take these drugs to decrease fatigue, increase alertness, and decrease reaction time. Most research has found, however, that these drugs do not improve athletes' quickness; rather, under influence of the drugs, the athletes only perceive themselves as being quicker. In addition, amphetamines offer only short-term reduction of fatigue; thus in using amphetamines athletes gain no real performance benefits while exposing themselves to

Operation Raw Deal

This excerpt from a U.S. Drug Enforcement Administration (DEA) press release, dated September 24, 2007, gives some idea of the scope of law-enforcement efforts to deal with the problem of trafficking in illegal performance-enhancing drugs.

DEA and federal law enforcement officials from the FDA's Office of Criminal Investigations and the U.S. Postal Inspection Service today announced the culmination of Operation Raw Deal, an international case targeting the global underground trade of anabolic steroids, human growth hormone (HGH) and insulin growth factor (IGF). . . . The investigation represents the largest steroid enforcement action in U.S. history and took place in conjunction with enforcement operations in nine countries worldwide. The Internal Revenue Service (IRS), Immigration and Customs Enforcement (ICE), Federal Bureau of Investigation (FBI), and the National Drug Intelligence Center (NDIC) also played key roles in the investigation.

143 federal search warrants were executed on targets nationwide, resulting in 124 arrests and the seizure of 56 steroid labs across the United States. In total, 11.4 million steroid dosage units were seized, as well as 242 kilograms of raw steroid powder of Chinese origin. As part of Operation Raw Deal, $6.5 million was also seized, as well as 25 vehicles, 3 boats, 27 pill presses, and 71 weapons.

. . . The nearly two-year-old operation . . . took place in conjunction with enforcement operations in Mexico, Canada, China, Belgium, Australia, Germany, Denmark, Sweden, and Thailand.

dangerous side effects: Amphetamines are highly addictive, and those who take them experience increased metabolism, loss of appetite, and weight loss.

Athletes also use two stimulants that are not regulated drugs: caffeine and ephedrine. Endurance athletes use caffeine to increase their bodies' use of fat for energy and to conserve carbohydrates for later stages of their competitive events. Research has found such use to be effective and to have limited side effects, which include increased urine output and blood vessel spasms. The sports federations have not banned caffeine, but most place limits on the amount allowed in a competing athlete's body. Ephedrine is a naturally occurring stimulant similar to amphetamines. Like amphetamines, it has not been shown to have performance-enhancing benefits, and it has similar side effects. Despite the fact that it is not regulated by the FDA, ephedrine is banned by most sports federations.

Blood Doping

Many athletes in the past have improved their performance through blood doping—that is, by increasing the amount of red blood cells, which carry oxygen, in their blood. This increases the oxygen available to muscles and improves athletic performance in endurance events.

Historically, athletes who practiced blood doping would have several units of their own blood drawn and placed in storage six to eight weeks before competition. Their bodies would produce more red blood cells in the intervening time, and then, prior to the competition, the athletes would reinfuse their stored blood to increase their red blood cells. This process has generally been replaced by the use of the hormone erythropoietin, which causes the body to increase the production of red blood cells. All methods of blood doping are banned by sports federations.

Important Issues

A major concern related to performance-enhancing drugs is the lack of information available about them. New drugs and variations on older drugs are continually being developed, in large part because manufacturers and users are interested in staying ahead of the technology available to test athletes for the use of banned and illegal drugs. When new drugs or new forms of older drugs are developed, several years of research are required to determine if they are effective, what the proper dosages are, and what their side effects are, as well as to develop new tests to detect their use by athletes.

Typically, a new drug formulation is available for more than a year before awareness of it becomes widespread enough that research on the drug is undertaken. After the research begins, more than another year might elapse before scientists are able to determine whether the drug is effective at all, and many years might pass before the negative side effects of the drug can be identified. Developing an effective method of testing for a new drug can also take months or even years. Given this lengthy process, athletes who use performance-enhancing drugs have a wide window of opportunity for cheating.

Another serious concern raised by the use of performance-enhancing drugs is the effect of such substances on athletes' health. Many athletes, whether taking FDA-approved drugs or nontested substances, take very high doses. In fact, many take higher doses than what researchers can ethically test, and thus the true benefits and side effects of these substances are not known. Given that many of the known side effects have negative health implications, athletes who use illegal and banned substances to enhance their performance are not only breaking the rules but also risking serious health problems.

Bradley R. A. Wilson

Further Reading

Aretha, David. *Steroids and Other Performance-Enhancing Drugs*. Berkeley Heights, N.J.: Enslow, 2005. Focuses on the negative effects of steroid use. Presented in easy-to-read style.

Bahrke, Michael S., and Charles E. Yesalis, eds. *Performance-Enhancing Substances in Sport and Exercise*. Champaign, Ill.: Human Kinetics, 2002. Text includes information on the history of athletes' use and abuse of performance-enhancing drugs.

Haley, James, and Tamara Roleff. *Performance-Enhancing Drugs*. San Diego, Calif.: Greenhaven Press, 2003. Presents a wide range of opinions on performance-enhancing drugs. Includes good information on resources.

Monroe, Judy. *Steroids, Sports, and Body Image: The Risks of Performance-Enhancing Drugs*. Berkeley Heights, N.J.: Enslow, 2004. Provides an overview of steroid use and abuse by athletes. Aimed at young readers.

Yesalis, Charles E. *Anabolic Steroids in Sport and Exercise*. Champaign, Ill.: Human Kinetics, 2000. Takes a scientific approach in discussing the problems with performance-enhancing drugs in sports.

See also: Amphetamines; Anabolic Steroid Control Act of 2004; Athlete drug testing; Drug classification; Drug Enforcement Administration, U.S.; Mandatory drug testing; Stimulants.

Peruvian Ice Maiden

Date: Remains discovered on September 8, 1995

The Event: Archaeologists discovered the mummy of a fully clothed young adolescent girl frozen atop 20,700-foot Mount Ampato in Peru. Investigation revealed that the girl, who became known as the Peruvian Ice Maiden, was about fourteen years old when she died, probably as the result of a human sacrifice, about 550 years earlier.

Significance: At the time the remains were discovered, the Ice Maiden was the best-preserved mummy ever found. Although the body had not been intentionally mummified, the low temperatures and dry, thin air on the mountain had created a mummy. Because the remains were frozen rather than dried, the DNA in the body was well preserved.

Archaeologist Johan Reinhard climbed Mount Ampato, in the Andes of Peru, to get a better view of an active volcano nearby—Mount Nevado Sabancaya. The heat from the volcanic eruption, which had begun in 1990, had cleared some of the snowpack from nearby mountains, including Mount Ampato. As Reinhard and his associate Miguel Zarate neared the summit, they saw some feathers that turned out to be part of the clothing on the mummified remains of a child who had died atop the mountain more

The mummy known as the Peruvian Ice Maiden on display in Arequipa, Peru, in 1997. The mummy was later taken to Japan, raising concerns among Peruvian archaeologists that too much travel would damage the delicate body. *(AP/Wide World Photos)*

than five centuries earlier. The body's burial site had been disturbed by the snow melting caused by the nearby volcano. Reinhard and Zarate carried the eighty-pound mummy down the mountain on their backs at night, when the temperatures were lowest, to keep the frozen body from melting. It was then loaded onto the back of a mule for further transport, with sufficient padding between the mule and the frozen mummy to protect the mummy from the animal's body heat.

Importance of the Discovery

Also known as Momia Juanita (Mummy Juanita in Spanish) and the Lady of Ampato, the Ice Maiden was such a significant discovery that *Time* magazine called the event one of the ten greatest scientific discoveries of the year. In addition to the remarkable condition of the body, the burial site itself had never been touched by looters, and the gold and silver statues found there provided archaeologists with information on traditional Inca religious rituals. Because the body was accompanied by many items believed to have been offerings to the gods, experts hypothesized that the girl had herself been a sacrificial offering. Two other children's bodies were later found near the site where the Ice Maiden's remains were found.

Amid criticism from a number of native Peruvian politicians, the mummy was temporarily moved to the United States in early 1996, where it was exhibited at the National Geographic Society headquarters in Washington, D.C. President Bill Clinton was one of those who viewed the body. In 1999, the mummy visited Japan, where it was viewed by thousands.

The Ice Maiden was the best-preserved mummy in the world until 1999, when another Reinhard-led expedition found three other frozen mummies on a mountain in Argentina. The Argentine mummies still had blood in their lungs and hearts—something that was not the case with the Ice Maiden.

The Forensic Investigation

Because the Ice Maiden's mitochondrial DNA (deoxyribonucleic acid) was well preserved, scientists were able to use genetic information provided by the Human Genome Project to learn that the girl had shared ancestry with the Ngöbe people of Panama, with old Taiwanese and Korean peoples, and with Native Americans. The mummification had also preserved the internal organs well enough that several biological tests were possible, with the result that new insights were gained into nutrition and health among the Inca during the fifteenth century. While the mummy was in the United States, it was taken to Johns Hopkins Hospital in Baltimore, Maryland, where a virtual autopsy was performed, and additional scientific tests were conducted in Peru. It was found that the Ice Maiden had a well-balanced diet, strong bones, and good teeth. In general, she was in excellent health. She died from blunt force trauma to her head.

The Ice Maiden is housed in a museum at the Universidad Católica de Santa María in the Andean city of Arequipa, Peru. In 2006, Peru's leading newspaper reported that the Ice Maiden was at risk from humidity, as dampness had gotten into the glass-enclosed refrigeration compartment where the mummy is stored. The temperature is kept at about –19 degrees Celsius (–2 degrees Fahrenheit). Peruvian authorities were informed that the mummy could deteriorate within five years unless the dampness problem could be solved. Changes in the mummy's skin color have been noted—a sign that storage conditions have not been optimal. Other, more recently discovered, frozen mummies are also kept at the same museum.

Dale L. Flesher

Further Reading

Bahn, Paul. *Written in Bones: How Human Remains Unlock the Secrets of the Dead*. Buffalo, N.Y.: Firefly Books, 2003. Provides information for general readers on various discoveries of mummies and old bones, including not only Incan bodies but also Ötzi the Iceman (also known as the Tyrolean Iceman), and the so-called bog bodies of Europe. Features many photographs.

Chamberlain, Andrew T., and Michael Parker Pearson. *Earthly Remains: The History and Science of Preserved Human Bodies*. New York: Oxford University Press, 2001. Readable and well-illustrated volume describes the ways in which bodies have been preserved over the years.

Cockburn, Aidan, Eve Cockburn, and Theodore A. Reyman, eds. *Mummies, Disease, and Ancient Cultures*. 2d ed. New York: Cambridge University Press, 1998. Collection of essays includes several accounts of mummy finds as well as a chapter on mummy research techniques.

Pringle, Heather. *The Mummy Congress: Science, Obsession, and the Everlasting Dead*. New York: Hyperion, 2001. Presents excellent discussion of the science of mummy studies, including a chapter on the Ice Maiden and a chapter on the destruction of Incan mummies by Spanish explorer Francisco Pizarro.

Reinhard, Johan. *Discovering the Inca Ice Maiden*. Washington, D.C.: National Geographic Society, 1998. Brief volume aimed at young readers details in simple terms the discovery of the Inca mummy and the treasures buried with her. Includes color photographs.

_______. *The Ice Maiden: Inca Mummies, Mountain Gods, and Sacred Sites in the Andes*. Washington, D.C.: National Geographic Society, 2006. Accounts of the discovery of the Ice Maiden and other archaeological expeditions in the Andes by the leader of the expedition that discovered the Peruvian Ice Maiden. Includes many interesting photographs.

See also: Ancient criminal cases and mysteries; Blunt force trauma; Forensic anthropology; Forensic archaeology; Kennewick man; Mummification.

Petechial hemorrhage

Definition: Bleeding from the capillaries into the skin or mucous membranes, which results in tiny (pinpoint) red marks.

Significance: The presence of petechial hemorrhages can help forensic pathologists to determine cause of death in many cases because such hemorrhages are often an indication of strangulation, hanging, or smothering.

Petechial hemorrhages, sometimes referred to as punctate hemorrhages, have been recognized for years as indicators of the increased pressure on the blood vessels in the head that occurs when the airway is obstructed. They have also been found to occur in many disorders and diseases that involve blood dyscrasias (abnormalities). The mechanism by which petechial hemorrhages occur was first delineated by J. G. Humble in 1949. Anything that leads to increased pressure within the capillaries can cause them to rupture, allowing blood to leak out into the skin or mucous membranes. Petechial hemorrhages are thus caused by tears in the blood vessels and fall into the category known as rhexis hemorrhages.

Forensic pathologists have long recognized the connection between petechial hemorrhages and asphyxiation. A pathologist will often make a diagnosis of "crush asphyxia" when findings include a history of traumatic compression of the chest or abdomen, swelling of the blood vessels due to overfilling (vascular engorgement), and the presence of petechial hemorrhages. It has been shown that if vascular congestion is not present (or possible), then petechial hemorrhages will not form at the site of the compression. Typically, no petechiae are found in areas underneath tight clothes, such as women's bras. The compression of the skin caused by a bra does not allow for vascular engorgement, so no petechial hemorrhages are found in this region, This "brassiere sign" (petechial hemorrhages over the upper chest with none in the area of the bra) is taken as an indicator of crush asphyxia.

Although petechial hemorrhages are often indicators of asphyxiation, particularly when they are present in the conjunctiva of the eye or on the face, they also occur in a wide variety of other conditions. Trauma that does not involve asphyxiation may also lead to petechial hemorrhage. In the case of shaken baby syndrome, the pinpoint red marks may be found on the retina or conjunctiva of the eye as well as on the earlobe. Low platelet counts (thrombocytopenia) or coagulopathies (defects in the body's blood-clotting mechanism) often lead to the existence of petechial hemorrhages, especially on the lower extremities. They are also seen as aftereffects of cardiopulmonary resuscitation (CPR). If CPR successfully restores blood flow to small blood vessels damaged by hypoxia, the vessels may easily rupture, resulting in petechial hemorrhages.

Robin Kamienny Montvilo

Further Reading

DiMaio, Vincent J., and Dominick DiMaio. *Forensic Pathology*. 2d ed. Boca Raton, Fla.: CRC Press, 2001.

Pyrek, Kelly M. *Forensic Nursing*. Boca Raton, Fla.: CRC Press, 2006.

Smith, David S. *Field Guide to Bedside Diagnosis*. 2d ed. Philadelphia: Lippincott Williams & Wilkins, 2007.

See also: Antemortem injuries; Asphyxiation; Blood residue and bloodstains; Choking; Drowning; Hanging; Hemorrhagic fevers; Homicide; Physical evidence; Shaken baby syndrome; Strangulation; Suffocation; Suicide.

Petrographic microscopy. *See* Polarized light microscopy

pH indicators. *See* Acid-base indicators

Phenolphthalein

Definition: Chemical that is the basis for the Kastle-Meyer test, a commonly used presumptive test for blood at crime scenes.

Significance: A positive reaction to phenolphthalein of a stain found at a crime scene suggests that the stain is probably blood; such information can facilitate an initial reconstruction of a crime and prompt follow-up.

In the presence of heme iron and hydrogen peroxide, phenolphthalein, which is clear in the reduced state, is converted to an oxidized state, which is pink. Because heme iron is present in hemoglobin, the protein that carries oxygen in red blood cells, a positive test can indicate the presence of blood. Such a test does not distinguish between human blood and animal blood, however; further testing is necessary to make that distinction and, if the blood is human, to determine whose blood it is. In addition, constituents of some plants, such as potatoes and horseradish, as well as oxidizing agents found in some cleansers, can catalyze the reaction. Accordingly, a phenolphthalein test is only presumptive for blood; a positive result must be confirmed by laboratory tests.

Typically, a forensic investigator performs the test by moistening a cotton swab with deionized water and rubbing the swab on the suspect stain, adding a drop of phenolphthalein solution to the swab, waiting thirty seconds, and then adding a drop of 3 percent hydrogen peroxide to the swab. A positive reaction will turn the swab a bright pink color within fifteen seconds. Often, a swab taken near the stain of interest is used as a control. If the swab turns pinkish before the hydrogen peroxide is added, the test is invalid. To ensure that the reagents have not deteriorated before use, the investigator validates the test using a known blood standard.

First introduced in 1901, the phenolphthalein test is fairly sensitive and quite specific. In addition, phenolphthalein does not destroy the sample, which can be kept and used in further tests at the lab. The use of phenolphthalein does not interfere with subsequent DNA tests. Furthermore, phenolphthalein is among the safest of the compounds used in presumptive tests for blood in the field; most others, including benzidine and orthotolidine, are known or probable carcinogens and thus pose a risk to investigators.

James L. Robinson

Further Reading

Geberth, Vernon J. *Practical Homicide Investigation: Tactics, Procedures, and Forensic Techniques*. 4th ed. Boca Raton, Fla.: CRC Press, 2006.

Lee, Henry C., Timothy Palmbach, and Marilyn T. Miller. *Henry Lee's Crime Scene Handbook*. San Diego, Calif.: Academic Press, 2001.

Owen, David. *Hidden Evidence: Forty True Crimes and How Forensic Science Helped Solve Them*. Richmond Hill, Ont.: Firefly Books, 2000.

See also: Acid-base indicators; Benzidine; DNA typing; Luminol; Orthotolidine; Presumptive tests for blood; Reagents; Serology.

Photocopier analysis. *See* Fax machine, copier, and printer analysis

Photograph alteration detection

Definition: Techniques used to determine whether photographs have been altered in any way to change the nature of the portrayal of their subjects.

Significance: People have altered photographs for many reasons since the invention of film photography, and forensic scientists have long been called upon to examine photographs for evidence of alteration. With the advent of digital photography, the ready availability of sophisticated tools and techniques for altering images has posed an increasingly difficult problem for investigators who must rely on photographs as evidence in criminal and other legal cases.

The picture at the top is an original photograph showing Spanish dictator Francisco Franco (center) walking with German chancellor Adolf Hitler during their meeting in a French town near the Spanish border in October, 1940. The government-controlled Spanish news agency altered the photography before releasing it to newspapers. In the altered version, at bottom, Franco's eyes are open, not closed, and his right arm is in a more relaxed position, making Franco look more comfortable in the German dictator's company. *(AP/Wide World Photos)*

The alteration of a photograph taken with a film camera requires the use of brushing techniques that cover or chemically remove parts of the image. All basic methods of film photo alteration leave very obvious traces of the alteration process in the form of chemical marks and brushstrokes. Even skillful alteration of film photographic prints can generally be detected easily through the use of computer software that registers changes in lighting, positioning, or displacement of the subjects in the prints with respect to horizontal and vertical planes of reference. The alteration of digital images is usually more subtle. Digital images can be copied, edited, and shared without the loss of image quality. Software programs that allow users to alter digital images, such as Adobe Photoshop, are readily available and widely used.

In the past, criminal and civil courts were willing to admit video recordings and photographs as reliable evidence without much question. Given the ease with which digital images can be altered, however, courts now require that photographs and digital video images undergo tests to determine if they have been altered before they can be admitted as evidence. Virtually all law-enforcement agencies in the United States routinely use specialized technology to determine the integrity of digital images.

Many images produced by digital cameras contain within them a kind of coding known as watermarking; this coding preserves records of the original images. Digital watermarks are not visible to the eye, but they can be detected through the use of certain software. Such software can tell users whether primary digital images have been altered by comparing the images with the information stored in their watermarks. Some law-enforcement agencies make use of sophisticated image-processing software to restore altered digital images to their original forms.

Because of the increasing ease of altering digital images and the possibility that forensic scientists' capability of detecting such alterations may be surpassed by new techniques of alteration, some observers have urged caution in the use of photographic evidence, and others have gone so far as to suggest that courts should not admit digital images as evidence. The use of the intentional alteration of images by forensic scientists, as in the digitizing of surveillance tapes to sharpen their images, has also come into question. For example, a dark spot on an image may sharpen under one resolution to reveal an object resembling a gun, whereas under another resolution the object may appear to be a knife, or it may be revealed to be simply a spot or blotch on the original image. Many have argued that evidence produced using such an unreliable technique should not be admitted in court.

Dwight G. Smith

Further Reading

Blitzer, Herbert L., and Jack Jacobia. *Forensic Digital Imaging and Photography*. San Diego, Calif.: Academic Press, 2002.

Russ, John C. *Forensic Uses of Digital Imaging*. Boca Raton, Fla.: CRC Press, 2001.

Tarantino, Chris. *Digital Photo Processing*. Indianapolis: Muska & Lipman, 2003.

Vacca, John R. *Computer Forensics: Computer Crime Scene Investigation*. 2d ed. Hingham, Mass.: Charles River Media, 2005.

See also: Art forgery; Counterfeiting; Direct versus circumstantial evidence; Eyewitness testimony; Forensic photography; Forgery; Handwriting analysis; Imaging; Sports memorabilia fraud; Steganography.

Physical evidence

Definition: Objects that are identifiable through several of the senses and are often used to prove facts in a court of law, such as establishing that a crime has been committed or a defective product has caused harm.

Significance: Forensic scientists analyze physical evidence collected from crime scenes and other locations to determine whether and how the evidence is relevant to criminal and civil investigations. Physical evidence may link suspects to crimes or civil wrongs or exonerate innocent persons.

Generally, physical evidence is defined as nonliving, although the sources of such evidence may be humans, animals, or plants. Body fluids—such as blood, semen, and saliva—and the DNA (deoxyribonucleic acid) extracted from them are examples of biological or serology evidence that may be considered physical evidence. Physical evidence is often divided into class evidence, which can be linked only to a type (or class) of items, and individual evidence, which can be linked to a specific individual, item, or civil wrong.

Physical evidence may include things that can be seen, whether with the naked eye or through the use of magnification or other analytical tools. Some of this evidence is categorized as impression evidence, including bite marks, fingerprints, footprints, knife cuts, tire tracks, and tool marks. Pattern evidence, a subcategory of physical evidence, might include blood spatter and burn patterns. Trace evidence is in most cases microscopic physical evidence that includes fibers, flakes, gunshot and bomb residue, hair, paint, plastic, pollen, soil, dust, and small fragments of physical objects such as glass, fingernails, fluids, and wood. Trace evidence might also include poisons that can be discovered only through body organ and tissue sampling.

Some physical evidence may be detected by smell or taste, often through the use of trained dogs. Such evidence might include accelerants, bombs, chemicals, and drugs. Among the most obvious kinds of physical evidence are weapons and other objects used to commit crimes, such as blunt instruments, guns and bullets, knives, ropes, and ligatures. Forged or altered documents are also physical evidence, as are actual objects or defective parts that caused harm in civil cases.

Forensic scientists are sometimes involved in gathering evidence of cybercrimes and civil wrongs committed with the use of computers. Although digital data evidence is not technically physical evidence, the physical objects used to create and transmit such data evidence are. Thus physical evidence includes computer hardware and peripherals as well as electronic devices such as cell phones and personal digital assistants.

The digital evidence stored within computers does not constitute physical evidence; however, computers themselves and other electronic hardware devices do. *(© iStockphoto.com/Matjaz Boncina)*

Among the types of evidence generally not considered to be physical evidence are testimonial evidence from eyewitnesses, documentary evidence such as drawings or diagrams depicting crime scenes, digital evidence, audio evidence, and behavioral evidence from profiling.

Carol A. Rolf

Further Reading

Byrd, Mike. *Crime Scene Evidence: A Guide to the Recovery and Collection of Physical Evidence*. Wildomar, Calif.: Staggs, 2001.

Lee, Henry C., and Howard A. Harris. *Physical Evidence in Forensic Science*. 2d ed. Tucson, Ariz.: Lawyers & Judges Publishing, 2000.

Owen, David. *Hidden Evidence: Forty True Crimes and How Forensic Science Helped Solve Them*. Richmond Hill, Ont.: Firefly Books, 2000.

See also: Ballistic fingerprints; Crime scene search patterns; Cross-contamination of evidence; Direct versus circumstantial evidence; Disturbed evidence; DNA extraction from hair, bodily fluids, and tissues; Evidence processing; Fibers and filaments; Footprints and shoe prints; Gunshot residue; Hair analysis; Prints; Tire tracks; Tool marks.

Physiology

Definition: Study of how living organisms and their parts function, including physical and chemical processes and factors.

Significance: One of the primary sciences at the root of the forensic sciences is physiology. Knowledge of how organisms function—particularly human bodies—contributes to many forensic procedures because it helps to establish cause in injuries and death. The physiology of dying is one important area of knowledge for forensic scientists; others include the physiology of drug and alcohol consumption, DNA analysis and polygraph testing, and the physiology of organisms such as plants and microbes.

The study of physiology begins with the cell, the fundamental unit that makes up living things. Groups of similar cells form tissues, and groups of tissues form organs. The organs combine into systems that make up higher-level living organisms. Some of the systems in the human body of particular interest to forensic scientists are the cardiovascular, nervous, digestive, and respiratory systems.

Human Physiology

The functions of the human body can contribute invaluable information that investigators can use in solving crimes. Human physiology plays a major role, for example, in determination of cause of death, DNA (deoxyribonucleic acid) analysis, blood spatter analysis, polygraph testing, and the effects of drug and alcohol consumption.

When a person dies, the physiological processes cease, and the cessation of these processes can provide valuable information about the time and cause of death. In an autopsy, a forensic pathologist completes a thorough investigation of the external and internal parts of the body. This investigation includes the evaluation of any wounds, the contents of the digestive system, and any residues on the body, such as gunpowder. Hair and nail samples are also analyzed, and toxicology tests are performed on the blood.

DNA stores a cell's information and directs its activities. A portion of the DNA molecule contains a code that directs its activities, and a portion of the molecule contains a unique code for each person. The primary use for DNA in forensics is thus the identification of persons. DNA can be used to identify crime victims or the perpetrators of crimes. By analyzing skin, blood, semen, or other body tissues collected from a victim's body, investigators may be able to make connections to suspects. DNA analysis has proven to be a valuable technique in solving crimes.

Bloodstains and blood spatter patterns provide important clues in many crimes. Forensic scientists evaluate the blood evidence at crime scenes by applying knowledge about the forces that act on blood to affect its patterns on surfaces. The pumping of the heart generates pressure, causing blood to spray from a bad wound. Gravity causes blood to drip toward the ground. Movement of a wounded body can cause the blood to spray in different directions as a result of centrifugal force. Additionally, blood forms different kinds of patterns when it comes into contact with various kinds of surfaces.

Polygraph (lie detector) testing is a procedure in which a qualified tester evaluates a subject's physiological responses to questions to determine whether the person is telling the truth. The polygraph device measures several physiological responses: respiration, pulse rate, blood pressure, and skin perspiration. In general, when people are being deceptive they experience increases in blood pressure, heart rate, respiration rate, and perspiration; when they are being truthful, these measures all stay relatively constant. Although the polygraph does not provide a perfect test of truthfulness, qualified testers can get a good idea whether subjects are lying or telling the truth for each question asked.

With knowledge about how the body processes drugs and alcohol, forensic scientists can determine what substances individuals have used and in what amounts. In the body, these foreign substances are generally removed and broken down by the liver or excreted in the urine. Analyses of blood, saliva, urine, or hair samples can produce information about the presence of substances and, in some cases, the amounts ingested.

Physiology of Other Organisms

Forensic evidence is sometimes provided by nonhuman organisms such as plants, insects, and microbes. Because plants produce pollen and seeds and are fixed in their particular geographic locations, evidence of plant life can be used to connect possible suspects to crime scenes. For example, at a crime scene where specific plants are present, the perpetrator may unknowingly carry away seeds or pollen from those plants on body, shoes, or clothing; by analyzing such evidence, investigators can connect the person to the crime scene.

Insects can provide forensic evidence through experts' analysis of insect bite marks and waste products found on the bodies of crime victims or suspects. In addition, the types of insects found on human remains, as well as the activity patterns of those insects, can help determine the time and location of death. Some kinds of insect activity are also used in the determination of neglect and abuse in children and the elderly. The types of insects found splattered on vehicle windshields and radiator grills can provide information about where the vehicles have traveled.

Microbes—that is, microscopic organisms—can provide information about the origins of infections. Forensic scientists may also examine microbes and their DNA in cases of biological crimes, such as mailings of the spores that cause anthrax. By comparing the DNA of microbes used in a crime with the DNA of any such microbes found in a suspect's home, for example, scientists may be able to link the suspect to the crime.

Bradley R. A. Wilson

Further Reading

Breeze, Roger G., Bruce Budowle, and Steven E. Schutzer, eds. *Microbial Forensics*. Burlington, Mass.: Elsevier Academic Press, 2005. Reviews the relationships between microbe physiology and forensics.

Coyle, Heather Miller, ed. *Forensic Botany: Principles and Applications to Criminal Casework*. Boca Raton, Fla.: CRC Press, 2005. Contains information on plant physiology and its relationship to forensic science.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005. Provides an overview of forensic science procedures, many of which are based on physiology.

Mozayani, Ashraf, and Carla Noziglia, eds. *The Forensic Laboratory Handbook: Procedures and Practice*. Totowa, N.J.: Humana Press, 2006. Covers most of the procedures based on physiology that are used in forensic laboratories.

Mozayani, Ashraf, and Lionel P. Raymon, eds. *Handbook of Drug Interactions: A Clinical and Forensic Guide*. Totowa, N.J.: Humana Press, 2004. Evaluates various drugs and describes their physiological effects on the body.

See also: Biometric identification systems; DNA analysis; Drug confirmation tests; Forensic pathology; Medicine; Nervous system; Polygraph analysis; Sobriety testing.

Poisons and antidotes

Definitions: A poison is any chemical or biological compound that can damage the body's organs or tissues. An antidote is any substance that can reverse or mitigate the damage done by a poison.

Significance: A forensic examination to determine cause of death may involve inspection of the body for poisonous residue or for the effects of poison on the body. Body tissues may also be subjected to toxicological analyses to identify any possibly poisonous substances present.

Many substances that are poisonous are, in fact, useful as medicines in the proper doses. The body can tolerate many poisonous substances; much depends on the amount of poison given and whether the body has been able to build up a tolerance to the substance. Some poisons, such as warfarin (a drug that keeps the blood from clotting), were developed as medicines but were later used as poisons. Poisoning can be acute (exposure on one occasion) or chronic (exposure over a period of time).

Types of Poisons

Poisons are generally divided into three large groups: biological poisons (such as plant substances), chemical poisons (such as insecticides and industrial substances), and drugs and pharmaceuticals. Biological poisons fall into three major categories: microbial toxins (produced by bacteria), phytotoxins (produced by plants), and zootoxins (produced by animals). These poisons are generally either ingested (as in the case of poisonous mushrooms) or taken in through the skin (such as through a bite or sting).

Chemical poisons, such as insecticides, herbicides, and industrial or household chemicals, generally cause body damage (skin damage or damage to the parasympathetic system, for example) but may also cause death by depressing the respiratory system. Organic compounds such as hydrocarbons, alcohols, or aldehydes are likely to cause damage involving the route through which they enter the body. For example, if inhaled, these compounds cause lung damage; if ingested, they cause damage to the gastrointestinal tract. Inorganic (generally metal) compounds such as mercury, lead, and cadmium can damage the brain, kidneys, nervous system, and gastrointestinal system. These types of poisons can accumulate in the body over a period of time and cause death.

Drugs and pharmaceuticals, which are generally ingested, tend to cause gastrointestinal irritation and may cause nausea and vomiting. Some compounds, such as morphine, can interfere with muscular activity, eventually causing death. Barbiturates can also depress the central nervous system, leading to respiratory failure and death.

How Antidotes Work

Antidotes work by counteracting the effects of poisons. Some poisons have specific antidotes, whereas other poisons have no known antidotes. One way to counteract a poison is to prevent the gastrointestinal tract from absorbing it. Activated charcoal can bind to a poison, making it difficult for the body to absorb it.

Another possible antidote is the introduction of a substance that keeps the body busy metabolizing it rather than the poison. For example, in ethylene glycol (antifreeze) poisoning, ethyl alcohol is administered. Ethyl alcohol is chemically similar to ethylene glycol, and the body be-

Graham Young, Poisoner

It has been said that one can be a successful poisoner or a famous poisoner, but not both. Somehow, Graham Young managed to achieve both success and fame with his uses of poison.

Young started experimenting with the effects of poisons on the human body when he was fourteen years old. He tested antimony and digitalis on members of his family, often making them violently ill. He escaped suspicion for quite some time, probably because he often ingested the food or drink he had poisoned and became sick, too. His stepmother eventually died from poisoning, and Young came under suspicion. He confessed to poisoning his stepmother as well as his father, sister, and a school friend, and he was subsequently sent to a secure psychiatric hospital for mentally unstable criminals. During his stay there, Young continued to study poisons and their effects and was suspected of continuing his experiments on his fellow inmates.

Released from the hospital in 1971, having been deemed "fully cured," Young began work at a large photography supply store. He began poisoning again; this time his victims were his supervisor and his coworkers. The illness his victims displayed was labeled as a strange flu, partly because of the enormity of Young's poisoning—he is thought to have poisoned up to seventy people during this time, mostly by lacing their tea with antimony or thallium. Only two became sick enough to die, however: a supervisor and a coworker whom Young particularly did not like.

Apparently, Young felt that his poisoning was not getting the attention it deserved, as he suggested to the company doctor that thallium poisoning could be the cause of the illness sweeping through his workplace. One of his coworkers knew of Young's interest in poisons, and he quickly became a suspect. After authorities found out about his previous poisoning conviction and discovered a diary listing in detail the persons he had poisoned and the amounts of poison he had given each, Young was convicted. He died in prison in 1990, at the age of forty-two. The official cause of death was a heart attack, but some speculation exists that his fellow inmates may have somehow caused his death because they suspected him of poisoning them.

Kit containing vials of an antidote known as BAL (from "British Anti-Lewisite"), which was developed during World War I for use against heavy-metal poisons, such as mercury and arsenic. The antidote was still being used in the United States during the early twenty-first century. *(AP/Wide World Photos)*

gins to metabolize the ethyl alcohol quickly, leaving the ethylene glycol to pass through the system.

Other antidotes involve binding or trapping poison molecules or the body's receptors to those molecules. Atropine is used as an antidote to nerve gas, for example; it binds to the nervous system's acetylcholine receptors, preventing the nerve gas from doing so. Poisons that affect the skin can be counteracted with ointments that trap the poison molecules and keep them from being absorbed by the skin.

Emetics (substances that cause vomiting, such as syrup of ipecac) and cathartics (agents that cause diarrhea) are generally no longer recommended as antidotes for poison.

Marianne M. Madsen

Further Reading

Emsley, John. *The Elements of Murder: A History of Poison*. New York: Oxford University Press, 2005. Focuses on five deadly poisons (mercury, arsenic, antimony, lead, and thallium) and their use throughout history in murders.

Flanagan, Robert J., and Alison L. Jones. *Antidotes*. New York: Taylor & Francis, 2001. Covers the development and clinical uses of antidotes and their mechanisms of action.

Gupta, S. K., ed. *Emergency Toxicology: Management of Common Poisons*. New Delhi: Narosa, 2002. Discusses the treatment of poisoning cases, focusing on household products and industrial chemicals.

Klaassen, Curtis D., ed. *Casarett and Doull's*

Toxicology: The Basic Science of Poisons. 7th ed. New York: McGraw-Hill, 2007. Comprehensive work includes discussion of the principles, concepts, and mechanisms of modern toxicology.

Nelson, Lewis S., Richard D. Shih, and Michael J. Balick. *Handbook of Poisonous and Injurious Plants*. 2d ed. New York: Springer, 2007. Informative reference guide is intended for clinicians as well as laypersons interested in plant life and its possible dangers. Includes color photographs.

Stevens, Serita, and Anne Bannon. *Howdunit Book of Poisons: A Guide for Writers*. Cincinnati: Writer's Digest Books, 2007. Focuses on the use of poison as a plot point for mystery and crime writers. Includes information about how toxicologists uncover poisoning crimes.

See also: Ancient science and forensics; Arsenic; Biotoxins; Botulinum toxin; Carbon monoxide poisoning; Chemical terrorism; Forensic toxicology; Markov murder; Product tampering; Ricin; Toxicological analysis.

Polarized light microscopy

Definition: Technique that employs special filters to enhance microscopic images.

Significance: Polarized light microscopy is one of the microscopic techniques most commonly used by forensic scientists in the examination and identification of specimens. It is critical in the analysis of small evidence samples.

Although polarized light microscopy has been in use for almost two centuries, it remains one of the most powerful tools available for trace evidence analysis. Polarized light microscopy is a type of light microscopy that uses special filters to enhance the image of a sample. This technique is also known as petrographic or chemical microscopy.

Polarized light microscopy is generally one of the first methods chosen for characterizing and identifying various microscopic materials. By analyzing the optical properties of a sample with this technique, a forensic scientist can collect specific sample characteristics that cannot be obtained with other types of microscopy. Optical properties can provide much information about the structural features and composition of a specimen.

Polarized Light Microscopes

A polarized light microscope is equipped with two special filters, called polarizers, that help enhance the image of a specimen. One filter is referred to as the polarizer and the other is called the analyzer. The two polarizing elements are positioned in the optical path of the microscope. The polarizer is placed in the light

A scientist examines a sample using a polarized light microscope. *(State of California)* path before the sample, such as underneath the microscope stage, with the preferred direction usually set left to right, or east to west. The analyzer is situated in the optical path in the body of the microscope above the objectives and is positioned between the sample and sample viewing. The analyzer is aligned opposite from the polarizer in a north-south direction. Both polarizer and analyzer can typically be rotated 360 degrees on most microscopes, and the analyzer can be moved into or out of the light path as required. Information can be collected using both plane-polarized light, in which only the polarizer is in place, or using crossed polarizers, in which both the polarizer and the analyzer are in place and positioned at right angles to each other.

Light is emitted from a source in all directions, but when this light is filtered through a polarizer, only light that vibrates in a specific direction can pass through the filter. In polarized light, the light waves all vibrate in the same direction. The direction in which light vibrates cannot be detected by the human eye, but it can be indicated by color effect or by intensity. Polarized light takes advantage of these features to enhance the image of the specimen. A common example of polarized light is polarized sunglasses, which reduce glare and improve visibility by filtering out all light except that traveling in one direction.

Optical Properties

Based on optical properties, materials can be divided into two general categories referred to as isotropic or anisotropic. Isotropic materials demonstrate the same optical properties in all directions; examples include gases, liquids, and certain glasses and crystals. Because they are optically the same in all directions, isotropic substances have only one refractive index. About 90 percent of all solid materials are anisotropic, however; that is, they have optical properties that vary with the orientation of incoming light and structure of the materials. Rather than having only one refractive index, as do isotropic materials, anisotropic materials have refractive indices that vary depending on the direction of incident light and the sample's structure.

When light interacts with an anisotropic sample, the light is split into component rays; this is called birefringence. Polarized light microscopy uses birefringence, or splitting of light, to cause light rays to interact in a specific way that generates information about the material being examined. When light hits anisotropic material, individual wave components are generated that vary in propagation direction and speed, and the light waves become out of phase. As out-of-phase light waves pass through the analyzer, they are recombined and are either added or subtracted through interference, and the light diffuses into various colors, known as interference colors. Interference colors are indicators of specific sample characteristics and can be used to identify samples. If the specimen is rotated, changes in brightness or color may be observed that can also help in sample identification.

Sample Analysis

The polarized light microscope is the instrument of choice for analyzing many types of small pieces of evidence (such as fibers, hairs, residues, inks, paints, illicit drugs, munitions, wood fragments, minerals, and soils) based on the specific appearance of different materials under polarized light. Information about important sample characteristics, such as shape, color, size, surface texture, and optical density, can be essential for determining the identity of an unknown specimen.

Polarized light microscopes are very sensitive and can be used for both quantitative and qualitative analyses. In addition to contributing important information about a sample's optical properties, polarized light microscopy can be used to make nondestructive analytical measurements. Enough information is generally collected from examination using polarized light microscopy to identify an unknown specimen or at least to reduce the number of possibilities. Additional chemical or structural analysis can follow to characterize the sample further or confirm the sample's identity. Polarized light microscopy is often combined with other techniques, such as spectroscopy, in a complete analytical scheme for examining forensic samples.

C. J. Walsh

Further Reading

Houck, Max M., and Jay A. Siegel. *Fundamentals of Forensic Science*. Burlington, Mass.: Elsevier Academic Press, 2006. General textbook geared toward both students and professionals covers many aspects of the forensic sciences. Includes an informative chapter on microscopy.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005. Introductory text includes sections on polarized light microscopy as it relates to the analysis of trace evidence.

Mozayani, Ashraf, and Carla Noziglia, eds. *The Forensic Laboratory Handbook: Procedures and Practice*. Totowa, N.J.: Humana Press, 2006. Comprehensive textbook presents discussion of the use of polarized light microscopy in various types of sample analysis.

Petraco, Nicholas, and Thomas Kubic. *Color Atlas and Manual of Microscopy for Criminalists, Chemists, and Conservators*. Boca Raton, Fla.: CRC Press, 2004. Presents a collection of photomicrographs of specimens examined using polarized light microscopy. Includes introductory material on forensic microscopy.

Saferstein, Richard, ed. *Forensic Science Handbook*. 2d ed. Vol. 1. Upper Saddle River, N.J.: Prentice Hall, 2002. Provides discussion of the use of analytical instruments in forensic science, including a chapter that covers polarized light microscopy.

See also: Analytical instrumentation; Confocal microscopy; Fibers and filaments; Hair analysis; Micro-Fourier transform infrared spectrometry; Microscopes; Microspectrophotometry; Paint; Physical evidence; Scanning electron microscopy; Trace and transfer evidence.

Police artists. *See* Composite drawing

Police dogs. *See* Cadaver dogs; Canine substance detection; Scent identification

Police psychology

Definition: Variety of professional services offered by psychologists in law-enforcement settings.

Significance: The varied contributions of psychologists to the work of law enforcement have altered the ways in which certain police tasks are performed and have greatly improved the processes of law-enforcement personnel recruitment and evaluation.

The initial involvement of psychologists with law enforcement had its roots in the early twentieth century work of well-known cognitive psychologists Louis Thurstone and Lewis Terman, who applied the measures of IQ that they developed to the assessment of police officers. It was not until the latter part of the century, however, that psychologists began to work with police departments in a full-time capacity and to increase the variety of their services. Two of the early pioneers in this regard were Martin Reiser of the Los Angeles Police Department and Harvey Schlossberg of the New York City Police Department. Reiser was best known for his work in the development of forensic hypnosis techniques and the treatment of police stress. Schlossberg was the first police officer to obtain a doctoral degree in clinical psychology. He went on to become his police department's first full-time psychologist.

Psychological work in law enforcement is commonly related to four primary areas: applicant screening, officer counseling, performance of assessments of officers' fitness for duty, and participation in hostage negotiations.

Applicant Screening

The screening of applicants for law-enforcement jobs is typically accomplished in two stages: A battery of psychological instruments, including various personality tests, is administered, followed by an interview with a staff psychologist to review the results. Taking the tests can be stressful in itself, as the tests are typically given one after the other and several contain more than three hundred response items. By far the most heavily used (and most researched) instrument is the Minnesota Multiphasic Personality Inventory (MMPI). The items on this test are subdivided into scales that assess various aspects of psychopathology, and applicants who score high on one or more of these scales are questioned about their responses by the psychologist. Often, questioned applicants claim that they misunderstood the items; if the psychologist decides that an applicant's scores on the instrument's internal lie scales indicate a lack of candor, the applicant may be asked to take the test again. If pathological tendencies remain unexplained to the examining psychologist's satisfaction, this may be grounds for rejection.

The administration of psychological tests is typically part of a "screening out" recruitment model, which focuses on detecting applicants' inability to tolerate stress and prejudicial attitudes toward various groups officers may encounter in their work (including women, homeless people, gays, and members of racial or ethnic minority groups). The California Personality Inventory (CPI) is another popular test; it is oriented toward measuring adaptive or prosocial psychological tendencies. The CPI is often used when recruitment is done using a "selecting in" model, which aims to identify applicants with particular qualities or abilities that are desirable for police work. This may be especially relevant for those police forces that have adopted a "community policing" model, which emphasizes close work between law-enforcement personnel and community members on a variety of projects that address quality-of-life issues. Personality attributes such as warmth, empathy, insight, and creativity are important types of selection criteria in these circumstances.

In a crisis-intervention training session, a Waycross, Georgia, police officer (left) talks to a student pretending to be a suicidal person preparing to jump from a high ledge. *(AP/Wide World Photos)*

Counseling

The counseling aspects of police psychology focus on addressing the immediate needs of officers referred by supervisors. The most common problems are difficulties in dealing with the inherent stresses of the work and unresolved anger management issues. This part of the police psychologist's role is especially controversial among police officers themselves. Officers who receive counseling are typically not being evaluated on a voluntary basis, and, in many departments, it is routine at the initial consultation for the psychologist to authorize a temporary removal of the officer's gun. Many of the officers referred for counseling have family members who served long careers in law enforcement without ever having to face this issue, and it is traumatic for them. The weapon itself is an integral part of an officer's self-identity, and its removal, even for a temporary period, is a devastating blow to the officer's ego and affects the officer's reputation on the force.

Most police counselors function in a short-term capacity. That is, a counselor will assess an officer's initial problem and then may offer a limited number of therapy sessions in attempting to define the parameters of the problem further and develop an approach toward resolution. Longer-term therapeutic interventions are usually referred to outside psychologists or psychiatrists, even when a police department is large enough to employ its own psychologists on a full-time basis.

Fitness for Duty

A specialized form of short-term psychological services is the fitness-for-duty evaluation (FFDE). FFDEs are often oriented toward the assessment of stress tolerance or other possible difficulties that officers may be perceived to have in carrying out their jobs. Such evaluations may be required on a regular basis for personnel in high-stress units. FFDEs are often conducted routinely after any incidents involving the use of weapons, as part of efforts to screen for ongoing psychological difficulties in the aftermath of particularly stressful events.

A full evaluation of fitness for duty involves multiple data sources, including standardized psychological tests and clinical interviews, citizen complaints, background check reports, and records of any medical interventions. U.S. courts have generally upheld the right of police departments to require their personnel to undergo FFDEs when specific circumstances indicate that this practice will support the interests of public safety or maintain or increase the efficiency of the department's work.

It has been recommended that FFDEs be conducted by licensed psychologists who are knowledgeable about the relevant police psychology literature and related civil rights issues that affect law-enforcement agencies. The rationale justifying the evaluation of an officer's fitness for duty should be specific and based on alleged job behavior. The report that the evaluating psychologist later provides to law-enforcement executives should include only information that is directly relevant to the performance of the officer's job duties. FFDE sessions are sometimes recorded on audio- or videotape to protect departments from later allegations of arbitrariness or bias.

Participation in Hostage Negotiations

Psychologists' involvement in police hostage negotiations and on related crisis-intervention teams has been significant, especially since the early 1970's, when the Attica prison riot and the murder of the Israeli Olympic athletes at the Munich Olympic games received worldwide attention. Although psychologists' ultimate goal in hostage negotiations is to diffuse these situations through the use of an active system of creative problem resolution, the first thing psychologists must address is the emotionality of the hostage takers. This part of the intervention often proceeds in distinct stages: First, the negotiation team establishes communication with the hostage takers and convinces them that the team clearly hears and understands their demands (even though they do not agree with them); the negotiation team then lets as much time pass as possible to decrease the emotional level of the situation while investigators work to obtain more detailed information about what caused the situation, the present dangers and their likelihood of occurrence, and what can be done to and for the hostage takers when the immediate crisis is over. Only after these stages have successfully passed can psychologists begin the active work of problem resolution with optimal chances for success.

A large part of the police training provided by psychologists working in the areas of hostage negotiation and crisis intervention is conducted in a role-playing format. Much of this work is based on actual past incidents, frequently cases involving domestic violence, workplace violence, or suicide. Role-playing exercises in such training may last from several minutes to several hours; those of relatively long duration have obvious advantages in terms of their ability to simulate actual situations realistically. Online training modules have also been developed that take full advantage of both synchronous and asynchronous communication modes.

Eric Metchik

Further Reading

Reiser, Martin, and Nels Klyver. "Consulting with Police." In *The Handbook of Forensic Psychology*, edited by Irving B. Weiner and Allen K. Hess. New York: John Wiley & Sons, 1987. Reviews a variety of psychological interventions in law enforcement. Reiser is widely acknowledged as the leading pioneer in the development of this field.

Rostow, Cary D., and Robert D. Davis. *A Handbook for Psychological Fitness-for-Duty Evaluations in Law Enforcement*. New York: Haworth Clinical Practice Press, 2004. Presents a comprehensive structural analysis of all major aspects of law-enforcement FFDEs within the broader context of police psychology.

Rostow, Cary D., Robert D. Davis, and Judith P. Levy. "Police Psychology: The Influence of *Daubert* and Its Progeny." *Journal of Police and Criminal Psychology* 17, no. 2 (2002): 1-8. Includes analysis of important legal developments related to the qualification of expert witnesses and offers practical suggestions for how experts can meet the legal requirements.

Vecchi, Gregory M., Vincent B. Van Hasselt, and Stephen J. Romano. "Crisis (Hostage) Negotiation: Current Strategies and Issues in High-Risk Conflict Resolution." *Aggression and Violent Behavior* 10, no. 5 (2005): 533-551. Traces historical developments in the field of crisis negotiation and analyzes a specific model developed by the Federal Bureau of Investigation. Also discusses possible future trends in the field.

Walker, Lenore E. A., and David L. Shapiro. *Introduction to Forensic Psychology: Clinical and Social Psychological Perspectives*. New York: Kluwer Academic/Plenum, 2003. Provides a comprehensive, multidisciplinary review of key advances in the work of psychologists in criminal justice agencies.

See also: Criminal personality profiling; *Daubert v. Merrell Dow Pharmaceuticals*; Federal Law Enforcement Training Center; Forensic psychiatry; Forensic psychology; *Frye v. United States*; Hostage negotiations; Minnesota Multiphasic Personality Inventory; Polygraph analysis; Psychological autopsy; Training and licensing of forensic professionals; Trial consultants.

Pollen and pollen rain

Definitions: Pollen is the male reproductive structure of all flowering plants that is transported by wind, water, or animals to the female flower. Pollen rain is the release of vast amounts of pollen by male flowering plants of an ecological landscape.

Significance: Palynological analysis of pollen rain can be an important tool in crime investigations because it can help determine chronology and the type of ecological community within which an event may have occurred.

Pollen is the male gametophyte of a flowering plant. It originates in the anther of a flower, which consists of chambers called pollen sacs. Each pollen sac gives rise to microscopic grains of pollen. Pollen grains are not the equivalent of sperm in animals; rather, each pollen grain consists of at least two cells, a generative cell that produces the sperm to fertilize the female egg and a larger tube cell that provides the corridor to deliver the sperm to the egg.

Transfer of pollen to the female flower is accomplished via wind, water, or animals; wind-borne pollen is known as pollen rain. To facilitate dispersal by wind, pollen is small, lightweight, unscented, and generally inconspicuous. The spores released by mosses, ferns, and fungi are also considered part of pollen rain, and the study of such spores is part of forensic botany.

The volume of pollen rain released annually in any given area is enormous, with pollen covering the landscape in a very fine layer. Despite the abundance of pollen, this coating is invisible, or nearly so, except with the aid of a microscope. Pollen may become lodged in respiratory tracts and can accumulate on clothes, hair, and body. The pollen rain of a given area is called a pollen assemblage. Because each species of plant and fungus contributes its own unique pollen, such pollen assemblages are natural fingerprints of the vegetation in their areas; these fingerprints may differ significantly from one area to another.

Palynology is the examination and analysis of pollen assemblages. By comparing the pollen grains found on or in corpses, on suspects and their possessions, and on other objects, forensic palynologists can link particular persons with crime scenes based on the expected pollen rain for those areas.

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Further Reading

Coyle, Heather Miller, ed. *Forensic Botany: Principles and Applications to Criminal Casework*. Boca Raton, Fla.: CRC Press, 2005.

Faegri, Knut, Peter Emil Kaland, and Knut Krzywinski. *Textbook of Pollen Analysis*. 4th ed. New York: John Wiley & Sons, 1989.

Horrocks, Mark, and Kevan A. J. Walsh. "Forensic Palynology: Assessing the Value of the Evidence." *Review of Palaeobotany and Palynology* 103 (1998): 69-74.

See also: Forensic botany; Forensic geoscience; Forensic palynology; Physical evidence; Trace and transfer evidence.

Polygraph analysis

Definition: Interrogation technique that measures physiological responses to detect deception.

Significance: Polygraph analysis, also known as lie detection, is widely used as part of law-enforcement investigations in the United States, although controversy exists regarding the reliability of the technique.

Polygraph analysis enjoys a rich history in the United States, where law-enforcement agencies have used it in interrogations with varying results since the early twentieth century. The reliability of the technique for detecting deception is the topic of ongoing controversy. Some proponents claim that polygraph analysis can detect deception with approximately 95 percent accuracy, whereas many scientists contend that the technique detects deception at rates only slightly better than chance.

History

William Moulton Marston is credited with inventing the discontinuous polygraph, which records physiological signals only at select times during an interrogation. As inventor and marketer, Marston brought great attention to the polygraph in the early twentieth century. He claimed that the polygraph was the end-all solution to difficulties with detecting deception during interrogation. Building on Marston's invention, John A. Larson developed a continuous polygraph, which he called a cardio-pneumo-psychograph, in 1921. Unlike Marston, however, Larson was critical of the polygraph and cautioned against its use in court proceedings. Mirroring Larson's viewpoint, the U.S. Supreme Court decided in *Frye v. United States* in 1923 that insufficient scientific support existed to allow polygraph results to be used as evidence in court proceedings.

In response to the *Frye* ruling, scientists worked toward developing scientifically validated polygraphy techniques. In 1930, Leonarde Keeler, an associate of Larson, and John E. Reid helped form the Scientific Crime Detection Laboratory of Northwestern University

A police lieutenant (left) asks the questions and a police detective answers them as the two demonstrate the equipment used in a polygraph examination. *(AP/Wide World Photos)*

to enhance polygraph interrogation methods. Keeler later opened the first polygraphy training school in 1938. Reid followed suit, opening John E. Reid and Associates in 1947. These two schools became the most prominent polygraphy schools in the United States.

Equipment

The equipment used during a modern polygraph interrogation includes a physiological data acquisition device that measures respiration, blood pressure, pulse, and palmar sweating on a continuous basis. The traditional polygraph is a mechanical instrument that records physiological signals on a moving paper chart; following the interrogation, the chart is hand-scored by the polygrapher.

Increasingly, the traditional polygraph is being replaced by the computerized polygraph, which acquires, stores, and analyzes data in digital form. Computerized polygraphs often score charts by applying mathematical formulas based on the results of previous polygraph examinations.

Interrogation Techniques

Although most polygraphs measure the same physiological indicators, the interrogation techniques used by polygraphers vary greatly. The three most commonly used methods of interrogation are the irrelevant/relevant (I/R) test, the control question test (CQT), and the guilty knowledge test (GKT).

The I/R test was the original method of interrogation in early polygraphy, and it is still commonly used by some employers during personnel screening interviews. This technique uses a combination of task-irrelevant and task-relevant questions. An example of a task-relevant question is “Have you ever stolen an item valued at more than twenty dollars?” An example of a task-irrelevant question is “Is your name Bob?” The underlying rationale is that more marked physiological responses during task-relevant questions suggest deception. For instance, if an interview subject who was asked the two preceding questions had stolen an item valued at more than twenty dollars, that person would presumably show a greater physiological response to the relevant question than to the irrelevant question.

The CQT, which is a variant of the I/R test, is the most commonly used polygraphic technique in the United States. The CQT uses a combination of control, task-relevant, and task-irrelevant questions. An example of a control question is “Have you ever stolen an item valued at more than two dollars?” An example of a task-relevant question is “Did you steal one hundred dollars from Joe’s wallet on December 17?” Control questions are designed to elicit known lies from just about everyone, thereby serving as a baseline with which to gauge the examinee’s physiological “lie” response. The rationale is that guilty examinees should react more to task-relevant questions than to control questions because they are concerned about being caught for the specific crime in question, whereas examinees who are innocent of the crime in question will respond more to control questions because they are concerned about appearing to be criminal types.

The GKT technique investigates criminal guilt without attempting to identify a lie response. In this respect, it contrasts sharply with the I/R test and CQT. Although the GKT is used rarely by law-enforcement agencies in the United States, it is the preferred interrogation method in Japan. Instead of asking directly whether an examinee participated in a crime, the GKT attempts to assess concealed knowledge. It does so by asking specific questions about the crime followed by multiple-choice options. For example, if the walls of the room in which someone was beaten were painted blue, a GKT question might be “The paint in the room where the beating took place was: red, white, blue, or green?” The assumption is that guilty examinees will react more strongly to correct details of a crime, whereas innocent examinees will not.

Applications

Until the late 1980’s, many American businesses used polygraphy as a tool for screening employees and job applicants, but with passage of the Employee Polygraph Protection Act of 1988, a federal law, private employers were prevented from using polygraphy in this way. Government agencies, contractors working with government agencies, and private-sector employees suspected of theft were exempted from this protection, however. Several government agencies, including the Federal Bureau of Investigation (FBI), the Central Intelligence Agency (CIA), the Department of Energy, and the National Security Agency, use the polygraph for employee screening on a regular basis.

Following the U.S. Supreme Court’s decision in *Frye v. United States*, polygraph results were rarely introduced as evidence during court proceedings. In 1993, the Court’s ruling in *Daubert*

Origins of the Polygraph

The Italian criminologist Cesare Lombroso is credited with developing the principles behind polygraph testing during the 1890’s. A pioneer of modern scientific criminology methods, he sought to explain criminal behavior through human biology. He discovered that blood pressure increased in test subjects after they provided deceptive responses to questions. Later, William Moulton Marston and John A. Larson separately came to the conclusion that blood pressure and respiration are correlated. Larson constructed the actual recording device in 1921, but Leonarde Keeler and Walter Summers refined the direct predecessor of the modern polygraph testing device around 1924. Following their advances, investigators and employers began to use the polygraph as a matter of practice.

Douglas A. Orr

v. Merrell Dow Pharmaceuticals built on the *Frye* ruling by developing guidelines for introducing scientific evidence into court proceedings. The guidelines the Court established, collectively known as the *Daubert* standard, are as follows: Scientific evidence must be based on a testable theory or technique, the theory or technique must be peer-reviewed, the technique must have a known error rate, and the underlying science must be generally accepted by the scientific community. Following the *Daubert* decision, polygraph evidence became largely inadmissible in criminal proceedings. In half of U.S. state courts, polygraph evidence continues to be admissible in criminal proceedings when the defense and prosecution agree to the admissibility of the results before the test is taken. The results of polygraph analysis are commonly used in civil proceedings, however, and law-enforcement agencies often use the technique in screening criminal suspects.

Continuing Controversy

In 1997, David T. Lykken and William G. Iacono polled 363 scientists from the American Psychological Association and the Society for Psychophysiological Research concerning the use of GKT and CQT polygraph interrogation techniques. They found that although 75 percent of the scientists surveyed believed that the GKT is based on sound scientific evidence, only 33 percent held this view of the CQT. Moreover, only about 25 percent of the scientists polled believed that polygraph evidence should be allowed in a courtroom.

Critics of polygraph analysis assert that the technique rests on the faulty assumption of a "Pinocchio response"—that is, a specific physiological lie response or "signature" of deception. Scientific studies have found no evidence of such a response. Moreover, real-world studies of people who have been conclusively found either guilty or innocent of crimes suggest that the polygraph has a high false positive rate, meaning that it mistakenly classifies many innocent people as guilty. These findings have led many critics, such as Lykken and Paul Ekman, to refer to the polygraph as an "arousal detector" rather than a lie detector. They assert that many people may fail polygraph tests not because they are guilty of crimes but because they display nervousness, indignation, or surprise in response to the relevant questions.

Polygraph analysis may also be plagued by false negatives, or guilty individuals mistakenly classified as innocent. Some false negative results can be produced by "countermeasures"—tricks that help people "beat" the polygraph by allowing them to boost their physiological responses to irrelevant or control questions. Such countermeasures can be physical (such as biting down on one's tongue during these questions) or mental (such as performing complex mental arithmetic during these questions).

Attempts to study the validity of polygraph results are complicated by at least two major obstacles. First, laboratory studies cannot simulate the intense pressure of real-world polygraph interrogations, because the arousal associated with a lie generated for the purposes of a study probably differs from that associated with a lie generated to avoid imprisonment or even capital punishment. Second, studies of polygraph use in real-world settings may overestimate the accuracy of the results as applied to the general population, because many suspects are guilty of the crimes of which they have been accused. For example, if thirty-six of forty suspects in a study sample are guilty and all forty polygraph tests indicated guilt, one could claim that the polygraph was 90 percent accurate. These obstacles suggest that novel research methodologies are required to evaluate the validity of polygraphy in practice.

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Further Reading

Iacono, William G., and David T. Lykken. "The Validity of the Lie Detector: Two Surveys of Scientific Opinion." *Journal of Applied Psychology*, 82 (1997): 426-433. Reports on the results of a survey of several hundred expert psychologists regarding their opinions on the utility and admissibility of the polygraph in court.

Iacono, William G., and Christopher J. Patrick. "Polygraph ('Lie Detector') Testing: Current Status and Emerging Trends." In *The Handbook of Forensic Psychology*, edited by Irving

B. Weiner and Allen K. Hess. 3d ed. Hoboken, N.J.: John Wiley & Sons, 2006. Provides a comprehensive examination of the history and scientific evidence surrounding the polygraph.

Inbau, Fred E., John E. Reid, Joseph P. Buckley, and Brian C. Jayne. *Criminal Interrogation and Confessions*. 4th ed. Boston: Jones & Bartlett, 2004. Presents a good discussion of polygraph interrogation techniques.

Larson, John A. *Lying and Its Detection: A Study of Deception and Deception Tests*. Chicago: University of Chicago Press, 1932. Outlines Larson's critical evaluation of the polygraph as a device for lie detection.

Lykken, David T. *A Tremor in the Blood: Uses and Abuses of the Lie Detector*. 2d ed. New York: McGraw-Hill, 1996. Provides a comprehensive and critical review of the history, development, implementation, and scientific study of the polygraph.

Marston, William Moulton. *The Lie Detector Test*. New York: Richard R. Smith, 1938. Discusses Marston's beliefs regarding the infallibility of the polygraph.

National Research Council. *The Polygraph and Lie Detection*. Washington, D.C.: National Academies Press, 2003. Presents the findings of the council's review of scientific studies of the polygraph.

Raskin, David C., and Charles R. Honts. "The Comparison Question Test." In *Handbook of Polygraph Testing*, edited by Murray Kleiner. San Diego, Calif.: Academic Press, 2002. Reviews the CQT polygraph interrogation technique.

See also: Ancient science and forensics; Brainwave scanners; Courts and forensic evidence; *Daubert v. Merrell Dow Pharmaceuticals*; Expert witnesses; *Frye v. United States*; Interrogation; Physiology; Police psychology; Pseudoscience in forensic practice.

Polymerase chain reaction

Definition: Laboratory technique used to generate large numbers of copies of DNA for analysis.

Significance: The technique of polymerase chain reaction allows forensic scientists to use extremely small amounts of sample DNA to identify individual humans, animals, and other organisms. Such analyses are used for many purposes, including to link suspects to crime scenes, to identify the victims of mass disasters, to establish paternity, and to identify pathogens.

The molecule of life, DNA (deoxyribonucleic acid), is the unique genetic blueprint of an individual. DNA is present in virtually every cell in the body. The uniqueness of DNA, which is composed of two long strands, stems from the specific order (sequence) of its different nucleotide building blocks, which are linked together to form each strand. Because the nucleotide sequence of each person's DNA is unique (the only exception being identical twins, who have identical DNA), DNA analysis is an integral part of forensic investigations. DNA may be isolated from biological samples (such as blood, skin, semen, or hair) found at the scenes of mass disasters or crimes, from cheek cells swabbed from the insides of mouths (as may be taken from the parties in paternity determinations or from criminal suspects), or from the environment (as in the case of pathogens).

The specific sequence of nucleotides in several regions of the isolated DNA (short tandem repeats, known as STRs, or other specific sequences) is compared with the sequence in identical regions of a DNA standard. This standard comes from a known source; it may be from a predeath biological sample recovered from a disaster victim's personal effects, from a crime suspect, from a party involved in a paternity case, or, in the case of a pathogen, from a previously experimentally derived sequence. When a crime is being investigated, the standard may be on file in the Federal Bureau of Investigation's Combined DNA Index System (CODIS). Even if there is no match in a criminal case, such information may help exonerate a suspect.

Frequently, the amounts of DNA obtained at crime or disaster scenes and in other situations are insufficient to allow such comparisons. When this is the case, scientists can use the technique of polymerase chain reaction (PCR) to generate a large number of copies of the DNA for analysis. This technique is so sensitive that the DNA isolated from a single cell is sufficient to obtain the desired nucleotide sequence.

In PCR, the DNA to be copied is placed in a plastic test tube along with nucleotides, DNA polymerase, and two or more short sequences of single-stranded DNA (called primers) that define where DNA polymerase will begin working. DNA polymerase is an enzyme that adds nucleotides to the growing strand. The test tube is then placed in a machine that can vary the temperature of the test tube and its contents.

The test tube is first heated so that the two strands of the original DNA molecule will separate from each other. Each strand will act as a template for production of a new strand. The temperature is then slightly decreased to allow the DNA primers to bind to each template adjacent to the start of nucleotide addition. The temperature is then slightly increased, and DNA polymerase adds nucleotides until a new strand is synthesized on each template, producing two double-stranded DNA molecules after the first cycle that are identical to the original DNA molecule. Each time the steps are repeated, the DNA doubles: Four DNA molecules are produced after two cycles, eight DNA molecules are produced after three cycles, and so on. Repeating these steps thirty times results in about one billion copies of the amplified DNA region.

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Further Reading

McPherson, Michael, and Simon Møller. *PCR (The Basics)*. 2d ed. New York: Taylor & Francis, 2006.

Rudin, Norah, and Keith Inman. *An Introduction to Forensic DNA Analysis*. 2d ed. Boca Raton, Fla.: CRC Press, 2002.

See also: CODIS; DNA fingerprinting; DNA profiling; DNA sequencing; DNA typing; Ebola virus; Electrophoresis; Louis XVII remains identification; Mitochondrial DNA analysis and typing; Paternity evidence; Pathogen genomic sequencing; Restriction fragment length polymorphisms; Short tandem repeat analysis; Y chromosome analysis.

Postconviction DNA analysis

Definition: Examination of DNA evidence in criminal cases that have already concluded with conviction of the accused.

Significance: The findings of postconviction DNA analysis can serve to affirm correct convictions, exonerate persons who have been wrongfully convicted, and identify the true perpetrators of crimes for which others were convicted. Such DNA analysis thus plays a vital role in maintaining the integrity of the criminal justice system.

The introduction of DNA (deoxyribonucleic acid) analysis revolutionized forensic science and provided law-enforcement agencies with a powerful tool for solving crimes. The proper use of DNA analysis can identify individuals with a higher degree of confidence than is possible with other forensic techniques, and such analysis has led to the conviction of many criminal offenders. Equally important, postconviction DNA analysis has resulted in the exoneration of many persons who had been wrongfully convicted of crimes. Postconviction analysis of DNA evidence may be conducted because access to such analysis was unavailable during the convicted offender’s earlier trial or because advances in analysis techniques since the individual was convicted may provide better evidence than was available at the time of the trial.

Background

As a tool of forensic science, DNA analysis has a relatively short history. It began in 1985 in Great Britain, when Alec Jeffreys, a geneticist, stumbled onto the use of DNA markers (restriction fragment length polymorphisms, or RFLPs) for personal identification while searching for disease markers in human DNA. He saw the potential for the method's use in criminal and civil investigations and coined the term "DNA fingerprinting," later explaining that he chose the term in a "deliberate move to emphasize the new forensic paradigm" that he foresaw. In April, 1985, Jeffreys was asked by Britain's Home Office to use DNA fingerprinting to solve an immigration dispute regarding the family identity of a boy. Although the blood group evidence supported the boy's claim of true kinship with the family, it was not convincing. The findings of the DNA analysis performed by Jeffreys and his colleagues supported the authenticity of the boy's claim.

The publicity that accompanied this case not only opened a floodgate of inquiries from immigrant communities over previously disputed cases but also led to the introduction of the use of DNA fingerprinting in paternity tests and many other applications. By 1986, the terms "DNA profiling" and "DNA typing" were also being used to refer to the technique. In the same year, DNA profiling saw its forensic debut in a murder case in Leicester, Jeffreys's hometown. This first admission of DNA typing evidence in a criminal court led to the exoneration of a young man who had falsely confessed to rape and murder. After that trial, the first-ever DNA-based manhunt subsequently brought the true perpetrator to justice; he was convicted in 1987. In the decades that followed, DNA typing became a standard tool of forensic science.

The Innocence Protection Act of 2004

This summary of section 411 of the Innocence Protection Act of 2004 (Title IV of the Justice for All Act of 2004) comes from the office of Senator Patrick Leahy of Vermont, who first introduced a version of this legislation in the U.S. Senate in 2000.

Federal postconviction DNA testing. Establishes rules and procedures governing applications for DNA testing by inmates in the Federal system. A court shall order DNA testing if the applicant asserts under penalty of perjury that he or she is actually innocent, and the proposed DNA testing may produce new material evidence that supports such assertion and raises a reasonable probability that the applicant did not commit the offense. Motions filed more than 5 years after enactment and 3 years after conviction are presumed untimely, but such presumption may be rebutted upon good cause shown. Penalties are established in the event that testing inculpates the applicant. Where test results are exculpatory, the court shall grant the applicant's motion for a new trial or resentencing if the test results and other evidence establish by compelling evidence that a new trial would result in an acquittal.

This section also prohibits the destruction of DNA evidence in a Federal criminal case while a defendant remains incarcerated, with certain exceptions. The government may destroy DNA evidence if the defendant waived the right to DNA testing; if the defendant was notified after his conviction became final that the evidence may be destroyed and did not file a motion for testing; if a court has denied a motion for testing; or if the evidence has already been tested and the results included the defendant as the source. . . . Intentional violations of these evidence-retention provisions to prevent evidence from being tested or used in court are punishable by a term of imprisonment.

Postconviction Exonerations

The power of DNA evidence to solve crimes and convict perpetrators is widely known, but the general public is perhaps less aware of the potential of such evidence to free wrongfully convicted individuals. The first person in the United States whose criminal conviction was overturned as the result of DNA evidence was a Chicago man named Gary Dotson. He was convicted in 1981 of a rape that never occurred and exonerated in 1989. The purported rape victim had recanted her testimony in 1985, but it was not until 1988 that DNA analysis positively excluded Dotson as the source of semen found on his accuser (the semen was that of the young woman's boyfriend, with whom she had consensual sex the day she claimed to have been raped). In 1993, Kirk Bloodsworth became the first person in the United States to escape a death sentence as the result of DNA analysis; he had been convicted of the 1984 rape and murder of a child, but postconviction DNA analysis proved that semen found on the victim was not his. The true perpetrator of the crime was eventually identified in 2003, also with the aid of DNA analysis.

Using postconviction DNA analysis to exonerate persons who have been wrongfully convicted is the central mission of the Innocence Project, an organization founded in 1992 by Barry Scheck and Peter Neufeld at the Benjamin N. Cardozo School of Law at Yeshiva University. The Innocence Project provides legal assistance to prisoners who could be proven innocent through DNA analysis, and it also works to publicize the fact that wrongful convictions are not rare and isolated incidents but instead the predictable results of defects in the criminal justice system. Beyond simply freeing innocent people who are incarcerated, the Innocence Project attempts to reform the system that is responsible for their unjust imprisonment.

Regulations Governing Postconviction DNA Testing

Although thirty-eight U.S. states have laws in place that allow convicts access to DNA testing, many rules and regulations limit the ways in which postconviction DNA evidence can be used. In most cases, it is typical for states to require that any new evidence be brought to court within six months following a conviction in order to warrant a new trial. In the case of DNA evidence, the drawback of such a rule is obvious:

Gary Dotson (right), who spent eight years in prison for a rape he did not commit and became the first person in the United States whose criminal conviction was overturned as the result of DNA evidence, looks on during an Illinois Prisoner Review Board hearing in October, 2002, as his attorney, Lawrence Marshall, asks the board to grant his client a pardon. Dotson sought a pardon to erase the stigma of his conviction and to draw attention to problems in the justice system. *(AP/Wide World Photos)*

It excludes individuals who were convicted before DNA typing was available but for whom such typing may now provide important evidence relevant to their cases. Since the use of DNA evidence has become commonplace, many states have revised their statutes to allow for the presentation of evidence secured through postconviction DNA analysis even after convicted persons have exhausted all of their appeals.

The Innocence Project has made several suggestions for the improvement of state statutes related to postconviction DNA analysis. The organization asserts that state laws should provide for access to DNA testing wherever it can establish innocence, even in cases in which defendants have pleaded guilty; should set no absolute deadlines on when such access will expire; should provide access to currently available DNA technology, not dependent on whether such technology was available at the time of trial; should allow for flexibility in where and how DNA testing is conducted; should require the preservation of biological evidence for a reasonable period of time; and should require the disclosure of evidence that is in the custody of state officials.

In 2004, the U.S. Congress passed the Justice for All Act; this law includes a section, known as the Innocence Protection Act of 2004, that stipulates that all convicts with reasonable claims of innocence must be granted the opportunity to prove their cases in court using postconviction DNA testing. States seeking to qualify for funding under the Justice for All Act must allow convicted persons the level of access to postconviction DNA analysis specified in the act.

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Further Reading

Johnson, Paul, and Robin Williams. "Post-conviction DNA Testing: The United Kingdom's First 'Exoneration' Case?" *Science and Justice* 44, no. 2 (2004): 77-82. Examines in detail the first case in England in which postconviction DNA testing was used in a successful appeal by an imprisoned offender.

Kobilinsky, Lawrence F., Thomas F. Liotti, and Jamel Oeser-Sweat. *DNA: Forensic and Legal Applications*. Hoboken, N.J.: Wiley-Interscience, 2005. Presents a general overview of the uses of DNA analysis.

Lazer, David, ed. *DNA and the Criminal Justice System: The Technology of Justice*. Cambridge, Mass.: MIT Press, 2004. Thought-provoking collection of essays explores the ethical and procedural issues related to DNA evidence.

Rudin, Norah, and Keith Inman. *An Introduction to Forensic DNA Analysis*. 2d ed. Boca Raton, Fla.: CRC Press, 2002. Provides a good introduction to the history and application of DNA fingerprinting in forensic investigations.

Scheck, Barry, Peter Neufeld, and Jim Dwyer. *Actual Innocence: Five Days to Execution, and Other Dispatches from the Wrongly Convicted*. New York: Random House, 2000. Describes some of the most prominent and successful cases taken on by Scheck and Neufeld's Innocence Project.

See also: DNA analysis; DNA fingerprinting; DNA isolation methods; DNA profiling; DNA typing; Ethics of DNA analysis; Innocence Project; Mass graves; National DNA Index System; Pseudoscience in forensic practice; Rape.

Presumptive tests for blood

Definition: Laboratory tests used to examine items for stains that may be blood.

Significance: Presumptive tests are widely used in the initial screening of scenes and items for the presence of blood; thus the correct use of such tests and correct interpretation of both positive and negative results is vital in analysis and case management.

Because blood is frequently shed during violent crimes, the search for and identification of blood is an important part of the work of forensic scientists both in the laboratory and at the crime scene. The presence of blood and its locations can provide information about the event and circumstances being investigated. Analysts may, if the case circumstances warrant it, subject any bloodstains identified to DNA (deoxyribonucleic acid) profiling to determine from whom the blood could or could not have come; this information can also shed light on the event and circumstances.

The Appearance of Bloodstains

Although the detection of bloodstains may seem like a simple process, in reality it can be quite complex. Immediately after it is shed, blood is a red liquid. It starts to clot within a few minutes, and in relatively large quantities of liquid blood, a separation of blood into clotted red material and a light-colored liquid can be noted. In smaller amounts, blood dries before clotting is complete, and a shiny, slightly translucent red stain is observed. Bloodstains darken and change color to brown with time. Any treatment of the stain with water or smearing of the stain will dilute the blood, or decrease the amount present, which results in a color change. Any treatment of the blood with a cleaning agent or other chemical will alter the stain's color to a greenish shade.

The material on which a bloodstain is present also affects the stain's appearance. The texture and absorbency of some materials can obscure the physical appearance of blood, and the color of the background material affects the analyst's perception of the color of a stain.

The visual identification of a stain as possibly being blood is a useful start in a forensic examination, but additional work needs to be done before the stain can be identified as blood. To confirm the presence of blood, a forensic scientist will usually carry out a presumptive test.

The Chemical Basis of Presumptive Tests

Blood is a unique and complex biological fluid containing many different cell types and a wide range of circulating proteins, glycoprotein, and ions. One of these cell types is the red blood cell, or erythrocyte. The major protein component of the red blood cell is hemoglobin, which contains an iron ion and is responsible for binding oxygen and transporting it around the body. Hemoglobin is found only in blood, so being able to identify this protein in a stain allows the forensic scientist to identify the stain positively as blood.

When hemoglobin binds oxygen, it effectively acts as a type of oxidizing enyzme called a peroxidase, and this enzymatic activity is used in presumptive tests. Certain dyes are colorless but can be oxidized to yield a colored product. When such a dye is added to a possible bloodstain in the presence of an oxidant, the change in color shows that an oxidizing agent, such as hemoglobin, is present. Phenolphthalein is the dye component of the Kastle-Meyer presumptive test for blood; the dye changes from colorless to dark pink. Another example is tetramethylbenzidine, which is the dye component of a commercial test for blood in urine, the Combur-Test, which can also be used to detect bloodstains. The dye in this test changes from colorless to dark green. The luminol test is also a presumptive test, although one with a far more complex reaction pathway than that of more basic presumptive tests; the action of hemoglobin on luminol produces light.

Practical Limitations of Presumptive Tests

Sometimes, substances other than blood can cause the dye to change color in a presumptive test. These substances fall into two categories. First, any chemical that can react directly with the dye to oxidize it—that is, one that does not require the oxidizing action of hemoglobin on the oxidant—can give a positive result. Examples of these are metal salts, such as some copper salts or rust, hypochlorites, and bleaches.

Presumptive Test for Blood

A basic equation for a presumptive test for blood is as follows:

$$AH_2 + ROOH \xrightarrow{\text{Hemoglobin}} A + ROH + H_2O,$$

where AH_2 is the colorless dye, ROOH is the oxidizing agent (usually hydrogen peroxide), and A is the colored dye.

Forensic scientists refer to results like these, where positive results are given by substances other than blood, as false positives.

This sort of false positive can be excluded—that is, not thought of as coming from a possible bloodstain—by the application of the dye to the stain in the absence of the oxidizing agent. A positive result under those conditions means the stain is not blood, as the oxidizing agent is needed for hemoglobin to give a positive result in presumptive tests.

The other kinds of substances that give false positives are enzymes such as catalases or peroxidases, which can break down the oxidizing agent in the same way as hemoglobin. The most common of these are plant peroxidases, which are widespread in the plant kingdom and are found in cabbage, horseradish, and other fairly common plants.

Presumptive tests are very sensitive, giving positive results to blood dilutions of between 1 in 10^5 and 1 in 10^6 under ideal conditions. Given that forensic samples are usually not tested under ideal conditions, because most are on substrates that are dirty or contaminated to some extent, the actual sensitivity in the field is probably lower. The sensitivity means that the tests can be used to screen items for small amounts of blood or diluted blood as well as to test stains that look like blood to see if they might be blood.

As other substances can give positive results in such tests, it is not possible for a forensic scientist to say that a stain that gives a positive result in a presumptive test is definitely blood. Such a stain can be described as a probable bloodstain or similar. Confirmatory tests need to be conducted before an analyst can say definitively that any given stain is blood. These are typically immunological tests that are capable of detecting proteins specific to blood; most scientists agree that crystal and spectroscopic tests for hemoglobin can be regarded as confirmatory as well.

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Further Reading

Gaensslen, R. E. *Sourcebook in Forensic Serology, Immunology, and Biochemistry*. Washington, D.C.: National Institute of Justice, 1983. Presents a comprehensive and detailed history of presumptive testing.

Houck, Max M., and Jay A. Siegel. *Fundamentals of Forensic Science*. Burlington, Mass.: Elsevier Academic Press, 2006. Good general textbook includes a clear section on presumptive testing.

James, Stuart H., Paul E. Kish, and T. Paulette Sutton. *Principles of Bloodstain Pattern Analysis: Theory and Practice*. Boca Raton, Fla.: CRC Press, 2005. Provides some useful detail on presumptive testing and the biochemical makeup of blood.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007. General text includes information on confirmatory tests for blood.

Webb, Joanne L., Jonathan I. Creamer, and Terence I. Quickenden. "A Comparison of the Presumptive Luminol Test for Blood with Four Non-chemiluminescent Forensic Techniques." *Luminescence* 21, no. 4 (2006): 214-220. Presents comparisons of some standard presumptive tests used by forensic scientists.

See also: Benzidine; Blood residue and bloodstains; Crime scene investigation; DNA recognition instruments; Drug confirmation tests; Kidd blood grouping system; Luminol; Orthotolidine; Phenolphthalein; Reagents; Serology.

Printer analysis. *See* Fax machine, copier, and printer analysis

Prints

Definition: Impressions left on surfaces by hands (palm prints and fingerprints) and bare feet (sole prints and toe prints).

Significance: Fingerprints are routinely collected at crime scenes as means of identifying persons who were present during the crimes, but prints from the soles of feet and the palms of the hands are equally unique and revealing. Any prints that are recoverable at a crime scene may provide information important to the investigation.

Prints from bare feet found at crime scenes can be as telling as fingerprints, but in the United States such prints are less often employed than fingerprints because most people involved in crimes commonly wear some sort of covering—shoes or at least socks—on their feet. Where bare footprints or toe prints are available, they can be as valuable forensically as fingerprints because such prints contain the same ridges and valleys that characterize fingerprints and are as unique to each individual as fingerprints are.

Although bare footprints, toe prints, and palm prints are available less frequently at crime scenes than fingerprints, they can be invaluable to investigators of crimes. Even footprints left by people wearing shoes or socks can be telling in several ways. By measuring the length of a footprint, for example, a forensic anthropologist can arrive at an approximation of the height of the person who left it, because the length of a person's footprint represents roughly 15 percent of that person's height.

Palm prints are more frequently available than sole prints and, like fingerprints, the palm prints of each individual are unique. When palm prints are found at crime scenes, the corresponding fingerprints are often present as well.

Fingerprints

Fingerprint analysis is by far the most common way in which law-enforcement investigators connect particular persons with crime scenes. The technology used to accomplish such analysis has advanced considerably through the years, but the basic elements remain the same. Fingerprint analysts compare certain characteristics visible in the prints collected from crime scenes with the characteristics in prints from known sources to identify the persons who left the crime scene prints.

The basic patterns seen in all fingerprints on record fall into one of three major categories: loop, whorl, or arch. The most common pattern is the loop, which is found in between 60 and 65 percent of all humans. The second most common is the whorl, found in 30 to 35 percent of all people. Approximately 5 percent of people have fingerprints with arches, and a very small percentage have a combination of the three patterns. Primates other than humans also have fingerprints and toe prints that are unique to each individual. Even identical twins have fingerprints different from those of their counterparts, although twins' prints are often quite similar.

The statistical probability that any two persons' fingerprints will be exactly alike is virtually zero. No two sets of fingerprints have ever been found to be identical, and fingerprint identification is considered valid in courts of law almost universally.

Even when a person's fingerprints are damaged by acid, fire, or surgery designed to eliminate them, prints identical to the original prints grow back on the affected fingers in a short time. Some criminals have attempted to destroy their fingerprints, but none has been known to succeed in doing so.

Classes of Prints

The fingerprints, palm prints, and bare footprints collected by forensic scientists fall into three classes: latent, visible, and plastic. Latent prints are those that are made when a hand or bare foot touches any surface, leaving behind a small amount of oily residue. Such prints are not necessarily immediately visible to the human eye, but forensic scientists can enhance their visibility by using a small brush to dust the surface with a powder specifically designed to highlight the ridges and valleys of these prints. After the prints are clearly visible, they are physically lifted from the surface with sterile transparent tape and transferred to special cards for transport to the laboratory for analysis. It is essential that crime scene investigators lift latent prints as quickly as they can, because the residue left behind on surfaces by hands and feet is mostly water and can evaporate very rapidly.

The visible prints found at crime scenes are usually made in some liquid or greasy medium, such as blood or oil. These prints can be seen without magnification. Plastic prints are those that are recovered from malleable materials, such as unfired clay or pastry dough. Both of these types of prints are photographed, and the photographs are transferred to print cards.

The FBI's Latent Print Operations Unit

Among the many specialized forensic services of the Federal Bureau of Investigation is the Latent Print Operations Unit (LPOU). Its advanced scientific examinations in the field of friction ridge analysis encompass the development and comparison of latent fingerprints, palm prints, and footprints. In addition to reporting its findings, the unit provides expert testimony in legal proceedings and offers training and forensic field support to law-enforcement agencies throughout the United States and other parts of the world.

Members of the LPOU have also participated in disaster relief work, helping to identify victims of such mass-casualty events as the space shuttle *Challenger* disaster of 1986, the Oklahoma City bombing of 1995, the terrorist attacks of September 11, 2001, Hurricane Katrina in 2005, and the Asian tsunami of 2004.

Forensic Uses of Footprints

In addition to suggesting the height of the person who made them, bare footprints or shoe prints made in sand or other soft surfaces can reveal the person's weight, through the depth of the impressions. Forensic scientists preserve such impressions by making plaster casts of them, and analysis of such casts often provides convincing evidence linking particular individuals to the scenes of crimes.

The foot impressions found at crime scenes are more often shoe prints than bare footprints, but shoe prints can also provide valuable information. Both footprints and shoe prints, for example, can reveal the direction in which the people who made them were traveling and approximately how fast they were moving (the prints left by the two feet of a person who is walking are closer together than the prints of a person who is running). The depth of foot impressions can suggest the weight of the person who left them and may also reveal whether the person was carrying something heavy.

Both shoe prints and bare footprints can reveal information about gait—that is, the way a person walks—that may help investigators to identify an individual. The angles of such prints, for example, can suggest the age and physical condition of the person who made them, such as whether the person is elderly or suffering from a condition such as arthritis.

Palm Prints and Sole Prints

When bare footprints are found at crime scenes, they are generally found in sand or in soft earth. Crime scene investigators must preserve and collect such prints immediately, as they can quickly be degraded and washed away by rain, wind, or tides.

Footprints are generally much less commonly found at crime scenes than are fingerprints. Sometimes bare footprints are retrieved as visible prints from crime scenes where considerable blood has been shed, and in such cases they can provide strong evidence of the presence of particular persons at the scene. In similar situations where only shoe prints are found, the shoe prints can provide suggestive evidence that generally falls short of being incontrovertible.

Latent fingerprints are more likely to be recovered from crime scenes than are latent palm prints, although, in some instances, investigators are able to collect both fingerprints and palm prints. In cases in which a person committing a crime has grabbed a cylindrical piece of wood, such as a bedpost, both latent palm prints and fingerprints can often be retrieved.

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Further Reading

Abbott, John Reginald. *Footwear Evidence: The Examination, Identification, and Comparison of Footwear Impressions*. Edited by Richard Germann. Springfield, Ill.: Charles C Thomas, 1964. Brief, classic work is remarkably thorough in detailing how forensic scientists deal with footwear impression evidence.

Bell, Suzanne. *Encyclopedia of Forensic Science*. New York: Facts On File, 2004. In addition to a strong section on fingerprints, provides valuable information on shoe prints, shoe impressions, footprints, and footwear impressions.

Bodziak, William J. *Footwear Impression Evidence: Detection, Recovery, and Examination*. 2d ed. Boca Raton, Fla.: CRC Press, 2000. Provides valuable fundamental information about how forensic scientists gather, preserve, and analyze the impressions left by shoes and other footwear found at crime scenes.

Conklin, Barbara Gardner, Robert Gardner, and Dennis Shortelle. *Encyclopedia of Forensic Science: A Compendium of Detective Fact and Fiction*. Westport, Conn.: Oryx Press, 2002. Offers an informative discussion of footprints, illustrated and replete with cogent examples, as well as extensive sections on tool marks, bite marks, and fingerprints.

Hilderbrand, Dwane S. *Footwear, the Missed Evidence: A Field Guide to the Collection and Preservation of Forensic Footwear Impression Evidence*. 2d ed. Wildomar, Calif.: Staggs, 2005. Provides information about all aspects of preserving, collecting, and interpreting footwear impressions.

Pentland, Peter, and Pennie Stoyles. *Forensic Science*. Philadelphia: Chelsea House, 2003. Includes excellent though brief sections on both fingerprinting and footprints. Intended for young adult readers.

Robbins, Louise M. *Footprints: Collection, Analysis, and Interpretation*. Springfield, Ill.: Charles C Thomas, 1985. Addresses footprint forensics from an anthropological point of view. Includes splendid illustrative drawings of Richard Gantt.

See also: Casting; Class versus individual evidence; Crime scene measurement; Ear prints; Fingerprints; Footprints and shoe prints; Integrated Automated Fingerprint Identification System; Physical evidence; Simpson murder trial; Sinus prints; Superglue fuming.

Product liability cases

Definition: Legal cases involving allegations that defective and dangerous products have harmed people and property.

Significance: Sophisticated evidence is necessary to prove that personal or property harm has resulted from defective products. Lawyers rely on forensic experts to conduct analyses of products suspected of being defective and prepare expert testimony to prove all elements of a legal theory or to defend an entity in the chain of distribution from liability. In addition, companies concerned with designing and manufacturing good-quality products rely on input from forensic scientists.

Manufacturers, wholesalers, distributors, retailers, assemblers, installers, and those who lease or rent products have the best ability to ensure that defective and dangerous products do not enter the marketplace. In the United States, when a defective product results in harm, the courts impose joint and several liability on the marketing participants as a matter of public policy. These deep-pocketed entities in the chain of distribution usually have insurance coverage and are able to spread the product liability risks and apportion damage costs among themselves better than those who suffer injury from defective products. Usually those who are not regularly in the business of selling or renting particular products, such as individuals who sell goods at yard or garage sales, are considered outside the chain of distribution and thus cannot be sued for product liability.

Historically, only those who had a buyer-seller relationship or were in privity of contract with a seller could sue, but U.S. states no longer limit those who have standing to sue under many of the product liability theories. This means that not only those who originally purchased a defective product have the right to sue but also any person who might foreseeably be harmed by the product may file a product liability action. This includes family members and friends of purchasers, remote purchasers, and any bystanders who suffer harm.

Causes of Action, Defects, and Remedies

Product liability cases are based on torts, or civil wrongs, and contract law. At least four significant causes of action are possible in a product liability case: strict product liability, negligence, misrepresentation or fraud, and breach of warranties. Some of the counts require plaintiffs to prove causation, whereas others do not. In every case, however, some proof must exist of a design, manufacturing, or warning defect or that the product is dangerous.

Companies conduct cost-benefit and risk analyses when determining the best designs for their products and whether reasonable alternative designs would avoid or reduce the risk of harm from the products. They balance the risks of potential harm against the costs of designs that will result in reasonably safe products while still ensuring that the companies can make a profit. Courts also consider cost-benefit analyses and reasonable alternative designs when a design defect is the issue in a product liability case. Plaintiffs may rely on forensic experts to prove that there is an alternative and safer design for the product, while defendants will try to show not only that no alternative design is reasonable but also that the alternative design suggested by the plaintiff is not cost-efficient.

Whenever a company manufactures a product with reasonable care but does not follow the intended design, a manufacturing defect may exist. When a product is seriously damaged or destroyed in an accident, forensic experts and those who attempt to reconstruct the accident may need to rely on the malfunction doctrine to prove product liability. The malfunction doctrine requires a plaintiff to eliminate all possible means of harm except for the product defect.

Warning defects consist of a lack of warnings or a failure to give adequate warnings concerning both the safe way to use a product and the potential dangers associated with the product, including those that are not obvious. It is impossible to warn against all potential risks of harm, but those in the chain of distribution have the responsibility to warn against foreseeable dangers in order to avoid liability based on a defective warning that renders a product unreasonably unsafe. Such warnings must be clear, understandable, and specific. Given the increasingly global nature of the marketplace, product instructions on use and warnings concerning dangers are usually provided in multiple languages, and many companies also use internationally understood symbols to warn of specific dangers.

Product liability cases are considered civil as opposed to criminal actions. Usually the plaintiffs who have personally been injured or whose property has suffered harm request monetary damages, but other remedies are available, including restitution and replacement of defective products. Moreover, when a court determines that monetary damages are not adequate, it may order relief such as an injunction that re-

A product liability case that drew a great deal of public attention involved motor vehicle accidents that were attributed to tread separation in Firestone Wilderness AT tires. This sport utility vehicle, which was equipped with the Firestone tires, was involved in a two-car accident that was apparently caused by malfunction of the tires. *(AP/Wide World Photos)* quires the company to remove the defective product from the marketplace.

Strict Product Liability

As a matter of public policy, courts and legislatures have determined that consumers must be protected against harm from dangerous and unreasonably unsafe products. Plaintiffs thus may sue on the basis of strict product liability, originally a common-law tort that is now written into many U.S. state statutes. A strict product liability case involves liability without fault. A plaintiff need only show harm from an inherently dangerous, defective, or unreasonably unsafe consumer product that has not undergone substantial change since its purchase. A defendant cannot claim exercise of reasonable care to prevent injury or lack of intention to cause harm, as fault is not an issue in a strict product liability case.

In such a case, forensic experts are likely to testify about the inherent dangers of the consumer product that make it unreasonably unsafe and thus defective. An unreasonably dangerous product is one that exceeds the dangers expected by an ordinary consumer or a product for which a less dangerous alternative was economically feasible. In addition, the defense may call on forensic experts to testify regarding substantial changes made to the product between the time the product was purchased and the injury.

Not all injuries from dangerous and unsafe products may result in cognizable product liability claims. The potential dangers presented by some products are outweighed by the benefits they provide to society. For example, many modern prescription drugs have side effects, but the benefits of the drugs outweigh their potential harm, and as long as individuals have received adequate warnings, product liability cases involving such drugs are unlikely to be successful.

In addition, the dangers associated with other products, many of which have great utility, may be commonly known. These products are unavoidably dangerous, and there are no reasonable alternatives for making these products safe for their intended and ordinary purposes. Warnings of known dangers are unnecessary. A person harmed by such a product assumes the risk of harm, and a lawsuit based on product liability is usually dismissed. For example, everyone knows and expects that a knife is sharp; a person thus needs to be careful in using a knife to avoid harm.

Negligence

The tort of negligence requires proof of fault. Negligence requires evidence of four elements: that there was a reasonable duty of care owed by the defendant to the plaintiff to provide a safe product, that the defendant breached the duty of care, that because of the breach the plaintiff suffered harm, and that the breach was the foreseeable and proximate cause of the harm, as there was nothing else that intervened and could be blamed for the harm. Many things can go wrong with products in the chain of distribution. Manufacturers may fail to exercise due care in designing, assembling, inspecting, and testing component parts and consumer products before releasing them for sale in the marketplace. A retailer may carelessly sell a product that lacks adequate warnings for the ordinary consumer. Moreover, in some cases a claim could be based on negligence per se because a defendant failed to comply with statutory laws, such as providing required information on a food product label.

To succeed in a negligence action, the plaintiff must offer proof regarding the party responsible for causing the harm. Forensic experts are asked to develop this causal evidence and to determine whether the harm was foreseeable. Experts may also testify about the standard of care that is reasonable and expected of those who sell or lease similar products.

Misrepresentation

Misrepresentation is generally a tort action, although misrepresentation may also be alleged in a contract or warranty count. If misrepresentation is based on a careless act or an accident, the plaintiff must prove the elements necessary for negligence. However, if the misrepresentation is intentional or reckless, such as failure to recall a defective product from the marketplace with knowledge that the product is defective and potentially harmful, then the misrepresentation is based on fraud.

To prove fraudulent misrepresentation, a plaintiff must show that the defendant knew or was reckless in making affirmative statements about a product's quality that were not true or in concealing or failing to discover defects in a product that would be important and material to a consumer. The consumer must reasonably rely on the defendant's material misrepresentations in deciding to buy or lease the product or in continuing to use the product. The consumer's reliance on the misrepresentations must result in a detriment—a personal or property harm caused by the product. Generally, a person who did not purchase the product is unable to sue on a theory of misrepresentation because there is no proof of reasonable reliance on a misrepresentation.

Breach of Warranties

The final cause of action comes out of the commercial world of contracts, warranties, and a uniform statutory law known as the Uniform Commercial Code (UCC). At least three separate warranties are governed by the UCC: an express warranty, the implied warranty of merchantability, and the implied warranty of fitness for a particular purpose. A breach of any of these warranties relied on by a consumer in deciding to purchase or lease a product may provide the basis for a product liability claim. Sellers and lessors of products may exclude some or all of the warranties, although federal and state consumer protection laws may limit the ability to exclude all warranties and thus avoid liability for defective consumer products.

Sellers and lessors of products provide express warranties in many ways. A person expects a product to conform to models and samples. In addition, catalogs, advertisements, brochures, pictures, diagrams, and specifications of features are generally considered express warranties of what the consumer expects, even if no warranty was intended. Oral affirmations and written contract provisions made for the purpose of selling or leasing a product are also considered express warranties. Affirmations may include descriptive terms and often pertain to quality, how the product will perform, and conditions that may limit the express warranty. Purchasers may also infer express warranties because of a seller's or lessor's conduct that enticed them to buy or lease a product.

The implied warranty of merchantability means that the product must meet industry or government standards for similar products. The product must adequately perform and meet the expectations of a typical consumer. For example, a new car should enable a person to travel between locations. Some products must also be wholesome and safe for consumption before they are considered merchantable. If a person finds pieces of glass in a jar of baby food, the food clearly does not meet the consumer's expected quality standards. A consumer might expect to find a fish bone in a bowl of freshly made fish chowder, but not in fish sandwich made from a frozen fish fillet.

Some people purchase or lease products after seeking input from sellers or lessors. In such a case, the purchaser of the product wants to make sure that the product will satisfy specific needs and relies on the skill and expertise of the seller or lessor in deciding to purchase or lease the product. A consumer who is told that a product will meet specific needs has an implied warranty of fitness for a particular purpose that is breached when the product proves to be unfit for the intended purpose.

Defenses

In product liability litigation, several defenses are available to defendants to counter the multiple theories on which such cases are based. One defense is that the injured person abnormally misused the product and did not follow instructions for use or heed danger warnings. If, however, the misuse was foreseeable, this defense is not likely to be effective and the defendants are obligated to provide warnings.

Another defense might be assumption of the risk—that is, the defendant argues that the person claiming harm from a defective product was fairly warned of the dangers associated with the product and understood the dangers. The defendant must prove that despite the risks associated with the product, the injured plaintiff decided voluntarily to purchase or use the product and thus assumed any risk of harm from the product.

Contributory negligence is a common-law defense that bars all liability if a plaintiff contributes in any way to an injury from a product. Modern laws allow for comparative negligence as a defense, which is not as harsh as contributory negligence. Under the comparative negligence defense, plaintiffs who bear some responsibility for their own injuries from defective products have their damage awards reduced in proportion to their negligence when compared with the defendants' negligence in producing and selling dangerous and defective products.

Finally, most manufacturers that discover defects in their products attempt to limit their liability. If those in the distribution chain use reasonable efforts to notify purchasers of product defects, such as by publishing notices of product recalls in generally circulated newspapers or magazines or sending letters or notices of product recalls or defects to known purchasers, the purchasers are obligated to have the defects corrected. Purchasers cannot simply ignore such notices and file product liability claims if they are subsequently injured by the recalled products.

Forensic Expert Standards and Evidence Preservation

Product liability cases are quite complex, and forensic experts engage in many types of analyses to prove liability or to provide evidence for the defense. Expert witnesses, however, are subject to the so-called *Daubert* standard, a test laid out by the U.S. Supreme Court that requires a court to determine the reliability and credibility of scientific evidence based on objective standards, including the replicability of study results and the general acceptance by scientific peers of the expert's evidence or method of analysis.

Plaintiffs must also be sure to preserve defective products once they have caused harm. It may be necessary for a plaintiff to obtain a court order to gain control and possession over the product. If a plaintiff loses control over a product, it may be destroyed or altered, thus seriously compromising the ability of forensic experts to determine whether the injury was the result of a defective product.

Carol A. Rolf

Further Reading

Derthick, Martha A. *Up in Smoke: From Legislation to Litigation in Tobacco Politics*. 2d ed. Washington, D.C.: Congressional Quarterly Press, 2004. Discusses the product liability cases that were filed against tobacco companies for harm caused to individuals from smoking. Defenses such as comparative negligence and assumption of risk barred this litigation at first, but the states joined in the litigation and alleged failure by the tobacco companies to provide adequate warnings concerning the health risks of smoking. The litigation resulted in a master settlement agreement in which the tobacco companies agreed to pay billions in damages and to revise marketing and advertising.

Geistfeld, Mark A. *Principles of Products Liability*. New York: Foundation Press, 2006. Provides a complete discussion of the various product liability theories, doctrines, and defenses and applies these legal concepts to potential cases to develop insights into the specialized area of product liability and tort law.

Gooden, Randall L. *Product Liability Prevention: A Strategic Guide*. Milwaukee: ASQ Quality Press, 2000. Intended for organizations in the chain of product distribution to help them better understand how to prevent liability from defective products. Suggests many proactive approaches that companies can follow to ensure that they produce and sell high-quality products and thus avoid future liability.

Kiely, Terrence F. *Science and Litigation: Products Liability in Theory and Practice*. Boca Raton, Fla.: CRC Press, 2002. Clearly addresses the process of gaining court acceptance of expert scientific opinion in liability cases. Notes that many cases present questions of first impression, which means that no legal precedents or peer-reviewed studies exist on which courts can rely in determining that new technologies comply with legal standards of reliability and credibility.

Owen, David G. *Products Liability Law Hornbook*. St. Paul, Minn.: West, 2005. Provides a comprehensive review of liability and the legal theories and defenses pertaining to product liability litigation both in the United

States and in the global marketplace. Addresses several tangential topics, including the forensic analysis involved in determining product defects and in proving liability and causation through testimony at trials.

Owen, David G., and Jerry J. Phillips. *Products Liability in a Nutshell*. St. Paul, Minn.: West, 2005. Presents an excellent and easy-to-understand summary of the theories of liability, defenses, and various types of defects involved in product liability litigation.

Samuel, Andrew E. *Forensic Engineering: A Casebook on How to Find the Winning Line*. New York: Springer, 2006. Reviews actual product liability cases and the successful opinions and techniques used in those cases by experts. The material is at an introductory level and addresses multidisciplinary examples of litigation strategies.

Stallard, Eric, Kenneth G. Monton, and Joel E. Cohen. *Forecasting Product Liability Claims: Epidemiology and Modeling in the Manville Asbestos Case*. New York: Springer, 2004. Focuses on one of the largest and best-known class-action product liability cases ever brought in the United States. Discusses the case in terms of statistical forecasting of the number, timing, and nature of legal claims. Presents the mathematical models used in the case in understandable terms.

See also: Accident investigation and reconstruction; Courts and forensic evidence; Expert witnesses; Food and Drug Administration, U.S.; Food poisoning; Food supply protection; Product tampering; Silicone breast implant cases; Thalidomide; Toxic torts; Trial consultants.

Product tampering

Definition: Adulteration of consumer products with foreign substances that may cause serious harm, even risk of death, to those who use the products.

Significance: The absence of witnesses and the potential for broad public harm make product tampering one of the most challenging types of crimes for law-enforcement agencies to investigate. In such cases, it is important for authorities to determine quickly the extent of the tampering and the danger to the public at the same time they are working to identify suspects and remove any tainted products from stores.

Product tampering first became a public concern in the United States in September, 1982, when someone deliberately poisoned Extra-Strength Tylenol capsules with cyanide, leading to seven deaths in Chicago, Illinois. Subsequent laws such as the 1983 and 1994 Federal Anti-tampering Acts made product tampering a federal crime. Because these kinds of crimes typically have few witnesses, law-enforcement investigators must rely on physical evidence in tracking down suspects. They also face the task of determining where the tampering occurred. Most cases of product tampering involve foods and over-the-counter medicines that can be easily accessed at supermarkets or drugstores.

The motives for product tampering vary. Some perpetrators are motivated by the desire to create panic by killing members of the public, whereas others use tampering as a means of extortion, threatening to poison products unless particular demands are met. Still others use product tampering to commit murder for gain, such as to collect a victim's life insurance.

Initial Response

Under the Pure Food and Drug Act (1906) and the antitampering legislation passed in the early 1980's, the Food and Drug Administration (FDA) has the responsibility for investigating all cases of product tampering in the United States. When a case of tampering is reported, federal investigators descend on the retail outlet where the adulterated product was purchased or discovered to collect physical evidence.

All containers of suspect products are handled carefully to protect fingerprint evidence, because often those who commit this type of crime purchase certain products, take them to a private place to adulterate them, and then manage to get the products returned to the retail shelves. To protect the public, investigators usually remove all similar products from relevant locations and have them tested for contamination.

Narrowing the Investigation

Because product tampering can occur at the manufacturing, distribution, or retail level, investigators must examine each possibility. They must determine whether a case of tampering is limited to a single package, to packages at a particular retail outlet, or to an entire brand across an extensive geographic area.

Investigators may be aided by the footage from surveillance cameras at retail outlets. Given that it is known that some perpetrators purchase products, tamper with them, and then return them to the shelves, video evidence that a person has made repeated visits to a store and has been in the vicinity of the adulterated product can point to that person as a suspect. Computerized tracking of products sold in stores can also provide valuable information to investigators regarding when a tampered product was purchased and if it was returned to a store.

In 1993, false claims were made that syringes were being found in cans of Pepsi-Cola in Seattle, Washington, and then in other cities across the United States. Photos from a surveillance camera in a supermarket revealed the first incident to be a hoax; a woman could be seen opening a Pepsi can and slipping a syringe into it. She later claimed that she discovered the needle after she purchased the soft drink. This evidence tipped off investigators that other claims of tampering involving Pepsi cans might also be hoaxes.

Psychological profiling is another forensic tool used by investigators of product tampering. Such profiling can narrow the probable range of suspects according to age, gender, socioeconomic status, and educational background. The level of knowledge and chemical sophistication needed to succeed in the type of contamination committed can also add to a profile.

Advice from the FDA

The U.S. Food and Drug Administration provides these tips for consumers.

How to Detect Product Tampering at the Grocery Store

- Carefully examine all food product packaging. Be aware of the normal appearance of food containers. That way you'll be more likely to notice if an outer seal or wrapper is missing. Compare a suspect container with others on the shelf.
- Check any antitampering devices on packaging. Make sure the plastic seal around the outside of a container is intact or that the safety button on the lid of a jar is down.
- Don't purchase products if the packaging is open, torn, or damaged. This includes products on the shelf or in the refrigerator or freezer sections of the grocery store.
- Don't buy products that are damaged or that look unusual. For example, never purchase canned goods that are leaking or that bulge at the ends. The same applies to products that appear to have been thawed and then refrozen.
- Check the "sell-by" dates printed on some products, and only buy items within that time frame.

How to Detect Product Tampering at Home

- When opening a container, carefully inspect the product. Don't use products that are discolored, moldy, have an off odor, or that spurt liquid or foam when the container is opened.
- Never eat food from packages that are damaged or that look unusual, such as cans that are leaking or that bulge at the ends.

What and When

Investigators must quickly determine what foreign substance was added to an adulterated product so that they can locate possible sources for the poison and attempt to track down any persons who recently purchased it. During the 1991 investigation of the poisoning of Sudafed capsules in Washington State, an incident that resulted in the deaths of two people, investigators identified the type of cyanide used to contaminate the pills. They then were able to trace the cyanide back to a distributor and then to the husband of

Chicago City Health Department employees test Tylenol capsules for cyanide content at a city laboratory in October, 1982. In September, 1982, seven people in the Chicago area died after ingesting cyanide-laced capsules of the over-the-counter medication. *(AP/Wide World Photos)*

one of the victims, who had purchased the cyanide in order to place it in his wife's medication.

Another crucial part of the investigation of product tampering is the determination of when the adulterating material was added to the product. Generally, chemical contaminants that are added to a product will change as they interact with the chemicals in the product. The rate of decomposition of the contaminant within the product thus provides clues regarding when the contaminant was added. Laboratory tests using spectroscopy can identify decomposition and narrow the period when the product was poisoned.

When contaminants are physical rather than chemical in nature, such as syringes in the Pepsi tampering hoaxes, investigators examine that evidence to find differences and similarities in the types of contaminants. In the Pepsi hoaxes, investigators discovered that the syringes were of different types and sizes, suggesting that the tampering was not committed by a single individual.

Douglas Clouatre

Further Reading

Byrd, Mike. *Crime Scene Evidence: A Guide to the Recovery and Collection of Physical Evidence*. Wildomar, Calif.: Staggs, 2001. Discusses the types of evidence to be found and collected at crime scenes and the use of evidence samples in the investigation and prosecution of criminals.

Fisher, Barry A. J. *Techniques of Crime Scene Investigation*. 7th ed. Boca Raton, Fla.: CRC Press, 2004. Details the methods used in the collection and preservation of evidence found at crime scenes, including DNA and fingerprint evidence.

Murphy, Douglas B. *Fundamentals of Light Microscopy and Electronic Imaging*. 2d ed. New York: John Wiley & Sons, 2008. Explains the science and technology behind light microscopy in a straightforward manner accessible to nonscientists.

Trestrail, John Harris, III. *Criminal Poisoning: Investigational Guide for Law Enforcement, Toxicologists, Forensic Scientists, and Attorneys*. 2d ed. Totowa, N.J.: Humana Press, 2007. Describes the investigative techniques used to determine whether intentional poisonings have occurred and the types of poisons used in crimes.

See also: Chain of custody; Crime scene investigation; Criminal personality profiling; Federal Bureau of Investigation; Food and Drug Administration, U.S.; Product liability cases.

Profiling. *See* Criminal personality profiling; DNA profiling; Geographic profiling; Racial profiling

Pseudoscience in forensic practice

Definition: Use in forensic settings of disciplines that possess the superficial appearance of science but lack its substance.

Significance: On a daily basis, law-enforcement officials confront a host of challenges that often force them to make critical decisions under extreme time pressure and highly stressful circumstances. These decisions involve complex questions of innocence versus guilt, the profiling of criminal suspects, lie detection, the validity of eyewitness testimony, and the interpretation of crime scene evidence, to name just a few. The accuracy of such techniques has the potential to determine crucial life-changing decisions, even capital punishment. As in many professions, individuals in law enforcement must evaluate techniques with a critical eye before using them. Like all disciplines that interpret data to make real-world decisions, forensic science can easily fall prey to the seductive charms of pseudoscience

Given the challenges of law-enforcement investigations, it is not surprising that forensic scientists have turned to psychology for assistance in evaluating the scientific support for the techniques they use. In the 1870's, Francis Galton, a cousin of Charles Darwin, experimented with a word-association test (in which a test examiner says a word, such as "money," and waits for a response from the subject) as a tool for lie detection. In the early twentieth century, Hugo Münsterberg performed experiments that demonstrated the fallibility of eyewitness testimony. Since that time, psychological researchers have spearheaded the development of scientifically grounded procedures to enhance the accuracy of forensic techniques. Nevertheless, the field of law enforcement continues to grapple with the pressing task of discriminating legitimate from illegitimate practices.

Central Characteristics of Pseudoscience

Pseudoscience differs from bona fide science in that pseudoscience does not "play by the rules" of science, even though it mimics some of the outward features of science. Philosopher of science Mario Bunge has suggested the categories of "research fields" and "belief fields" to distinguish science from pseudoscience, arguing that scientific practices are distinguished by scientific support as opposed to intuition or faith. For instance, experience alone is not sufficient for police officers to believe that their interrogation procedures produce accurate confessions; these procedures must be validated by scientific evidence.

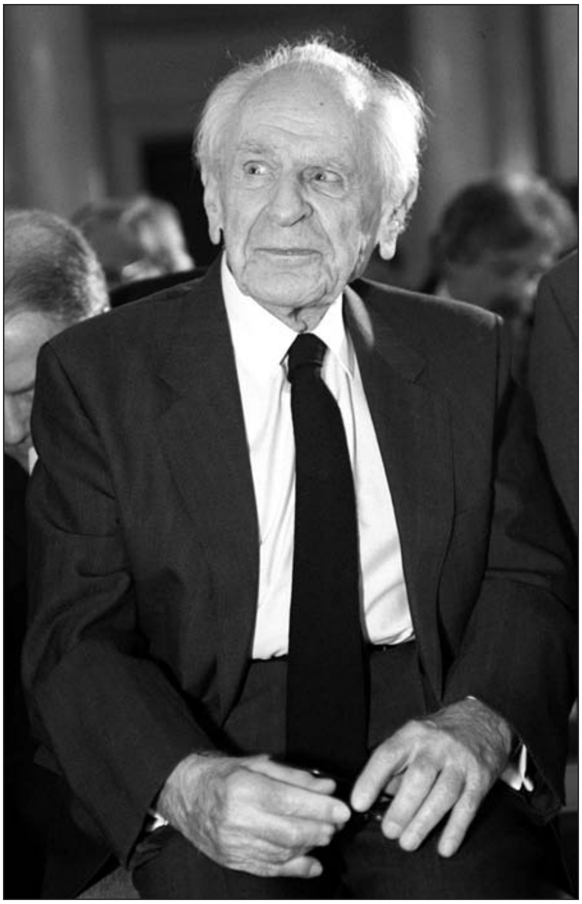
In a scientific discipline, data must be reproducible—that is, replicable—across multiple studies, ideally studies conducted by independent investigators. In addition, most sciences display connectivity, meaning that they build on previous findings in a cumulative fashion. In contrast, most pseudosciences lack replicability and connectivity.

Science and pseudoscience are not always easy to distinguish, because they lie at opposite ends of a continuum, differing in degree rather than in kind. Nevertheless, a number of indicators can help locate practices, including those used in forensic settings, on the fuzzy spectrum between science and pseudoscience. Seven especially crucial indicators are described below.

Lack of Falsifiability and Overuse of Ad Hoc Maneuvers

Philosopher of science Karl Raimund Popper proposed that falsifiability is the key criterion distinguishing science from nonscience—that is, scientific claims can be shown to be wrong if evidence exists to contradict them. Statements such as "God created the universe" may be true or false, but they are not falsifiable using scientific methods because they cannot be refuted with observable evidence. As Popper observed, when research generates findings that seemingly falsify a given claim, pseudosciences often invoke ad hoc maneuvers—that is, escape hatches or loopholes—to explain away these negative findings.

In the case of fingerprint analysis, for example, some proponents claim an accuracy rate as high as 99.9 percent. They assert that a given fingerprint can be perfectly matched to an exemplar print, to the exclusion of all other possible sources of that print. When the technique fails, they often point to such special circumstances as distorted or insufficient prints or misuse of a fingerprint apparatus to explain why the findings did not support the claims. The repeated use of such ad hoc explanations after the fact to explain away negative findings renders a good deal of fingerprint analysis more pseudoscientific than scientific. In some cases, the limited use of ad hoc explanations can provide directions for future research, but pseudosciences invoke such explanations more often than not, rendering their claims virtually unfalsifiable.



An expert on the philosophy and nature of science, Austrian British philosopher Karl Raimund Popper (1902-1994) earned an international reputation with his publication of *The Logic of Scientific Discovery* in 1935. *(AP/Wide World Photos)*

Evasion of Peer Review

Mature sciences rely on a procedure called peer review as a safeguard against error. In peer review, submitted journal articles that evaluate scientific claims are read by outside experts (at least one, and typically three or more) who are entrusted with the task of subjecting the work to relatively impartial scrutiny. In many cases, the peer-review process results in outright rejection of articles; in others, articles are either rejected with an invitation to resubmit following substantial revisions or accepted provisionally.

Peer review is not a perfect filter against poor-quality research, but it is often an essential safeguard. Many pseudosciences bypass this safeguard, preferring to evaluate claims on their own. For example, graphology, the examination of handwriting to infer personality characteristics (not to be confused with forensic handwriting examination or analysis), has been used to profile child molesters and sadistic criminals although virtually no evidence exists to support the validity of this technique. Different and often contradictory schools of graphology have continued in isolation for centuries, ignoring the extensive scientific evidence that shows graphology to be an invalid means of assessing personality characteristics. Despite the overwhelming scientific literature debunking their claims, most graphology proponents continue to advance strong assertions without the restraint and objectivity afforded by the peer-review process.

Lack of Self-Correction

In the long run, science is self-correcting: Incorrect claims tend to be revised or weeded out, whereas correct claims tend to survive. In contrast, in pseudosciences, faulty claims tend to persist for lengthy periods of time, resulting in intellectual stagnation. For example, so-called truth serums are drugs, typically barbiturates, that supposedly elicit truthful information from reluctant individuals. Research has shown, however, that such drugs work in much the same way alcoholic beverages do: They reduce people's inhibitions, making them more likely to disclose both false and true information. The continued use of truth serums to elicit confessions and to unearth supposedly buried memories despite contrary evidence illustrates a lack of self-correction.

Confirmation Bias

Some psychologists, such as Carol Tavris, have argued that the scientific method is a safeguard against confirmation bias—the tendency of human beings to seek out evidence that supports their own hypotheses while ignoring, minimizing, or distorting evidence that does not. Most pseudosciences lack protections against confirmation bias. For example, the interrogation process used by many law-enforcement investigators lacks this safeguard. Investigators often form conclusions about a target suspect prior to obtaining sound evidence, and the process of interrogation may become more about confirming those conclusions than about obtaining impartial information. Such presumptions can lead interrogators to close their minds toward alternative hypotheses and make them likely to seek out support selectively for their beliefs.

Research has shown that the presumption of guilt can influence investigators to adopt an interrogation style that elicits guilty behavior from suspects. Saul M. Kassin and Gisli Gudjonsson have described how suspicion of guilt on the part of interrogators can shape their behavior and lead suspects to act anxiously or defensively, thereby inadvertently confirming the interrogators' suspicions. If questioners increase their bodily movement during an interrogation, the suspect is likely to mimic them and in turn appear nervous and "guilty." As with any belief, interrogators' confidence in their beliefs or "hunches" that they are right about suspects can make it difficult for them to attend to data that do not support their beliefs.

Overreliance on Testimonial and Anecdotal Evidence

Informal testimonials and anecdotes suggesting that a technique is effective can sometimes provide justification for investigating that technique further in systematic studies, but they are never sufficient for concluding that a technique is effective. Many pseudosciences rely on informal personal evidence to validate their claims. For example, in more than 75 percent of cases in which postconviction analysis of DNA (deoxyribonucleic acid) evidence has demonstrated that the convictions were in error, eyewitness misidentification was a primary cause of the initial guilty verdicts. In such cases, law-enforcement officials relied too heavily on anecdotal testimony for proof of guilt. Individuals' subjective experiences are neither recorded nor preserved in memory exactly as the events occurred, and recollections can be contaminated at many steps between the witnessing of an event and the relayed testimony given at the police station or in the courtroom.

Extravagant Claims

Good scientists are aware that their claims are almost always provisional and might be overturned by later evidence; they are also careful not to overstate assertions in the absence of compelling evidence. In contrast, advocates of pseudoscience frequently advance extreme claims that greatly outstrip scientific evidence.

For example, some proponents of the polygraph or "lie detector" test make excessive claims regarding the accuracy of the device in detecting lies, asserting an accuracy rate of close to 100 percent. However, as psychologist David T. Lykken has observed, voluminous evidence suggests that polygraphs probably perform better than chance but are nowhere near as accurate as promoters claim. Because they measure physiological arousal rather than lying per se, they are especially prone to mislabeling innocent subjects as guilty. As with any tool or method, such extravagant claims should be seen as indicators that proponents of a given practice have overstated its ability and that the practice is operating outside the bounds of good science.

Ad Antequitem Fallacy

As the history of science shows, claims that have been around for a long time are not necessarily correct. For example, even though the practice of astrology is more than thirty-five hundred years old, there is no scientific support for astrologers' claims. Many pseudosciences fall prey to the *ad antequitem* fallacy: the error of concluding that because a claim is old, it must be valid. For example, hair comparison and blood type matching have been relied on in criminal cases since the nineteenth century, but the use of these techniques is based on relatively scant scientific validation. Scientific research has exposed these practices as lacking in specificity in identifying given individuals as having been present at crime scenes.

By keeping the indicators described above in mind, consumers of the forensic literature, including jurors, lawyers, judges, and police officers, can better distinguish science from pseudoscience. Moreover, knowledge of such indicators may help to bridge the wide gap between the law-enforcement and scientific communities and help ensure that forensic practices are based on solid research evidence.

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Further Reading

Beyerstein, Barry. "Graphology." In *The Encyclopedia of the Paranormal*, edited by Gordon Stein. Amherst, N.Y.: Prometheus Books, 1996. Presents a penetrating discussion of how graphology falls outside the realm of bona fide science.

Cole, Simon A. "The Fingerprint Controversy." *Skeptical Inquirer* 31 (July/August, 2007): 41-46. Discusses the controversy surrounding identification through fingerprinting, focusing particularly on the absence of scientific validation and problems with the use of fingerprint analysis in the courtroom.

Huber, Peter W. *Galileo's Revenge: Junk Science in the Courtroom*. New York: Basic Books, 1991. Explains how scientific illiteracy is exploited in the courtroom, especially through the use of professional witnesses to advance unsupported pseudoscientific claims. Points to the scientific principles of publication, replication, verification, consensus, and peer review as defenses against courtroom junk science.

Kassin, Saul M., & Gisli Gudjonsson. "The Psychology of Confessions: A Review of the Literature and Issues." *Psychological Science in the Public Interest* 5 (November, 2004): 33-67. Provides a comprehensive look at the various decisions involved in identifying guilty parties and the psychological factors that contribute to false confessions.

Lilienfeld, Scott O., Steven J. Lynn, and Jeffrey M. Lohr, eds. *Science and Pseudoscience in Clinical Psychology*. New York: Guilford Press, 2003. Collection of essays highlights the indicators of pseudoscience and discusses the nature of both good and bad science, offering examples from within clinical and forensic psychology.

Lykken, David T. *A Tremor in the Blood: Uses and Abuses of the Lie Detector*. 2d ed. New York: McGraw-Hill, 1996. Offers a thorough and readable discussion of the history and pitfalls of lie detector tests, including a review of the scientific evidence on the polygraph.

Tavris, Carol, and Elliot Aronson. *Mistakes Were Made (But Not by Me): Why We Justify Foolish Beliefs, Bad Decisions, and Hurtful Acts*. Orlando, Fla.: Harcourt, 2007. Presents engaging discussion of how the human brain is predisposed toward self-justification, rendering humans prone to cognitive biases.

Wells, Gary L. "Helping Experimental Psychology Affect Legal Policy." In *Psychology and Law: An Empirical Perspective*, edited by Neil Brewer and Kipling D. Williams. New York: Guilford Press, 2005. Discusses how findings from psychological research can be applied to improving legal policies and suggests how scientific data can inform forensic practices in more productive ways.

See also: Ancient science and forensics; Celebrity cases; Courts and forensic evidence; Eyewitness testimony; Fingerprints; *Forensic Files*; Interrogation; Polygraph analysis; Truth serum; Wrongful convictions.

Psychological autopsy

Definition: Set of postmortem investigative procedures carried out to gain a better understanding of the psychological circumstances that may have contributed to a suicide.

Significance: Psychological autopsies allow researchers and investigators to gather information on suicidal behavior that cannot be obtained through the use of other methodologies. In addition to helping investigators determine the modes of death in cases of suicide, psychological autopsies can shed light on the reasons people commit suicide.

Edwin S. Shneidman, one of the founders of the field of suicidology, coined the term "psychological autopsy" to describe the procedure he developed with his colleagues at the Los Angeles County Medical Examiner's Office to assist medical examiners and coroners in clarifying equivocal deaths (deaths the causes of which are unknown). The psychological autopsy entails the analysis of medical autopsy and police reports, personal documents left behind by the deceased, and interviews with those who knew the deceased. Since the late twentieth century, the psychological autopsy has gained widespread usage in suicidology, and research studies of psychological autopsies have been conducted in several countries, including Sweden, Finland, Scotland, Taiwan, New Zealand, and Great Britain. The psychological autopsy has also become a widely used forensic investigatory tool.

Psychological Autopsies and Forensic Investigations

Psychologists conducting psychological autopsies compile information retrospectively about the behaviors, psychological states, and motives of deceased persons. For a death to be considered a potential suicide, evidence surrounding the death must show that the wound suffered could have been self-inflicted. Psychologists and law-enforcement officials must also determine that the deceased understood the consequences of the actions that led to the person's death (also called lethal intent).

During forensic investigations of possible suicides, the physical evidence should corroborate the findings of the psychological autopsies. For example, when it occurs, cadaveric spasm (instant rigor mortis) can help establish whether a death was homicide or a suicide. The presence of a weapon (such as a gun, knife, or razor blade) tightly clutched in the hand of the deceased as the result of cadaveric spasm strongly indicates suicide. The absence of cadaveric spasm, however, does not preclude suicide, as this phenomenon does not occur in every case. For reasons such as this, the careful consideration of both physical evidence and findings from psychological autopsies is critical to successful forensic investigations into possible suicides.

Elements of a Psychological Autopsy

A psychological autopsy includes semistructured interviews with relatives, friends, and other persons connected to the deceased. Another central component is a review of the medical and psychiatric histories of the deceased.

In analyzing the information gathered, the psychologist attempts to understand the final days and hours of the dead person's life. In doing so, the psychologist may rely on examination of the death scene as well as examination of such materials as the deceased's journals and suicide notes, books and music owned by the deceased, and the deceased's school, military, and employment records.

Many psychologists also gather information about the deceased person's family history of death and mental illness, familiarity with death methods, stress reaction patterns, involvement with alcohol or drugs, habits and routines, and relationship history when conducting a psychological autopsy. Of particular interest in this search for information is anything that indicates that the deceased person experienced any major life disruptions, such as the loss of a job or a loved one, in the days and hours leading up to the death.

Admissibility of Psychological Autopsies in Court

Because no standard procedures and methods have been established for the conduct of psychological autopsies, testimony concerning the findings of these investigations is not always accepted in court. The *Daubert* standard of evidence, derived from the U.S. Supreme Court's decision in *Daubert v. Merrell Dow Pharmaceuticals* (1993), provides a two-pronged test for evaluating evidence presented by expert witnesses. In short, the relevance prong of the standard requires that the evidence "fit" the facts of the case, and the reliability prong requires that the evidence be derived from the scientific method. With *Daubert*, the Supreme Court made trial judges, specifically federal trial judges, the final gatekeepers of scientific evidence; thus decisions regarding the admissibility of the findings of psychological autopsies can vary from judge to judge.

Limitations of Psychological Autopsies

Despite the obvious utility of the psychological autopsy, much has been written about the limitations of this technique. Critics have noted, for example, that because the deceased are not available for questioning, psychologists must rely on interviews with those who knew them, and any of these people may contaminate the process by providing "biased" recollections.

The most commonly cited limitation or weakness of psychological autopsies is the lack of any standardized procedures for conducting them. Although psychologists have developed a guide with twenty-six categories to assist investigators in conducting psychological autopsies, not all of the categories are applicable to every case or are considered by every psychologist conducting a psychological autopsy. Despite these limitations, the psychological autopsy has proven to be an invaluable investigative tool, and findings from studies on psychological autopsies have led to innumerable advances in suicide prevention and the treatment of persons with suicidal tendencies.

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Further Reading

Cohen, Ronald J., and Mark Swerdlik. *Psychological Testing and Assessment: An Introduction to Tests and Measurement*. 5th ed. New York: McGraw-Hill, 2002. Provides a fine introduction to widely used psychological tests and assessment procedures, including the psychological autopsy.

Eliopulos, Louis N. *Death Investigator's Handbook*. Expanded ed. Boulder, Colo.: Paladin Press, 2003. Widely used by homicide divisions in federal and local law-enforcement agencies for its useful information on crime scene processing and investigative techniques.

Joiner, Thomas. *Why People Die by Suicide*. Cambridge, Mass.: Harvard University Press, 2006. Provides a thorough overview of the major theories and evidence for why people commit suicide.

Maris, Ronald W., Berman, Alan L., and Morton M. Silverman. *Comprehensive Textbook of Suicidology*. New York: Guilford Press, 2000. Provides a clear and comprehensive overview of the field of suicidology.

Shneidman, Edwin S. *Autopsy of a Suicidal Mind*. New York: Oxford University Press,

2004. Shneidman and eight other renowned experts in the field of suicidology examine a suicide note provided to them by a distraught mother seeking to understand her son's death.

_______. *Lives and Deaths: Selections from the Works of Edwin S. Shneidman*. Edited by Antoon A. Leenaars. Philadelphia: Brunner/Mazel, 1999. Collection of thirty-seven articles by one of the founders of the field of suicidology.

See also: Antemortem injuries; Autoerotic and erotic asphyxiation; Autopsies; Coroners; Crime laboratories; Crime scene investigation; *Daubert v. Merrell Dow Pharmaceuticals*; Forensic psychology; Forensic toxicology; Hanging; Hesitation wounds and suicide; Suicide.

Psychopathic personality disorder

Definition: Psychological disorder characterized by egotistical, self-centered, impulsive, and exploitative behaviors, lack of remorse, and emotional callousness.

Significance: Psychopathic offenders are among the most physically violent, aggressive, and dangerous perpetrators of crimes. Although they make up only a small percentage of all offenders, they commit a disproportionate number of offenses and are often responsible for the most heinous of criminal acts. The ability to identify psychopaths accurately is thus critical to the protection of law-abiding citizens and the reduction of crime.

One of the most important and most influential treatises on psychopathic personality disorder was set forth in 1941 by Hervey Cleckley in his book *The Mask of Sanity: An Attempt to Reinterpret the So-Called Psychopathic Personality*. Cleckley outlined sixteen different core personality traits that define a psychopath, including pathological lying, superficial charm, lack of empathy, and egocentricity. Since the first edition of Cleckley's book was published, a wealth of research has examined a number of different issues germane to psychopathic personality disorder, including the potential causes and correlates of psychopathy, ways to assess and diagnose psychopathy, and how psychopathic personality disorder relates to violent offending. This line of research has shown that psychopathic criminals are qualitatively and quantitatively different from nonpsychopathic offenders.

Psychopathic criminals inflict more damage and commit more crimes than any other group of criminal offenders. Given their frequent involvement in antisocial behaviors, psychopaths are also at risk for being incarcerated for lengthy periods of time. Once imprisoned, however, they do not refrain from committing crimes; rather, they engage in a constellation of violent behaviors, ranging from assaulting other inmates to victimizing prison staff. Incarcerated psychopaths are frequently identified as the worst inmates in prison populations. When released from prison, psychopaths usually begin to offend again immediately. Some criminologists have estimated that, in the United States, 80 percent of psychopaths who have been released from incarceration are reconvicted of new crimes and returned to prison.

Not all psychopaths are criminals. Some find success in businesses that benefit from cutthroat practices; others make their way in the world as smooth-talking philanderers. All psychopaths, however, regardless of whether they are criminals per se, tend to inflict a great deal of harm on other persons and on society in general.

Assessment and Diagnosis

One of the more difficult issues facing clinicians is how to determine accurately whether an individual meets the criteria for being considered a psychopath. The most reliable and valid method of diagnosing psychopathy involves the use of some type of standardized actuarial assessment tool. Although a number of different instruments are available, the most widely used is the Psychopathy Checklist-Revised (PCL-R), developed by Robert D. Hare.

The PCL-R is administered by a doctoral-level clinician who conducts a face-to-face interview with the person being assessed for psychopathy. During the interview, which can last up to two hours, the clinician rates the person on twenty different traits.

Each trait is assigned a value ranging from zero to two, with higher scores indicating a greater likelihood that the person possesses that characteristic. A score of zero on a trait means that the person does not display the trait; a score of two means that the person definitely possesses the trait. When the interview is completed, the clinician tabulates the scores for all twenty traits; a person who receives a total score of thirty or higher is considered to be a psychopath. Overall, criminal offenders have an average PCL-R score of about twenty-two; nonoffenders, in contrast, have an average score of about five.

The twenty items that make up the PCL-R measure two different dimensions of psychopathy. Some items are designed to assess the personality traits of psychopaths, such as short-temperedness and impulsiveness; others indicate the extent to which the person leads an antisocial, unstable, and deviant lifestyle. Usually a person who scores high on one dimension also scores high on the other, but that is not always the case. In terms of the behaviors associated with these two dimensions, individuals who score high on the personality dimension are at much greater risk for becoming involved in acts of serious physical violence. The fact that psychopaths typically score high on both dimensions indicates their heightened propensity to engage in violent criminal acts and other types of antisocial behaviors.

Hare also developed a psychopathy checklist for adolescents ages twelve to eighteen, the Psychopathy Checklist: Youth Version (PCL:YV), which uses a semistructured interviewing platform to determine the extent to which an adolescent interviewee exhibits an array of psychopathic traits. Similar to the PCL-R, the PCL:YV is made up of twenty different items that tap behavioral, emotional, affective, and interpersonal traits often displayed by psychopathic adults. The PCL:YV has been shown to be a reliable and valid way of measuring psychopathy in samples of adolescents and is useful for examining the early development of psychopathic traits.

Traits of a Psychopath

In his classic work The Mask of Sanity, *published in 1941, Hervey Cleckley outlined sixteen different core personality traits that define a psychopath:*

- Superficial charm and good "intelligence"
- Absence of delusions and other signs of irrational thinking
- Absence of "nervousness" or psychoneurotic manifestations
- Unreliability
- Untruthfulness and insincerity
- Lack of remorse or shame
- Inadequately motivated antisocial behavior
- Poor judgment and failure to learn by experience
- Pathologic egocentricity and incapacity for love
- General poverty in major affective reactions
- Specific loss of insight
- Unresponsiveness in general interpersonal relations
- Fantastic and uninviting behavior with drink and sometimes without
- Suicide rarely carried out
- Sex life impersonal, trivial, and poorly integrated
- Failure to follow any life plan

Prevalence and Offending Frequency

It is somewhat difficult to establish the prevalence of psychopathy in the general U.S. population because researchers studying psychopaths usually draw their samples from forensic populations. Some scholars, however, have calculated estimates of psychopathy in the adult population of the United States and have asserted that approximately 1 to 3 percent of male adults could be considered psychopaths, and about 1 percent of all female adults would meet the criteria for psychopathy.

The exploitative and aggressive behaviors displayed by psychopathic criminals are also relatively stable over long swaths of the life course. Psychopaths tend not to change their behaviors: Youthful psychopaths are likely to remain psychopaths as they mature into adulthood. This is especially true for those who score high on the personality dimension of the PCL-R.

Among the general public, psychopaths are a statistical aberration, but psychopaths are much more prevalent in prison populations. Although estimates vary, the general consensus is that psychopaths constitute about 20 percent of all incarcerated American prisoners, but they make up an even larger percentage of all inmates incarcerated for serious, violent crimes. Psychopathic criminal offenders not only commit a disproportionate percentage of the most serious acts of predation, but they also offend at much higher rates than do nonpsychopathic criminal offenders. In short, although psychopaths make up only a relatively small percentage of all offenders, they account for the vast majority of all criminal acts.

Causes and Treatment

The origins of psychopathy have long baffled scholars. Although it was once believed that social factors and environmental conditions were solely responsible for individuals' development of psychopathy and psychopathic traits, leading researchers now generally agree that biological and genetic factors play a large role in the process. Research has revealed, for example, that certain core psychopathic personality traits, such as impulsivity and callousness, are under significant genetic control. Evidence also suggests that brain abnormalities, such as problems with the amygdala, neuropsychological deficits, and a malfunctioning prefrontal cortex,

Serial killer Jeffrey Dahmer (center), flanked by his attorneys, at his 1991 murder trial in Milwaukee, Wisconsin. A textbook example of psychopathic personality disorder, Dahmer showed no remorse for the seventeen people he is believed to have killed. He often engaged in sex acts with his victims' bodies, many of which he dismembered, and he even ate parts of his victims. After being sentenced to fifteen consecutive life sentences plus ten years, he was beaten to death in prison by another inmate. *(AP/Wide World Photos)* may be important factors in the etiology of psychopathy.

Given the vast amount of death and destruction caused by psychopathic criminals, great interest exists in whether treatment programs can have any impact on the violent behavioral patterns evinced by psychopaths. In general, violent and aggressive psychopaths are extremely nonresponsive to treatment efforts. Although some rehabilitation programs have reported success in reducing aggressive behaviors among psychopaths, this appears to be the exception rather than the rule. Psychopaths in treatment settings are known for resisting treatment, manipulating staff members, and victimizing fellow patients. Psychopathic criminals often leave treatment programs before completion, and even those who successfully complete such programs tend to have extremely high rates of recidivism. Some experts have argued that the only way to control psychopathic offenders is through incarceration.

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Further Reading

Babiak, Paul, and Robert D. Hare. *Snakes in Suits: When Psychopaths Go to Work*. New York: HarperCollins, 2006. Discusses the impacts of psychopathic personalities on corporate environments.

Blair, James, Derek Mitchell, and Karina Blair. *The Psychopath: Emotion and the Brain*. Malden, Mass.: Blackwell, 2005. Presents a cogent theoretical framework on which to base the argument that psychopaths have brain abnormalities.

Cleckley, Hervey. *The Mask of Sanity: An Attempt to Clarify Some Issues About the So-Called Psychopathic Personality*. 5th ed. Saint Louis: C. V. Mosby, 1976. Updated edition of the first book written about psychopaths, which was published in 1941. Provides one of the earliest and one of the most influential discussions about psychopathy and psychopaths.

DeLisi, Matt. *Career Criminals in Society*. Thousand Oaks, Calif.: Sage, 2005. Presents an excellent overview of habitual offenders, including psychopathic criminals.

Hare, Robert D. *Without Conscience: The Disturbing World of the Psychopaths Among Us*. New York: Guilford Press, 1999. Work by a leading expert on psychopathy provides a good introduction to the main concepts and issues relating to research in this field.

Meloy, J. Reid. *The Psychopathic Mind: Origins, Dynamics, and Treatment*. Lanham, Md.: Rowman & Littlefield, 1998. Comprehensive text discusses the causes of psychopathy and some different methods of treating psychopaths.

See also: Antipsychotics; Borderline personality disorder; Criminal personality profiling; Criminology; *Diagnostic and Statistical Manual of Mental Disorders*; Forensic psychiatry; Forensic psychology; Guilty but mentally ill plea; Minnesota Multiphasic Personality Inventory.

Psychotropic drugs

Definition: Broad group of substances that are capable of affecting human minds and behavior.

Significance: Forensic scientists are often called upon to determine whether psychotropic drugs are present in persons or at crime scenes as well as the exact nature of any such substances found.

Psychotropic drugs are also known as psychoactive substances. They include licit and illicit drugs as well as plants, foods, and household products not commonly thought of as drugs or druglike. Because of this breadth of forms, the potential range of effects of these substances is very broad. In general, however, psychoactive drugs have primary action on the central nervous system (brain and spine) and the behaviors and reactions it controls. These include processes such as attention, awareness, physical and other perceptions and feelings, emotions, concentration, learning, judgment, and thinking.

Drugs that are considered psychoactive are generally classified into groups based on the conditions they are legally used to treat and how they affect the body. Some common groupings include analgesics, antidepressants, antiepileptics, antiparkinsonian drugs, antipsychotics, anxiolytics, central stimulants, contraceptives, fertility drugs, general depressants, psychedelics, sedative-hyponotics, and tranquilizers. Substances of abuse can be classified into many of these categories as well; however, for diagnostic purposes, they are considered separately. Substances of abuse include alcohol, amphetamines, caffeine, cannabis (or marijuana), cocaine, hallucinogens (such as club drugs), inhalants, nicotine, opioids, phencyclidine (known as PCP), sedative-hypnotics, and anxiolytics.

Caffeine, hallucinogens, and inhalants illustrate the fact that psychotropic substances are not always found in pill or other common medicinal form. Caffeine is found in many everyday food items, including coffee, tea, and chocolate. Hallucinogens may be found in plants and fungi. Inhalants are found in household and workplace substances, such as gasoline, glue, lighter fluid, liquid correction fluid, paint, paint thinner, and varnish, as well as in the forms of amyl and butyl nitrate, general anesthetics, and nitrous oxide.

Not all psychotropic drugs are prescription or illicit drugs. The caffeine found in coffee, tea, soft drinks, chocolate, and other commonly consumed beverages and foods is a powerful psychotropic drug that can alter behavior and become the object of dependencies. *(© iStockphoto.com/José Luis Gutiérrez)*

Common Uses

Psychotropic drugs have many positive uses. Various types of these substances are used in the treatment of mental illnesses such as attention-deficit/hyperactivity disorder (ADHD), depression, bipolar disorder, and schizophrenia. Antidepressants and mood-stabilizing drugs such as lithium are good examples of the psychoactive substances used for these purposes. Analgesics, including morphine, are used to treat pain. Other psychotropic drugs that are used to treat some complex conditions, such as epilepsy, have direct effects on the conditions they are used to treat as well as side effects that affect the mind.

Psychotropic drugs are also used recreationally and abused, but it is not only illicit recreational drugs that are of forensic interest. The most commonly used licit drugs—alcohol, caffeine, nicotine, and prescription drugs, including opioids—are also of interest to law enforcement. Alcohol, for instance, has long been related to crime; forensic scientists are often involved in determining the presence and amounts of alcohol in the blood in cases of persons accused of driving under the influence, public intoxication, and underage drinking. Caffeine intoxication may cause agitation, which, when combined with other circumstances, may lead to problems such as aggressive driving or verbal assault. Forensic scientists may conduct examinations of nicotine for cases related to accusations of smoking in restricted areas, such as on airplanes, or for lawsuits related to health damages caused by nicotine. Psychotropic drugs that are available by prescription, such as oxycodone, are often linked to crimes involving prescription forgery or improper prescribing of these substances by physicians.

Continuing Controversies

In the United States, a number of controversies surround psychotropic drugs and their effects. These include long-running debates about the regulations attached to production of these substances as well as the laws concerning the distribution of such drugs and access to them. The characteristics of the users themselves also spark controversy. Although many psychotropic substances have been shown to be valuable in addressing suffering, debates continue about "good" and "bad" drugs, and the context of use is often ignored. Fierce disagreements are also ongoing regarding why, how, and when research on the value of any drug should be revisited.

Debates among lawmakers continue about which substances should be regulated, by what means, and to what extent. The process from drug production to end users is a long chain of events, and insufficiencies at any point can cause problems for those involved in the chain, costing them money. Decision making around the regulation of psychotropic drugs thus receives great scrutiny, because a delicate balance must be maintained in assigning who—producers, distributors, dispensers, users, the public at large—should pay the costs associated with any one drug and its impacts.

Many of the concerns about the users of psychotropic drugs tend to center on recreational users, focusing on how they should they be controlled, cured, or prosecuted. Some argue that users of these substances have certain moral or ethical weaknesses, but given that the use of psychoactive drugs—in one form or another—is the norm, this argument is ill founded. Another issue is the nonuse of these substances by individuals who might benefit from them under medical care and thus indirectly benefit society. Not all persons who might need psychotropic drugs are willing to take them, and some might take them only in certain circumstances, if they are able to make such judgments at all. If their refusal to use these substances will endanger their safety or the safety of others, should these persons be forced to take the drugs? Such matters are relevant to law enforcement in that they involve the balance of protecting individuals and society from harm while honoring hard-won civil liberties.

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Further Reading

Julien, Robert M. *A Primer of Drug Action: A Comprehensive Guide to the Actions, Uses, and Side Effects of Psychoactive Drugs*. 10th ed. New York: Worth, 2005. Describes how drugs are absorbed and processed by the body as well as their effects on the body and mind.

Kuhn, Cynthia, Scott Swartzwelder, and Wilkie Wilson. *Buzzed: The Straight Facts About the Most Used and Abused Drugs from Alcohol to Ecstasy*. 2d ed. New York: W. W. Norton, 2003. Easy-to-read guide provides basic information on commonly used drugs.

Rudgley, Richard. *The Encyclopedia of Psychoactive Substances*. New York: St. Martin's Press, 2000. Easy reference resource notes the histories, regions and patterns of use, and effects of various drugs.

Weil, Andrew, and Winifred Rosen. *From Chocolate to Morphine: Everything You Need to Know About Mind-Altering Drugs*. Rev. ed. Boston: Houghton Mifflin, 2004. Discusses the broad range of substances that affect the mind.

World Health Organization. *Neuroscience of Psychoactive Substance Use and Dependence*. Geneva: Author, 2004. Describes psychotropic drug effects at the level of neurotransmitters.

See also: Amphetamines; Antianxiety agents; Antipsychotics; Attention-deficit/hyperactivity disorder medications; Club drugs; Crack cocaine; Drug abuse and dependence; Drug classification; Halcion; Hallucinogens; Legal competency; Narcotics; Opioids.

Puncture wounds

Definition: Injuries made when pointed objects—such as knives, nails, needles, screwdrivers, or teeth—are forced into the body.

Significance: Deep or forceful puncture wounds can cause death, particularly if they affect internal organs such as the heart, liver, lungs, or kidneys.

Puncture wounds may appear insignificant, as little damage may be visible on the surface. Such wounds, however, may be deep even though they are not very wide (in contrast with cuts, which are wide but not necessarily deep). Deep puncture wounds may cause significant internal bleeding, and the weapons used to make the wounds may leave behind chemical residues that can cause infections that may lead to death.

The most significant types of puncture wounds examined by forensic scientists are generally knife wounds, as these are the most likely kinds of puncture wounds to cause death. Other types of materials may cause puncture wounds, however. These include glass, hypodermic and other needles, nails, screwdrivers, and even obscure objects such as hat pins. Puncture wounds may also be caused by other forces, such as when a falling body hits a fence stake or when a broken rib punctures a lung.

A puncture wound can be particularly dangerous if the tip of the instrument that made the wound has been treated with a poison or some other chemical. If the instrument is long, it can deposit these substances deep into the body, perhaps even into an organ. Even if no chemicals were present on the instrument, a puncture wound can heal over on the surface while bacteria are left to grow and fester inside the wound, causing infection and more internal damage. Puncture wounds that enter internal organs, known as penetrating puncture wounds, may cause irreparable organ damage that may not be obvious when the wound is first inflicted.

With careful examination during autopsy, a forensic pathologist can usually determine what type of weapon has caused puncture wounds. The pathologist may use X rays or other types of imaging, such as computed tomography (CT) scanning or magnetic resonance imaging (MRI), to determine the path or paths of the weapon through the body. The pathologist also examines the entry point of the instrument and inspects the decedent's clothing for holes and blood spatter patterns. (With puncture wounds, however, bleeding is often minimal.) Sometimes, especially if the weapon hit bone, the tip or some other small piece of the weapon may be left behind, giving the pathologist more evidence to use in determining the cause of the wound. Careful examination of a puncture wound can also help determine whether the wound was accidental, self-inflicted, or inflicted by an assailant.

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Further Reading

DiMaio, Vincent J., and Dominick DiMaio. *Forensic Pathology*. 2d ed. Boca Raton, Fla.: CRC Press, 2001.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005.

Shkrum, Michael J., and David A. Ramsay. *Forensic Pathology of Trauma: Common Problems for the Pathologist*. Totowa, N.J.: Humana Press, 2007.

See also: Autopsies; Blood spatter analysis; Blood volume testing; Defensive wounds; Forensic pathology; Hesitation wounds and suicide; Knife wounds.

Q

Quality control of evidence

Definition: Documented and demonstrable processes and procedures used to ensure the integrity of all items of evidence.

Significance: Demonstrable procedures for the collection, packaging, handling, transport, examination, and storage of items of evidence are crucial to ensuring that those items retain their evidential value. It is of the greatest importance that confidence can be placed in the integrity of an evidential item and any findings derived from it.

Quality-assurance programs have become commonplace in forensic organizations, and a number of accreditation bodies have been formed for the purpose of assessing the performance of forensic organizations against strict standards of practice. Accreditation allows organizations to demonstrate that they have been assessed and that their procedures were found to be satisfactory. They must also be able to demonstrate that those procedures are put into practice, however.

One of the most significant parts of any forensic organization's quality-assurance, or accreditation, program is that relating to the handling of evidence. The organization must be able to demonstrate that each item of evidence has been handled appropriately from the moment of its discovery up to its presentation in court for trial, and sometimes through subsequent appeals and retrials. If it can be demonstrated that an evidential item has been, or may potentially have been, compromised or contaminated in some way, the significance of its evidential value becomes questionable. Doubt about the handling of a single piece of evidence may also call into question the evidential value of any items held or handled in any way by the same specific laboratory or individual. This may also have ramifications for other cases involving that laboratory or individual.

Scene Security

When police personnel take control of a crime scene, they have a responsibility to take all reasonable steps to protect all potential evidence at the scene from deleterious change. Initially this involves ensuring that appropriate scene boundaries are put in place, a task that can be logistically difficult, particularly when a scene is outdoors.

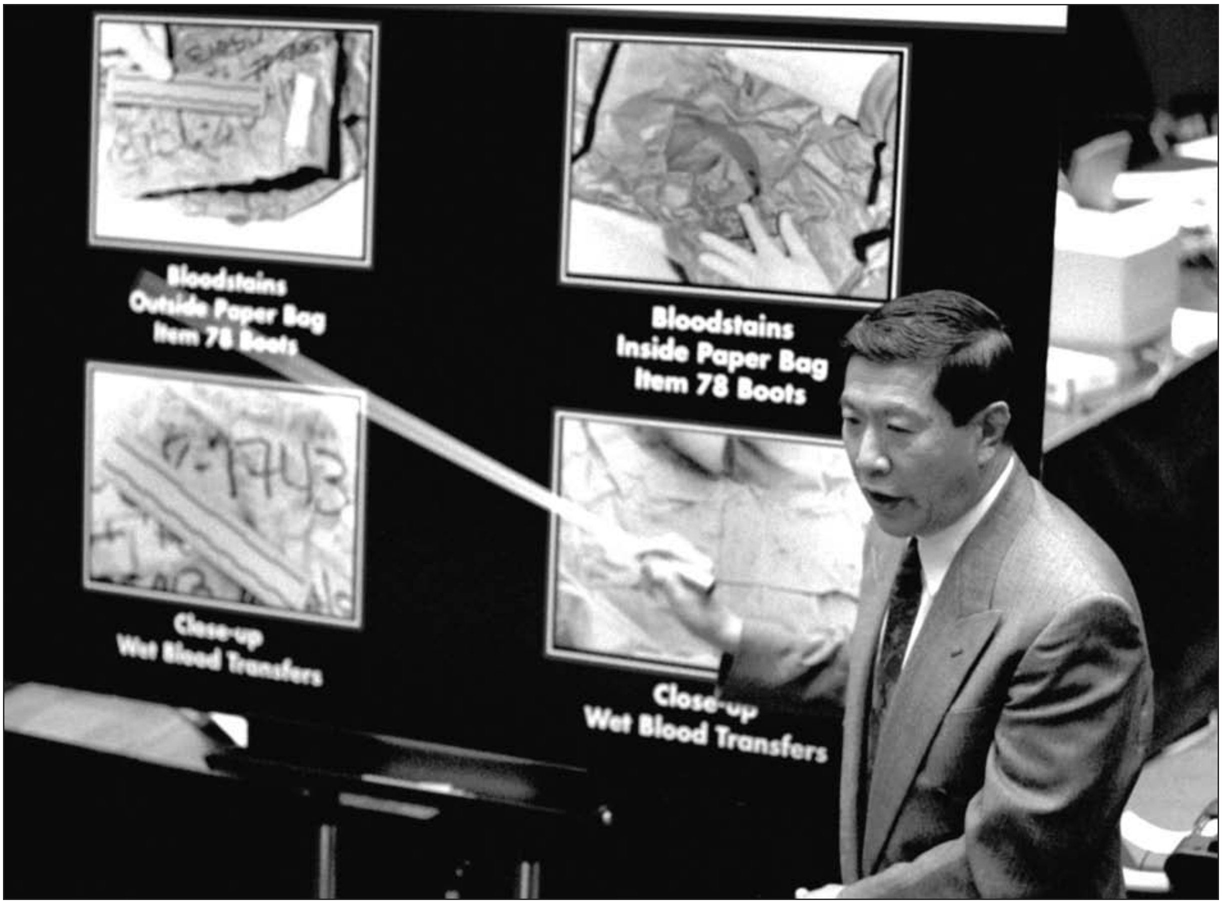
After the scene parameters are in place, law-enforcement authorities must maintain control of the area to prevent entry to the scene by anyone other than those strictly required for processing and recording of the scene. Wherever possible, those individuals should all be well-trained, competent, and experienced crime scene personnel.

Chain of Custody

When an item of potential evidence is identified, its location within the crime scene and its conditions must be recorded. This is typically done through photography, scene sketches, and general notes. After possession is taken of the item, it becomes part of an official exhibits register.

The exhibits register, or evidence log, is a list of all items that come into the possession of the police, whether collected from a scene or by other means, in relation to an investigation. The register typically assigns a unique identifier to each item and records a description of the item along with information concerning where it was found and by whom and when it was physically seized. After an item is entered into the exhibits register, the register records the physical location of the item and every instance when custody of the item changes.

During the course of an investigation, items may be transferred between sections of an organization or between organizations in order for required examinations to occur. Each section or organization should have its own process in place for recording the chain of custody of any items within its possession.



At O. J. Simpson's double-murder trial in 1995, Dr. Henry C. Lee, a renowned forensic scientist, was engaged by the defense to provide testimony that questioned the quality of the handling of evidence in the case by crime scene investigators. Here he explains how bloodstains were transferred from evidence items in the case to the paper sacks in which they were carried. *(AP/Wide World Photos)*

The Importance of Packaging

The method of packaging of an item of evidence is also crucial to maintaining its evidential value. Inappropriate packaging may destroy evidence. For example, the DNA (deoxyribonucleic acid) in biological fluids can rapidly degrade if stored in a moist environment, such as inside a sealed plastic bag; such evidence should therefore be stored in breathable packaging, such as paper bags. Flammable liquid residues in a fire debris sample, in contrast, should not be packaged in paper, as this allows them to evaporate; such residues should be packaged in airtight containers. It is important that all personnel who handle evidential items understand how packaging can affect the items and thus potentially affect the results of subsequent analyses.

Item Examination and Preservation of Item Integrity

During the laboratory examination of items of evidence—whether they are bullet fragments, bloodstains, or articles of clothing—some degree of physical handling of the items is inevitable. Following examination of an item, it is the responsibility of the examiner to be able to demonstrate that all reasonable steps were taken to ensure that the item was not detrimentally affected by the examination any more than was strictly necessary to perform the examination properly.

Crime laboratories often have strict requirements in place detailing what is considered to be acceptable practice in the examination of evidence. For example, the examination of items for DNA, particularly trace or contact DNA, can often involve elaborate precautions to prevent contamination. Examination spaces need to be thoroughly cleaned before and after items are examined. All equipment used must be either disposable or able to be cleaned thoroughly between item examinations. Examiners must wear disposable lab coats and gloves, face masks, and hair coverings to minimize their DNA contribution. This protective clothing must also be completely changed between the examinations of different items.

Records are kept of when an item was examined, who the examiner was, and where the examination took place. Any tests performed on an item are also recorded, as are the details of any subsamples collected.

Examination strategies for items involved in an investigation should also be considered. For example, if practical, a crime lab might schedule examinations of items from complainants, suspects, and scenes in a particular case to take place in different examination rooms on different days and by different analysts. This sort of strategy effectively eliminates any reasonable suggestion of cross-contamination occurring between case items.

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Further Reading

Adams, Thomas F., Alan G. Caddell, and Jeffrey L. Krutsinger. *Crime Scene Investigation*. 2d ed. Upper Saddle River, N.J.: Prentice Hall, 2004. Handbook for law-enforcement professionals focuses on excellence in the conduct of crime scene procedures, including the preservation of the integrity of evidence.

Inman, Keith, and Norah Rudin. *Principles and Practice of Criminalistics: The Profession of Forensic Science*. Boca Raton, Fla.: CRC Press, 2001. Provides an introduction to best practices in the forensic science profession. Includes discussion of evidence collection and preservation.

Pyrek, Kelly M. *Forensic Science Under Siege: The Challenges of Forensic Laboratories and the Medico-Legal Investigation System*. Burlington, Mass.: Elsevier Academic Press, 2007. Addresses the problems and challenges facing the field of forensic science, the history behind them, how they have been promulgated, and what could and should be done in the future to remedy them.

St. Clair, Jami J. *Crime Laboratory Management*. San Diego, Calif.: Academic Press, 2002. Presents excellent discussion of the unique needs and requirements involved in the management of forensic science laboratories.

See also: American Society of Crime Laboratory Directors; Chain of custody; Control samples; Courts and forensic evidence; Crime laboratories; Crime scene documentation; Crime scene investigation; Crime scene protective gear; Crime scene search patterns; Cross-contamination of evidence; Direct versus circumstantial evidence; Disturbed evidence; Evidence processing.

Quantitative and qualitative analysis of chemicals

Definition: Processes of identifying and measuring the individual components within chemical mixtures.

Significance: Analytical chemistry plays a major role in forensic laboratories. Techniques from the field of analytical chemistry are used to examine various types of physical evidence such as glass, soil, drugs, ink, paint, body fluids and tissues, explosives, and petroleum products. In forensic science, analysis of such evidence can be either qualitative or quantitative, depending on the information required, sample size, the technique used, and how the results are interpreted.

In chemical analysis, the components of a sample are identified and their concentrations determined. The main objective of qualitative analysis is to identify one or more substances or chemicals that may be present in a sample. The main goal of quantitative analysis is to determine how much of a particular chemical or substance is present in the sample. Most forensic analysis techniques currently in use are qualitative and are used to identify or confirm the presence or absence of certain materials. Subsequent analyses provide additional information, such as the amounts of component substances present in a sample. Forensics scientists conduct qualitative and quantitative analyses on chemical components of materials, objects, solutions, and biological specimens, including body fluids.

Qualitative Analysis

Qualitative analysis is an integral part of forensic science, with the primary goal to identify unknown substances and chemical elements present in a sample. Qualitative analyses are often used to confirm the presence or absence of certain materials in a sample. Although qualitative analysis can be used to separate components into categories, it is not useful for determining the amounts of certain compounds that are present. Comparison of samples is qualitative and can be conducted to determine whether the chemical compositions of two or more samples are similar.

Qualitative analyses are often based on physical properties, such as melting point, color, texture, density, and other properties that are distinctive for specific elements or compounds. Qualitative analyses are often conducted to determine whether illicit drugs or poisons are present in a sample. After it is known which substances are present, quantitative analysis follows to determine the concentration of each substance present in the sample.

Quantitative Analysis

When the presence of certain substances in a sample has been confirmed, the absolute or relative abundance of these compounds can be determined using quantitative techniques. Quantitative analysis is used to determine the quantity or concentration of a specific substance in a sample. For example, qualitative analysis is used to determine the presence of alcohol in the blood of a person suspected of driving under the influence; quantitative analysis is used to determine the amount of alcohol present in the blood (that is, the blood alcohol level).

Qualitative and Quantitative Analyses in Combination

A more complex analytical situation occurs when both qualitative and quantitative data are required. Although qualitative analyses are generally conducted for identification, in some situations quantitative information is also important. For example, reliable identification of a compound present in a sample is not possible unless a minimum amount of material is also present, which is quantitative information.

If comparing samples requires that the amount of a specific substance present in a sample be known in addition to the chemical elements that are present, then comparative qualitative methods also have quantitative features. Chemical analysts in forensic laboratories conducting qualitative analyses may also need to be involved with quantitative analysis.

Analytical Techniques

Many sophisticated laboratory techniques are used in forensic science for various types of chemical analyses. Some techniques are more suited for qualitative analysis, and others are more appropriate for conducting quantitative analysis. Some methods can be useful for both qualitative and quantitative analyses, depending on how the data are collected and analyzed. Techniques that are primarily used for qualitative analyses, such as substance identification, include "wet" chemical techniques to collect physical properties of sample components, some chromatographic techniques and spectroscopic methods, and DNA (deoxyribonucleic acid) analysis.

Although microscopy is generally qualitative in nature, it can be quantitative when used in combination with specific spectrophotometric measurements. Spectroscopy can be qualitative or quantitative or both, depending on the procedures used and the types of measurements collected. For example, ultraviolet and visible spectrophotometry is generally used as a screening tool to determine the presence or absence of suspected compounds, but it can also be quanti-

A chemist at the Centers for Disease Control and Prevention sets up a system using liquid chromatography coupled with mass spectrometry to analyze a sample. *(Centers for Disease Control and Prevention)*

tative in single-substance solutions or with appropriate standards. Other forms of spectroscopy, such as infrared (IR) or Fourier transform infrared (FTIR), are also recognized as useful for collecting quantitative measurements.

Chromatographic methods are used extensively in forensic science labs to analyze body fluids for the presence of illicit drugs, to analyze samples collected from crime scenes, and to analyze residues from explosives. Although thin-layer chromatography has generally been considered qualitative, many quantitative procedures involving this method are being developed. High-performance liquid chromatography (HPLC) has been used extensively for both qualitative and quantitative analyses of drugs, metabolites, explosives, marker dyes, and inks. Liquid chromatography coupled with mass spectrometry (LC-MS) is widely used in forensics for confirmatory and quantitative analyses and is a powerful tool for drug screening. Gas chromatography is also used for drug screening and can be used to quantify alcohol or illicit drugs in body fluids.

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Further Reading

Bogusz, M. J., ed. *Handbook of Analytical Separations*. Vol. 6 in *Forensic Science*, edited by Roger M. Smith. 2d ed. New York: Elsevier, 2007. Describes the applications of various separation methods used in forensic laboratories. Includes chapters devoted to methods of screening for various chemicals.

Harris, Daniel C. *Quantitative Chemical Analysis*. 7th ed. New York: W. H. Freeman, 2006. Widely used text covers all aspects of quantitative analytical chemistry.

Houck, Max M., and Jay A. Siegel. *Fundamentals of Forensic Science*. Burlington, Mass.: Elsevier Academic Press, 2006. Introductory textbook provides discussion of the basic methods of analysis used in forensic examinations.

Langford, Alan, et al. *Practical Skills in Forensic Science*. New York: Pearson Prentice Hall, 2005. Good introductory text addresses all of the various methods used in the forensic sciences. Includes several chapters on quantitative analyses, listed by technique.

Tebbett, Ian, ed. *Gas Chromatography in Forensic Science*. New York: Ellis Horwood, 1992. Provides an introduction to chromatography and then discusses specific issues regarding the uses of this technique in forensic chemistry, including in drug analysis, analysis of explosives, and toxicology.

See also: Acid-base indicators; Analytical instrumentation; Chromatography; Forensic toxicology; Gas chromatography; Mass spectrometry; Polarized light microscopy; Spectroscopy; Toxicological analysis; Ultraviolet spectrophotometry.

Questioned document analysis

Definition: Examination of documents to determine their origins or establish their authenticity.

Significance: Questioned document analysis has a broad scope, given that it can involve any item containing writing or symbols to convey meaning (such as a handwritten letter, a contract, or even graffiti on a lavatory wall). Forensic document examiners play important roles in the analysis of evidence in cases of fraud, forgery, counterfeiting, threats, and many other offenses.

The need for forensic document examiners emerged in the legal system as the courts needed help in handling, preparing, and interpreting document evidence. Document examiners employ many different methods depending on the questions they seek to answer. For example, is the signature on a given piece of art genuine? Were the diaries attributed to a particular person really written by that individual? Can a threatening letter be linked to a suspect? Was a page added to a business contract prior to or after the date of the original signature on the contract? A typical questioned document examination includes handwriting identification and analysis, analysis of printing devices, paper identification, ink identification, and examination of elements within the document such as indented markings, erasures, alterations, and obliterations. Document examiners also sometimes are called upon to analyze written materials that have been damaged by fire or water.

Both paper and print examinations involve the comparison of questioned items to known sources, which are called standards. Through this process, forensic document examiners may be able to link questioned materials to established sources. Forensic document examiners are often asked to determine the authenticity of documents based on the documents' purported dates, and comparisons with known standards can enable them to establish the histories and origins of such documents. Another common task performed by forensic document examiners is the assessment of whether multiple documents have a common origin—for example, to determine whether certain documents can be linked to materials that have been seized from a suspect.

The FBI's Questioned Documents Unit

In addition to its many other specialized forensic units, the Federal Bureau of Investigation operates the Questioned Documents Unit (QDU), which offers forensic support to fellow FBI units and other federal, state, and local law-enforcement agencies. This unit examines and analyzes handwritten, typed, and printed evidence collected during investigations. The QDU helps train federal, state, and local law-enforcement forensic examiners in its specialized field and disseminates information on document examination.

Knowledge of paper production processes and printing processes can help document examiners to identify class and individual characteristics in questioned documents. For instance, forensic document examiners are commonly asked to identify the types of printers used to produce particular documents. To do so, they might focus on watermarks, indentations, or accidental markings that result from the printing process.

By using scanners, microscopes, combinations of light sources and filters, and chemical testing techniques such as thin-layer chromatography (TLC), gas chromatography (GC), and mass spectrometry (MS), document examiners can identify the similarities in chemical properties in the elements used in documents. This often enables them to determine how and when the documents in question were created, and thus can lead to information on who created the documents.

Stephanie K. Ellis

Further Reading

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005.

Kelly, Jan Seaman, and Brian S. Lindblom, eds. *Scientific Examination of Questioned Documents*. 2d ed. Boca Raton, Fla.: CRC Press, 2006.

Storer, William H. "Questioned Documents." In *Introduction to Forensic Sciences*, edited by William G. Eckert. 2d ed. Boca Raton, Fla.: CRC Press, 1997.

See also: Document examination; Fax machine, copier, and printer analysis; Forensic accounting; Forensic linguistics and stylistics; Gas chromatography; Handwriting analysis; Hitler diaries hoax; Hughes will hoax; Mass spectrometry; Oblique lighting analysis; Paper; Thin-layer chromatography; Typewriter analysis; Writing instrument analysis.

R

Racial profiling

Definition: Law-enforcement practice of using race, ethnicity, or country of origin as a primary reason for detaining, questioning, or searching potential suspects.

Significance: As a single indicator of criminal intent, or in conjunction with a larger criminal profile, racial profiling is controversial and often leads to tensions between the police and targeted groups. Scientific investigation into the assumptions behind racial profiling has tended to debunk their validity.

Taking various forms, "profiling" is a modern investigative tool used by law enforcement to help investigate and prevent criminal activity. "Criminal profiles" are based on analyses of patterns of evidence left at crime scenes, as tangible physical evidence may offer clues to a culprit's motives, methods, and, in some instances, personality. "Racial profiling" differs in that it is not based on crime scene analyses. It is instead based on the notion that certain crimes are more likely to be committed by members of groups defined by race, ethnicity, or country of origin. A typical example would be the assumption that a person of Russian heritage is more likely than a person of Mexican heritage to belong to the Russian mob. Controversy would enter this kind of profiling, however, if law enforcement were to act on the assumption that *all* Russians might be members of the Russian mob. However, while all—or nearly all—members of the Russian mob are indeed likely to be Russians, not all Russians are likely to be mob members.

The rationale behind racial profiling is that members of certain racial and ethnic groups are more likely than other people to commit certain types of crime. For example, the fact that many African American youths commit drug crimes leads many people to think that African American youths in general are more likely than others to commit such crimes. Acting on that assumption, law-enforcement officers might therefore be inclined to stop and question all young black men they encounter on the street solely because such youths seem to fit their profile of drug dealers. Such random stops occasionally do lead to the apprehension of drug dealers, but the practice also fosters police harassment of many innocent youths whose chief offense is being black.

Indeed, a common public perception in the United States is that law-enforcement officers frequently target innocent people who happen to be members of racial and ethnic minorities for traffic stops to check for possession of illegal drugs, violation of immigration laws, and other criminal activities. Such impressions are popularly supported by the publicizing of anecdotal accounts of famous African Americans, such as actors Wesley Snipes and Will Smith and football coach Tony Dungy, who have been stopped and harassed by police without apparent cause. Further contributing to public perceptions that law-enforcement officers are racially biased are numerous reports of nonwhite American citizens being detained at border crossings and airports under suspicion of carrying contraband drugs or engaging in possible terrorist activities.

Racial Profiling and the Law

Viewed by proponents as a useful tool in reducing crime and protecting law-abiding citizens, racial profiling has been at the center of many legal battles over the proper balance between protecting the rights and liberties of citizens and the need to fight crime. At issue is the right of citizens, guaranteed by the Fourth Amendment to the U.S. Constitution, "to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures." Several key U.S. Supreme Court rulings on the Fourth Amendment have directly or indirectly affected the use of racial profiling in police work. For example, in *Terry v. Ohio* in 1968, the Court ruled that police acting under reasonable suspicion could stop and quickly search persons without a warrant. This ruling gave police greater discretion in determining whom to stop, thereby increasing the potential for their using racial profiling to determine whom to stop.

Generally, however, using racial or ethnic identities as the only or primary reasons to approach, detain, or search suspects has been ruled illegal. Evidence obtained as the result of such a profile is generally regarded as in violation of the Fourth Amendment. For example, in *United States v. Brignoni-Ponce* (1975), the Supreme Court ruled that U.S. Border Patrol agents could not regard a person's ethnic appearance alone as justification to have a reasonable suspicion of criminal activity. Although immigration law was at issue in that particular case, the broader impact of the ruling was clear: Any law-enforcement officer's use of race or ethnicity as the sole basis for detaining a person violates that person's constitutional protections.

It is, however, permissible to use race, ethnicity, or country of origin as one element in a larger criminal profile in most situations. The behavior, rather than the race or ethnicity, of a suspect can always be a justifiable reason for police to detain or search the person. The Supreme Court ruling in *Whren et al. v. United States* (1996) made it legal for law-enforcement officers to use traffic violations as a pretext to check for other evidence of criminal activity. The impact of this ruling increased the discretionary power of the police and obscured potential racial motivations for stopping and searching nonwhite persons.

Political Responses

State and federal government responses to racial profiling have been mixed. In some instances, legislative bodies have increased the discretionary powers of police, while others have attempted to reduce it to balance individual rights with crime control. Presidents Richard M. Nixon, Ronald Reagan, and George H. W. Bush all tended to support expanded discretionary powers of police in the national fight against illegal drugs. Opponents of racial profiling have claimed that their actions led to an increase in the illegal use of race to detain and search nonwhite persons. By contrast, President Bill Clinton strongly discouraged the use of racial profiling. He issued an executive memorandum to federal law-enforcement agencies requiring their officers to collect information on the race, ethnicity, and countries of origin of individuals whom they detained for the purpose of collecting data that would reveal investigative patterns at the federal level.

President George W. Bush also opposed racial profiling. With his support, the End of Racial Profiling Act was introduced in the U.S. Senate in February, 2004, but no further action was taken on the bill. Meanwhile, the terrorist attacks of September 11, 2001, renewed American fears about their safety and soon led to Congress's enactment of the Patriot Act of 2001, which increased discretionary powers for law enforcement for national security purposes. Many observers have criticized the

The Mathematics of Racial Profiling

The seductive appeal of racial profiling lies in the belief that if members of group *X* are disproportionately more likely than members of other groups to commit a particular crime, it makes sense to focus attention on group *X* in regard to that crime. However, if only a tiny percentage of group *X* members commit the crime, then such a focus may be ethically questionable, as it would burden the overwhelming majority of law-abiding members of group *X*. It is instructive to consider the mathematics of profiling.

If a particular crime that is committed by only 0.1 percent of the general population is committed by 1.0 percent of the members of group *X*, then any individual member of group *X* is ten times more likely to commit the crime than is a member of the general population. However, 99 percent of the members of group *X* are law-abiding with respect to this crime. Moreover, if all the members of group *X* constitute less than 10 percent of the total population, then less than half of the people who commit the crime in question are actually members of group *X*.

Patriot Act as an erosion of the constitutional rights of private citizens and a mechanism to justify using race or ethnicity as a primary reason for questioning and detaining suspects.

Applying Science to Racial Profiling

The science of racial profiling is in its infancy. It has mostly focused on whether nonwhite motorists are actually stopped and searched more frequently than white motorists and whether stereotypes of racial and ethnic minorities do in fact guide police in their discretionary decisions. Public awareness of the subject of racial profiling increased greatly during the early 1990's, after a black Washington, D.C., attorney named Robert Wilkins filed a suit against the Maryland State Police for subjecting him and his family to an illegal search based on a racial profile. The Wilkins case prompted experts to analyze Maryland traffic arrest patterns. They found that while white and black drivers exceeded the speed limit at the same rate, a much higher percentage of primarily black drivers were stopped and searched. Wilkins's case was settled out of court in 1996, but Maryland State Police implemented a no-tolerance policy on the use of race-based profiles and began to maintain records on the race and ethnicity of drivers stopped for traffic violations to track patterns of racial profiling.

Similar cases in other states have led to changes in police procedures and oversight by the federal government to eliminate highway stops based on the race of the driver. As other law-enforcement agencies began collecting racial and ethnic data during traffic stops, a consistent pattern emerged. Although black and Hispanic citizens are stopped and searched at higher rates than are white citizens, the rates at which they are found to be in possession of drugs and other evidence of illegal activity are equal to those of white citizens. Race and ethnicity thus are not the best predictors of illegal activity. Moreover, research into police decisions to use deadly force has found that proper training reduces the likelihood that race will be a factor in officers' decisions to shoot at suspects.

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Further Reading

Cole, David. *Terrorism and the Constitution: Sacrificing Civil Liberties in the Name of National Security*. 2d ed. New York: New Press, 2002. Presents a critical examination of the impulse to trade liberty for security in the United States since the terrorist attacks of September 11, 2001.

Costanzo, Mark. *Psychology Applied to Law*. Belmont, Calif.: Wadsworth, 2004. Contains a chapter on psychological perspectives of racial and criminal profiles that focuses on how law-enforcement officers use stereotypes to make discretionary decisions involving whom to stop and search, whom to investigate, and whom to arrest.

Davis, Kelvin R. *Driving While Black: Coverup*. Cincinnati, Ohio: Interstate International Publishing, 2001. Presents the author's personal account of how he was victimized by racial profiling.

Egendorf, Laura K., ed. *Terrorism: Opposing Viewpoints*. San Diego, Calif.: Thomson & Gale, 2004. Two sections focus on the use of racial profiling for national security purposes. Proponents argue that profiling could have prevented the terrorist attacks of September 11, 2001; the opposition argues that Americans are losing their civil liberties as the result of the Patriot Act of 2001 and increased discretionary powers of law enforcement.

Gaines, Larry, and Victor Kappeler. *Policing in America*. 4th ed. Cincinnati: Anderson, 2002. Excellent survey addresses the functions, culture, and discretionary authority of police officers. Includes an informative discussion of racial profiling.

Harris, David. *Profiles in Injustice: Why Police Profiling Cannot Work*. New York: New Press, 2002. Highly regarded work examines issues related to racial profiling.

Holbert, Steve, and Lisa Rose. *The Color of Guilt and Innocence: Racial Profiling and Police Practices in America*. San Ramon, Calif.: Page Marque Press, 2004. Provides an accessible account of anecdotal and scientifically based evidence of racial profiling and its effects and implications. Includes suggestions for addressing law-enforcement assumptions about race and crime.

Pampel, Fred C. *Racial Profiling*. New York: Facts On File, 2004. Provides a detailed historical account of the perceptions of racial profiling in the United States, legal summaries of important judicial decisions and their impact on racial profiling, and a useful glossary and bibliography on racial profiling.

Withrow, Brian L. *Racial Profiling: From Rhetoric to Reason*. Upper Saddle River, N.J.: Pearson Prentice Hall, 2006. Presents comprehensive discussion of racial profiling from a historical and contemporary perspective. Includes recommendations for research that can further understanding of the roles that race and ethnicity play in law enforcement and justice administration.

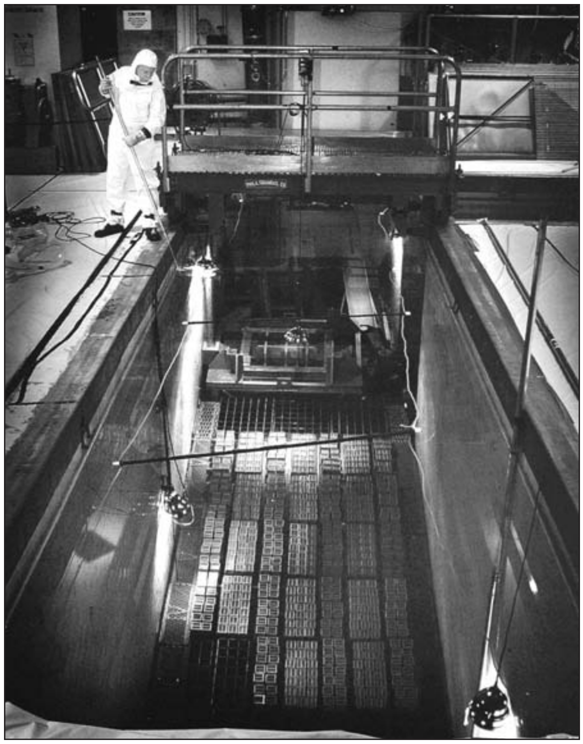
See also: Airport security; Anthropometry; Crime scene investigation; Criminal personality profiling; DNA database controversies; DNA profiling; Drug Enforcement Administration, U.S.; Ethics of DNA analysis; Federal Bureau of Investigation; Gang violence evidence; Geographic profiling.

Radiation damage to tissues

Definition: Injury caused to the human body by energy waves as they pass through the body emitting ions.

Significance: Radiation damage may be a cause of death or injury that is not immediately obvious. By examining the pattern of damage in a body, a forensic pathologist can determine whether radiation caused the damage and, if so, what type of radiation was involved.

Radiation is everywhere, including in sunlight, and can pass through the body harmlessly. Certain types of radiation, however, can cause massive internal or external damage leading to death. Depending on the level or concentration of radiation, it may cause damage internally without noticeable external damage.



A worker in protective clothing cleans out the 68,000-gallon pool used to store spent fuel rods from the high flux beam reactor of the Brookhaven National Laboratory on New York's Long Island. During the 1990's, the storage pool was suspected of leaking radioactive materials into the groundwater that provided Long Island's drinking water. *(AP/Wide World Photos)*

Types of Radiation

Radiation is either ionizing (ions are emitted into body tissues as the radiation passes through) or nonionizing. Nonionizing radiation is considered to be less dangerous because it passes through tissues without emitting any energy; sunlight is an example of this type of radiation. Types of ionizing radiation, which cause tissue damage as they emit ions into the tissues they penetrate, include alpha particle radiation, beta particle radiation, gamma rays, and X rays.

Different types of radiation damage body tissues in different patterns. For example, alpha particle radiation (often called alpha rays) causes an intense, local concentration of energy. Gamma radiation penetrates more deeply into the tissues, causing a more even and wide distribution of damage. By examining such damage patterns, a forensic pathologist can gain information about what type of radiation was involved in the radiation exposure.

Tissue Damage from Radiation

Radiation damages body tissues when ions are emitted into tissues. These ions are charged atomic particles, and they take electrons from atoms and molecules in the tissues, making those atoms and molecules unable to function. Radiation is most damaging to tissues when a concentrated amount of radiation destroys molecules in a small, defined area. This is why radiation can be used beneficially, for example, in destroying cancerous cells.

High levels or concentrations of radiation can cause massive burning of the skin and trigger death nearly immediately. However, low levels of radiation can be damaging as well. They may cause cell mutations or increase the likelihood that already mutated cells will reproduce at faster speeds. They may also cause internal damage that is not immediately obvious. The calculation of the amount of radiation absorbed by tissues is known as dosimetry.

Alpha rays generally do not penetrate below the first layer of dead skin cells and, as such, do not generally cause much tissue damage. Beta rays penetrate slightly deeper and cause damage such as surface burns to the skin (much like sunburn, but these burns take longer to heal). Although it is possible for beta rays to penetrate more deeply into the body, it is generally unlikely that these rays could cause much damage to internal organs. Gamma rays have the ability to penetrate deeply into the body and are much more likely to cause damage to internal organs than are the other types of ionizing radiation.

All cells in the body are not affected by radiation in the same way. Cells that divide rapidly or are more nonspecialized (relatively speaking) are affected at lower doses or concentrations of radiation than are cells that divide less rapidly or are more specialized. When radiation enters cells in the body, the cells can be affected in four different ways: They can remain undamaged and continue to function normally; they can become damaged, repair the damage, and continue to function normally; they can become damaged and repair the damage but be unable to continue functioning normally; or they can die and cease to function altogether.

Radiation damage is first noticeable in those cells that affect the body's rapidly changing tissues—cells in the intestines, skin, bone marrow, and reproductive organs, particularly the testicles. Damage to these tissues results in symptoms such as vomiting, burns, hair loss, changes in white blood cell count, and sterility. Long-term effects include eye cataracts, cancers, and genetic mutations.

Possible Sources of Radioactive Contamination

The Centers for Disease Control and Prevention provides this information on the possible sources and spread of radioactive contamination.

Radioactive materials could be released into the environment in the following ways:

- A nuclear power plant accident
- An atomic bomb explosion
- An accidental release from a medical or industrial device
- Nuclear weapons testing
- An intentional release of radioactive material as an act of terrorism

How Radioactive Contamination Is Spread

People who are externally contaminated with radioactive material can contaminate other people or surfaces that they touch. For example, people who have radioactive dust on their clothing may spread the radioactive dust when they sit in chairs or hug other people.

People who are internally contaminated can expose people near them to radiation from the radioactive material inside their bodies. The body fluids (blood, sweat, urine) of an internally contaminated person can contain radioactive materials. Coming in contact with these body fluids can result in contamination and/or exposure.

Acute Radiation Syndrome

An acute radiation dose (a large dose delivered to the whole body in a short period of time, such as in a radiation bomb blast or an accidental industrial exposure) can cause a pattern of damage referred to as acute radiation syndrome. This syndrome is characterized by damage to bone marrow, spleen, and lymph tissue, causing symptoms such as fatigue, fever, infections, and internal bleeding. The central nervous system is also affected, with damage to nerve cells causing symptoms such as confusion, coma, convulsions, loss of coordination, and shock. In addition, damage to the lining of the stomach and intestines causes symptoms such as bleeding ulcers, dehydration, diarrhea, digestive problems, electrolyte imbalance, nausea, and vomiting. An acute dose can also cause lasting damage to the thyroid gland, ovaries, and testicles.

Exposure to radiation can also have an effect on an embryo or fetus because as the fetus grows, its tissue cells are growing and dividing rapidly. If a pregnant woman is exposed to radiation, her child may have increased risks of mental problems or childhood cancers.

Marianne M. Madsen

Further Reading

Ahmed, Syed Naeem. *Physics and Engineering of Radiation Detection*. San Diego: Academic Press, 2007. Comprehensive textbook offers informative discussion of radiation detection. Appropriate for use by both students and professionals.

Byrnes, Mark E., David A. King, and Philip M. Tierno, Jr. *Nuclear, Chemical, and Biological Terrorism: Emergency Response and Public Protection*. Boca Raton, Fla.: CRC Press, 2003. Presents thorough discussion of the effects of radiation on the human body and addresses ways to reduce the risk of radiation poisoning in the event of terrorist use of nuclear weapons.

Holmes-Siedle, Andrew, and Len Adams. *Handbook of Radiation Effects*. 2d ed. New York: Oxford University Press, 2002. Provides information on all aspects of radiation, including its effects on the human body.

Knoll, Glenn F. *Radiation Detection and Measurement*. 3d ed. New York: John Wiley & Sons, 2000. Standard textbook discusses techniques for measuring radiation and various kinds of radiation detection equipment. Covers both basic principles and practical applications.

National Council on Radiation Protection and Measurements. *Management of Terrorist Events Involving Radioactive Material*. Bethesda, Md.: Author, 2001. Provides information on the ways in which radiation can damage human tissues.

Stabin, Michael G. *Radiation Protection and Dosimetry: An Introduction to Health Physics*. New York: Springer, 2007. Presents comprehensive discussion of radiation's effects and methods of protecting against them. Suitable both as an introduction to the field for students and as a practical handbook for health physics professionals.

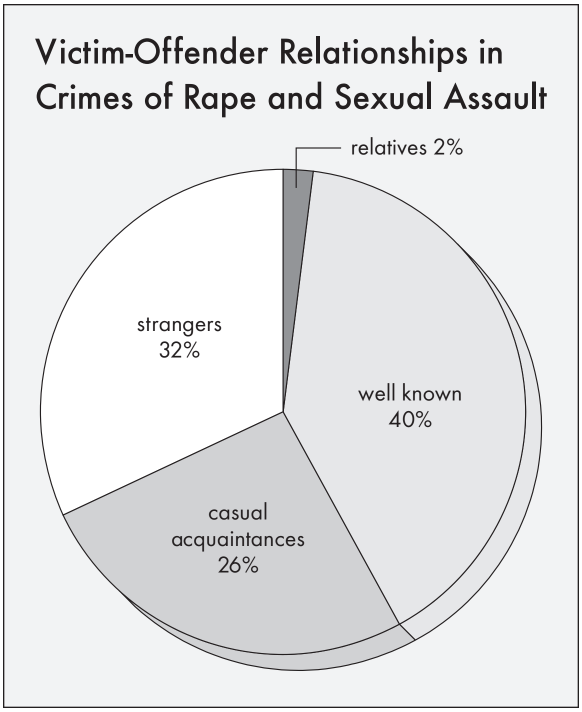
See also: Decontamination methods; Dosimetry; Electromagnetic spectrum analysis; Environmental Measurements Laboratory; Nuclear detection devices; Nuclear spectroscopy; Silkwood/Kerr-McGee case.

Rape

Definition: Unlawful sexual intercourse with a person without that person's consent.

Significance: An inherently violent crime, rape is most often directed at women and children. The fact that rape is one of the most underreported crimes in the United States poses special problems for investigators as well as for attempts to prevent this crime and to collect data on its prevalence.

The crime of rape is one that generally involves offenders acting out issues of power and control over their victims. The sexual gratification experienced in normal sexual relations is generally a secondary motivation to those who commit rape. Most rape offenses fall into one of two mutually exclusive categories: cases in which



Source: U.S. Bureau of Justice Statistics, *Criminal Victimization*. Figures are based on all reported rapes and sexual assaults in the United States in 2002.

victims already know their assailants and those in which victims do not.

According to the National Crime Victimization Survey conducted by the U.S. Bureau of Justice Statistics, approximately two-thirds of all rape victims are assaulted by people whom they already know. This is particularly true in cases of "date rape," or acquaintance rape, which occur when offenders and their victims are together for social occasions. When rape victims are the spouses of their assailants, the assaults are termed marital rape or spousal rape. Assaults on persons under the legal age of consent are classified as statutory rape. The work of investigators in all these cases is made simpler by fact that victims can usually identify their attackers easily.

Serial and Stranger Rape

Serial rapists are predators who frequently stalk their victims and commit most of their offenses against strangers who are unlikely already to know them. Investigations of serial rape and other stranger rape cases thus have the added challenge of investigators' need to find evidence that identifies the offenders.

Serial rapists generally take great care to conceal their identities and disguise their appearance from their victims. This behavior increases the difficulty of identifying them. At the same time, however, each serial rapist tends to repeat predictable patterns of behavior—the offender's so-called modus operandi (MO), or method of operation. Offenders' distinctive MOs, trademark behaviors, and psychological signatures all provide evidence that helps investigators to connect similar rape cases and eventually track down the offenders.

Psychological Evidence

Building psychological profiles of offenders is central to most investigations of serial and stranger rapes. The Federal Bureau of Investigation (FBI) has developed a system called criminal investigative analysis that examines the known behavior of unidentified offenders and builds psychological profiles that can be used to link offenders' personality traits to physical evidence. The combination of criminal investigative analysis, physical evidence, and crime scene reconstruction provides the structure and direction for successful rape investigations. Most important, it provides a means for rape investigators, forensic profilers, and scientists to work collaboratively.

The FBI's National Center for the Analysis of Violent Crime (NCAVC) has developed a system for classifying the core behaviors of rapists. Psychological profiles alone do not enable investigators to identify specific suspects, but suspect profiles can help investigators find matches in databases of signature behaviors, travel distances, victim profiles, and similar information. The goal of comparative case analysis is to identify rape offenders by matching their psychological core behaviors, methods of operation, and psychological signatures with information in the databases. Among the behavioral variables of rapists that are entered into database records are the following: methods of approaching victims, techniques used to control victims, amounts of force used, sexual dynamics of the rapes themselves, methods of evading detection, and postoffense behaviors.

Rapist Typologies

The NCAVC places rapists in four primary categories based on their behavior: power-reassurance, power-assertive, anger-retaliatory, and anger-excitation. Rapists in the power-reassurance category generally execute surprise attacks and initially reassure their victims that no harm will come to them. These rapists also tend to pay compliments to their victims and act almost apologetically for the harm they are inflicting. Sometimes, they ask their victims to evaluate their sexual performance in order to meet their need to be reassured. They tend to use minimal physical force to achieve their objectives.

Rapists classified in the power-assertive category assume immediate and strong command over their victims, to whom they give specific sexual instructions. Tending to use profane language throughout their rapes, their goal is to demean and humiliate without regard for their victims' feelings, pain, or distress. Rapists in this category may carry weapons and generally use from moderate to excessive force in their attacks; they may apply brutal force to victims who resist.

Anger-retaliatory rapists initiate their sexual assaults with immediate applications of physical force and often use weapons of opportunity they find at the scenes. Their devastating blitz attacks combine with their angry and unsympathetic manner to overcome their victims rapidly. Male rapists in this category generally harbor deep-seated hatred of women. Their female victims serve as symbolic targets on whom they release their rage.

Anger-excitation rapists are sadists who often engage in violent, antisocial behavior to serve their obsessive and compulsive need to dominate others. In their initial approaches to their rape victims, they try to establish mutual trust. However, after they get their victims under control, the victims' distressed responses to the physical and emotional pain they are experiencing stimulates these rapists sexually. Investigators of crimes committed by anger-excitation rapists must be alert to signs indicating that the rapists are becoming more violent and possibly are escalating into serial killers.

Physical Evidence

Rape investigations are multidimensional, interdisciplinary, and team-oriented. Successful prosecutions of rape cases draw on the professional expertise and training of both investigation teams and forensic specialists. Sexual assault response teams of law-enforcement agencies typically include four members: first responders, investigator/detectives, victim advocates, and sexual assault nurse examiners. All of these specialists play roles in the collection of the forensic evidence that is critical to establishing that rape crimes have occurred.

Most of the physical evidence collected in rape investigations is found at the scenes of the crimes, on the bodies and clothing of the victims and the suspected offenders, and at so-called dump sites, where items connected with the crimes may have been discarded. Investigators look for trace evidence left on victims' clothing; signs of physical injuries to the victims, including bite marks and bruises; and trace evidence left by the offenders, including blood specimens, hair, semen, fibers, soil, and bits of vegetation.

The Geography of Serial Rape

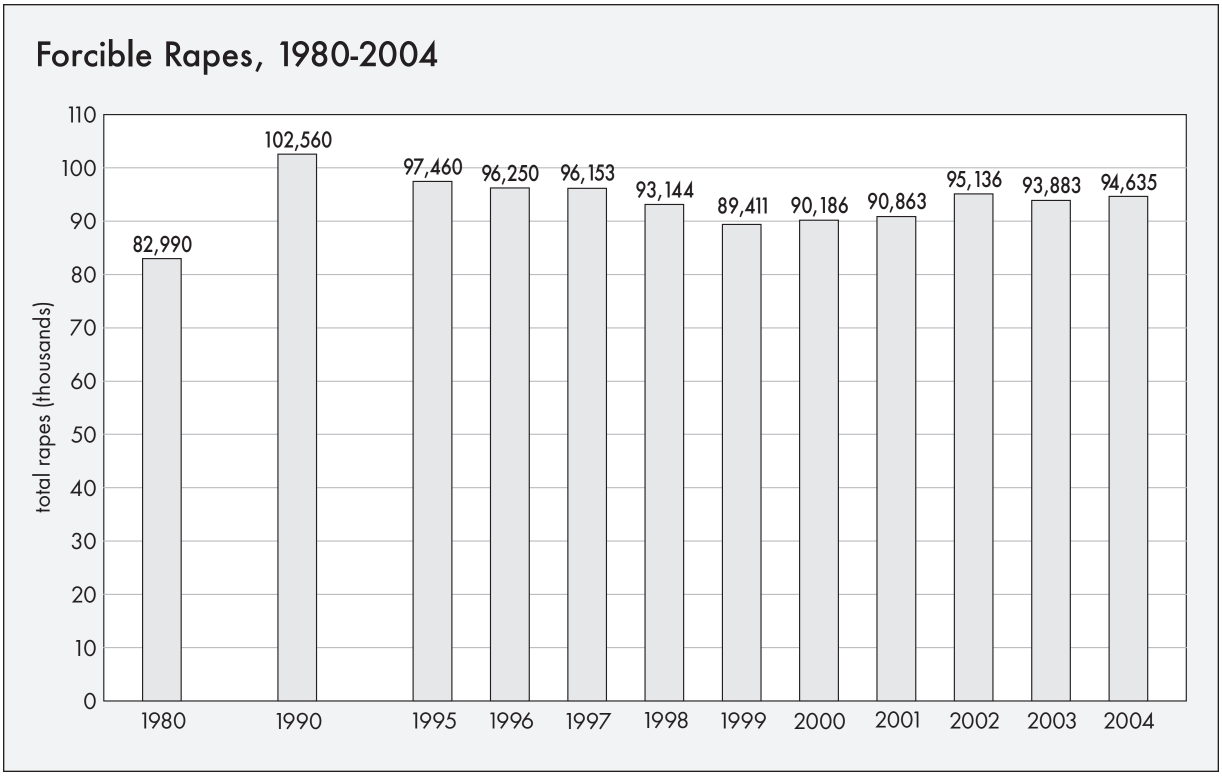
The obsessive fantasies and compulsive personalities of rapists motivate some of them to commit multiple rapes. Those who become serial rapists tend to operate within limited geographic regions. Geographic information system (GIS) technology, or computerized crime mapping, can assist law-enforcement agencies in tracking the movements of such rapists. The distances that serial rapists travel between their crimes tend to be short—usually less than two miles—and rapists generally commit their first offenses close to their own homes or places of employment. Using GIS technology, investigators can build digital and statistical geographic profiles that can help to predict the locations where serial offenders may strike next and also help to locate where the offenders live or work.

To assist in organizing and protecting the evidence that is gathered, investigators use specially designed sexual assault evidence kits, which are commonly known as rape kits.

Medical examinations of rape victims are conducted by sexual assault nurse examiners and attending physicians. These teams make a special effort to gather biological evidence left on victims' bodies by their assailants; when such material contains DNA (deoxyribonucleic acid), analyses can result in DNA profiles that can be fed into the database of the Combined DNA Index System, better known simply as CODIS. Administered by the FBI, CODIS contains DNA profiles collected from throughout the United States, from samples taken from both convicted offenders and unsolved cases. An unfortunate limitation to this system, according to the National Institute of Justice, is that the evidence contained in hundreds of thousands of rape kits has never been processed, so the potential resulting DNA profiles have not been sent to CODIS; hence a wealth of potentially valuable information on rapists is not available for comparison.

When rape victims are examined, large pieces of clean butcher paper are placed under them while they disrobe to reduce the chances of losing potentially valuable trace evidence that falls from their bodies and clothes. After the victims disrobe, their clothing is carefully examined for trace evidence. Each individual piece of clothing is packaged separately; moisture stains are dried out, and sheets of paper are inserted between folds of clothing for additional protection against cross-contamination.

When bite marks and other injuries are found on the bodies of rape victims during their examinations, photographs are carefully taken of the wounds as soon after the attacks as possible. Additional photographs taken about forty-eight hours later often prove valuable in documenting emerging bruise marks. Photographic evidence is often presented to juries in rape tri-



Source: Federal Bureau of Investigation, *Population-at-Risk Rates and Selected Crime Indicators*. Figures represent total completed and attempted rapes throughout the United States.

als to demonstrate the extent of physical injuries inflicted during assaults.

Thomas E. Baker and James C. Roberts

Further Reading

Dobbert, Duane L. *Halting the Sexual Predators Among Us: Preventing Attack, Rape, and Lust Homicide*. Westport, Conn.: Praeger, 2004. Presents a study of strategies that can be employed to prevent sexual assaults.

Hazelwood, Robert R., and Ann W. Burgess, eds. *Practical Aspects of Rape Investigation: A Multidisciplinary Approach*. 3d ed. Boca Raton, Fla.: CRC Press, 2001. Collection of essays describes the roles of police investigators, medical examiners, forensic scientists, crisis counselors, and public prosecutors in crimes involving rape.

Holmes, Stephen T., and Ronald M. Holmes. *Sex Crimes: Patterns and Behavior*. 2d ed. Thousand Oaks, Calif.: Sage Publications, 2002. Provides information from sociological studies of the characteristics of sex offenders.

National Institute of Justice. *The Future of Forensic DNA Testing: Predictions of the Research and Development Working Group*. Honolulu: University Press of the Pacific, 2005. Discusses advances in DNA collecting and testing as well as likely future uses of DNA analysis in law enforcement.

Rossmo, D. Kim. *Geographic Profiling*. Boca Raton, Fla.: CRC Press, 1999. A leading text in the field offers unique insights into criminal travel patterns, which often play important roles in criminal rape investigations.

Savino, John O., and Brent E. Turvey, eds. *Rape Investigation Handbook*. Boston: Elsevier Academic Press, 2005. Collection of essays by legal scholars, forensic scientists, and law-enforcement practitioners covers all aspects of the investigation of crimes of rape and demonstrates best practices in the field of rape case investigations.

Smith, Merril D., ed. *Sex Without Consent: Rape and Sexual Coercion in America*. New York: New York University Press, 2001. Collection focuses on the historical study of rape, exploring what rape meant to its victims and to American society at time times and places in the past.

Stuart, James H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005. Presents comprehensive discussion of the techniques used by forensic scientists. Includes many useful illustrations and photographs.

Telsavaara, Terhi V. T., and Bruce A. Arrigi. “DNA Evidence in Rape Cases and the Debbie Smith Act: Forensic Practice and Criminal Justice Implications.” *International Journal of Offender Therapy and Comparative Criminology* 50 (October, 2006): 487-505. Presents a detailed discussion of the growing backlog in analyses of the evidence contained in rape kits.

U.S. Department of Justice. *Using DNA to Solve Cold Cases*. Washington, D.C.: Government Printing Office, 2002. Brief practical guide is designed for criminal investigators who are responsible for working cold rape cases. Describes success stories and some of the limitations of using DNA evidence.

See also: CODIS; Criminal personality profiling; DNA profiling; Geographic information system technology; Living forensics; Paternity testing; Postconviction DNA analysis; Rape kit; Semen and sperm; Sexual predation characteristics; Strangulation; Violent sexual predator statutes.

Rape kit

Definition: Package of examination materials used by a doctor or nurse (examiner) for gathering evidence from a victim following a sexual assault.

Significance: The rape kit is part of the standardized protocol used in the collection and preservation of physical evidence following any alleged serious sexual assault. The evidence gathered and preserved through the use of a rape kit can aid in the criminal investigation and prosecution of the suspected assailant.

Christopher L. Morano, Connecticut chief state's attorney, announces the issuance of a new kit for the collection of evidence in sexual assault investigations at a news conference in October, 2004. The kit previously used in Connecticut is seen in Morano's right hand; the new kit, in his left hand, is aimed toward the collection of evidence of drug-facilitated sexual assault, which is often seen in cases of so-called date rape. *(AP/Wide World Photos)*

The standardization of approach provided by the rape kit—alternatively known as the sexual assault evidence kit or sexual assault forensic evidence (SAFE) kit—is thought to limit further physical and psychological trauma to the complainant (victim) by ensuring consistency of treatment. This evidence is gathered only after consent has been obtained from the complainant, who can give consent to just part of the examination and can withdraw consent at any time during the examination. Rape kit evidence can be gathered if the complainant (who may be male or female) consents to the examination but does not want to make a report to the police at that time, as the evidence can be stored for use in the future. A number of varieties of rape kits have been developed, but the kind most commonly used in the United States is known as the Vitullo kit; it was developed by former Chicago police sergeant Louis R. Vitullo, who headed the Chicago Police Department's crime laboratory in the 1970's. The evidence gathered using a rape kit may help police to identify a suspect and may be used in court during any subsequent trial.

Conduct of the Examination and Contents of the Kit

The examination is conducted by a medical professional, typically a doctor or nurse, who may or may not have specialized knowledge or experience in working with sexual assault victims. In many U.S. states, rape kit exams are conducted by specially trained professionals who are part of sexual assault forensic examiner (SAFE) or sexual assault nurse examiner (SANE) programs. To secure the chain of custody after the examination is completed, the medical professional seals the rape kit in a box, which is then kept in a secure place until it is given to the police to be sent to the crime laboratory for analysis.

The rape kit typically contains instructions and forms, diagrams and checklists, slides, swabs, sterile urine collection containers, sterile sample containers, and self-sealing envelopes, bags, and labels. It is important that such materials are not "lick-sealed," as such cross-contamination would jeopardize the integrity of the evidence. For the same reason, all sample swabs and slides must be dry before they are placed in sterile containers.

How the Kit Is Used in the Examination

Prior to using the rape kit, the examiner collects a health history from the complainant; if relevant, a gynecological history is taken, including the date of last menstruation, type of usual contraception used, and last consensual sexual contact. It is important to the chain of evidence that the complainant is at no point left alone in the room once the examination has started, and neither the complainant nor anyone accompanying the complainant is allowed to handle the evidence. If the complainant wants to urinate or defecate prior to the examination, this material is gathered as part of the evidence, and the complainant is cautioned not to wipe the area until after the examination. The complainant is also advised not to remove any menstrual protection or contraceptive device from the body.

The complainant is asked to undress over a sheet of paper to minimize any loss of trace evidence (the paper is later examined for evidence that may have fallen from the complainant's clothing or body). The examiner then uses the rape kit to collect blood, semen, and other body fluid samples from the genitals, rectum, and mouth. The examiner combs the complainant's head and pubic area to collect samples of the complainant's hair and to look for any hairs or loose debris left by the perpetrator. Some hairs may be plucked from these sites. The examiner scrapes under the complainant's fingernails to collect material that may contain skin cells, fibers, or other materials from the perpetrator. An ultraviolet light is used to identify any dried secretions on the complainant's skin, and swabs (moistened with a little water) are used to collect samples of any substances found. Each item of evidence is labeled and marked with a description of the sample, the complainant's name, the name of the examiner, the date, and the initials of everyone who handled the sample.

Photographs are taken of any injuries, bite marks, lacerations, or bruises on the complainant's body, and the clothes worn by the complainant are also preserved as evidence. The clothing and all photographs are packaged, sealed, and labeled to secure the chain of evidence.

Limitations of the Use of Rape Kits

Some physical evidence in sexual assault cases must be collected within seventy-two hours of the attack. In many U.S. jurisdictions, if an attack occurred more than ninety-six

Rape Kits Go Untested

The forensic analysis of rape kit evidence costs approximately five hundred to one thousand dollars per kit. In 2002, *The Oprah Winfrey Show* provided evidence suggesting that across the United States, the evidence collected in 300,000 to 500,000 rape kits was awaiting testing. Commenting on this backlog, the former police commissioner of New York City, Howard Safir, suggested that some 16,000 untested kits were in storage in New York and that this amounted to telling a woman, "You are not worth five hundred dollars." Also in 2002, the television newsmagazine *20/20* paid for half of the processing to test 50 rape kits in Baltimore, and the subsequent investigation solved five major crime cases and exonerated a wrongfully imprisoned man. The rape kit backlog was further investigated in 2003 by Court TV, and in 2007 the *Denver Post* reported on two cases in which rape kit evidence was lost before it could be tested.

hours prior to the examination, a rape kit is not deemed necessary. Despite the presumed scientific objectivity of the rape kit protocol, discretionary practices exist across the United States.

In some states, a complainant in a sexual assault case has the right to ask for the examination to be conducted by someone of the same gender as the complainant. The insufficient numbers of female medical personnel available in some areas may prevent some female complainants from being seen by female examiners in a timely manner. Another limitation of rape kit examinations is that the medical professional does not typically check for pregnancy or sexually transmitted infections; checks for these may need to be done at a later stage.

A rape kit can only help to determine if sexual contact has been made between certain people. It cannot provide evidence of consent or of *mens rea* (guilty mind). Severe injuries might suggest forced intercourse, but this cannot be proved by forensic evidence. Although rape kit evidence cannot prove guilt, it can exclude persons from suspicion; DNA (deoxyribonucleic acid) evidence gathered through the use of rapes kit has been used to clear innocent people.

Helen Jones

Further Reading

Campbell, Rebecca, Debra Patterson, and Lauren F. Lichty. "The Effectiveness of Sexual Assault Nurse Examiner (SANE) Programs: A Review of Psychological, Medical, Legal, and Community Outcomes." *Trauma, Violence, and Abuse* 6, no. 4 (2005): 313-329. Scholarly article describes the rape kit collection process in detail.

Carney, Thomas P. *Practical Investigation of Sex Crimes: A Strategic and Operational Approach*. Boca Raton, Fla.: CRC Press, 2003. A former commanding officer of the Manhattan Special Victims Squad presents case histories to illustrate the skills needed to investigate sex crimes effectively.

Hazelwood, Robert R., and Ann W. Burgess, eds. *Practical Aspects of Rape Investigation: A Multidisciplinary Approach*. 3d ed. Boca Raton, Fla.: CRC Press, 2001. Describes the roles of the police investigator, the medical examiner, the forensic scientist, the crisis counselor, and the prosecutor in crimes involving rape.

LeBeau, Marc A., and Ashraf Mozayani, eds. *Drug-Facilitated Sexual Assault: A Forensic Handbook*. New York: Academic Press, 2001. Collection of essays provides extensive information on this complex area of investigation and highlights the key issues surrounding evidence gathering.

Littel, Kristin. *Sexual Assault Nurse Examiner Programs: Improving the Community Response to Sexual Assault Victims*. Washington, D.C.: U.S. Department of Justice, 2001. Brief bulletin from the Justice Department's Office for Victims of Crime documents the impacts of specialist nurse training programs in providing services to victims of rape.

Savino, John O., and Brent E. Turvey, eds.. *Rape Investigation Handbook*. New York: Academic Press, 2005. Covers the investigative and forensic processes related to sex crimes and demonstrates best practices in the field of rape case investigations.

Telsavaara, Terhi V. T., and Bruce A. Arrigi. "DNA Evidence in Rape Cases and the Debbie Smith Act: Forensic Practice and Criminal Justice Implications." *International Journal of Offender Therapy and Comparative Criminology* 50 (October, 2006): 487-505. Discusses in some detail the backlog in the analysis of rape kit evidence.

See also: Bite-mark analysis; Cross-contamination of evidence; DNA extraction from hair, bodily fluids, and tissues; DNA fingerprinting; Evidence processing; Forensic nursing; *Mens rea*; Physical evidence; Rape; Semen and sperm; Trace and transfer evidence; Victimology; Violent sexual predator statutes.

Reagents

Definition: Substances that bring about chemical reactions when added to particular other substances.

Significance: Forensic scientists use reagents at crime scenes to discover "hidden" evidence, such as the presence of fingerprints that cannot be seen with the naked eye, and to conduct preemptive tests to determine whether substances present may be blood or other bodily fluids. Reagents are also useful for determining the presence of illegal substances, such as drugs.

Reagents are used to test questioned substances at crime scenes and in forensic laboratories. In the presence of the substances with which they are designed to react, reagents produce chemical reactions that usually involve color changes or other changes that can be seen, such as causing a substance to glow under a black light. If the substance with which a reagent is known to react is not present, the chemical reaction does not occur. For example, if a reagent known to react with blood does not react on a stain, that stain is not blood. If that reagent does react on a stain, the stain may be blood, but because other substances could cause the same reaction, the scientist cannot conclude that the stain is blood until further testing is done.

Chemical Reactions

Reagents react chemically with substances usually either through synthesis or through replacement. In synthesis, the reagent and the substance form a new substance. In replacement, the reagent acts on the substance by replacing some of the substance's elements with its own elements.

Forensic scientists must take care when preparing and using reagents. A reagent must be pure enough to react properly with the substance it is intended to detect, so it must be prepared according to strict procedures. In addition, because reagents may be carcinogenic, caustic, or explosive, scientists must handle them carefully; the use of protective clothing and equipment is recommended.

Uses in Biological and Chemical Labs

Many different reagents can be used to identify blood or other bodily fluids on different surfaces. The choice of reagent depends on the surface on which the bodily fluid is thought to be and whether the reagent is being used at the crime site or in the laboratory. For example, some reagents work well on porous materials but are poor choices for nonporous materials. Other reagents may cause violent chemical reactions and therefore must be used only in laboratory settings.

Some of the reagents that identify blood are amido black, leuco crystal violet, luminol, and Takayama reagent. Amido black reacts with the protein in blood to produce a blue-black color, whereas leuco crystal violet, along with hydrogen peroxide, reacts with the hemoglobin or its derivatives in blood to produce a deep violet color.

Luminol reacts on the oxidizing activity of hemoglobin derivatives in blood to produce a blue-white chemiluminescent reaction (that is, it glows in the dark), so luminol tests must be conducted in darkness. The reaction produced by luminol does not last long (perhaps one to two minutes), and photographs of the tested area need to be taken quickly to preserve the results. Takayama reagent (a mixture of glucose, sodium hydroxide, pyridine, and deionized water) reacts with the hemoglobin in blood when heated to form pink needle- or rhomboid-shaped crystals that can be seen under a microscope.

Other reagents can identify other bodily fluids, such as semen. The reagent nuclear fast red stain, for example, stains spermatozoa so they are visible under a microscope.

Reagents can also identify illegal or poisonous substances. For example, copper sulfate reacts with ephedrine, pseudoephedrine, or norephedrine to produce a purple color, and cobalt thiocyanate reacts with cocaine or phencyclidine (PCP) to produce a blue color. A reagent made from solutions with sodium phosphate, chloramine-T, and a color reagent reacts with cyanide to produce a red color. The reagent used in the Dillie-Koppanyi test reacts with barbiturates to produce a violet color, and the Duquenois-Levine reagent, along with hydrochloric acid and chloroform, reacts with marijuana resins to produce a purple, then pink, color.

Uses with Impression Evidence

Powder or chemical reagents can be used to bring out fingerprints where none can be seen.

For example, ninhydrin is a reagent that reacts with some of the protein left behind by fingerprints. When ninhydrin is placed on a surface that has fingerprints, a deep blue/purple color highlights the prints. Gentian violet is another substance used to develop fingerprints. These types of reagents must be used with caution, however, because they destroy any DNA (deoxyribonucleic acid) evidence that may have been left behind with fingerprints.

Reagents can also be used with shoe prints to determine the type of soil in which the person wearing the shoe walked. For example, if the soil contains iron, ammonium/potassium thiocyanate will react with the iron to produce a reddish-brown color. Hydroxyquinoline reacts with calcium, magnesium, iron, aluminum, and other metals that may be present in small amounts in shoe or tire impressions to produce fluorescence that can be seen under an ultraviolet light. Iodine reacts with small amounts of waxy or oily substances on footprints or tire tracks and may be used in enhancing wet impressions.

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Further Reading

American Chemical Society Committee on Analytical Reagents. *Reagent Chemicals: Specifications and Procedures*. Washington, D.C.: American Chemical Society, 2005. Discusses the requirements and methods for determining the purity of analytical reagents.

Bell, Suzanne. *Forensic Chemistry*. Upper Saddle River, N.J.: Pearson Prentice Hall, 2006. Describes the methods that forensic scientists use involving chemistry and chemical reactions.

Cobb, Cathy, Monty L. Fetterolf, and Jack G. Goldsmith. *Crime Scene Chemistry for the Armchair Sleuth*. Amherst, N.Y.: Prometheus Books, 2007. Presents basic information on chemistry-related forensic techniques, including the use of reagents in identifying body fluids.

Johll, Matthew. *Investigating Chemistry: A Forensic Science Perspective*. New York: W. H. Freeman, 2007. Textbook designed for nonscience majors includes introductory material on basic chemical concepts, including the use of reagents, in crime solving.

Lundblad, Roger L. *Chemical Reagents for Protein Modification*. Boca Raton, Fla.: CRC, 2004. Discusses how protein modification relates to the analysis of individual amino acids.

Wang, Zerong. *Comprehensive Organic Name Reactions and Reagents*. New York: Wiley-Interscience, 2008. Describes the reactions, applications, and related reactions of reagents and provides experimental examples.

See also: Acid-base indicators; Benzidine; Blood residue and bloodstains; Crime scene screening tests; DNA isolation methods; Evidence processing; Footprints and shoe prints; Luminol; Microcrystalline tests; Orthotolidine; Phenolphthalein; Presumptive tests for blood; Semen and sperm; Tire tracks.

Restriction fragment length polymorphisms

Definition: Variations in the lengths of pieces of DNA cut with restriction enzymes.

Significance: Restriction fragment length polymorphisms are used as markers in gene mapping and to identify individuals in DNA fingerprinting. They are used to determine disease status, to test for paternity, and as forensic evidence to identify the sources of DNA samples.

Restriction fragment length polymorphisms (RFLPs) were the first DNA (deoxyribonucleic acid) typing to be used as forensic evidence. English geneticist Alec Jeffreys and his colleagues identified DNA fingerprints for forensic application in 1985. They examined regions of the human genome called minisatellites, which are made of a DNA sequence that is tandemly (end-to-end) repeated hundreds of times. These are also called variable number of tandem repeats (VNTRs). Individuals vary in the numbers of tandem repeats of that DNA sequence they have in their genomes.

In detecting these RFLPs, DNA is isolated from cells. A restriction enzyme (which makes sequence-specific cuts in DNA) is used to cut outside the repeating sequence. DNA is separated based on size through the use of gel electrophoresis. The DNA fragments are transferred from the gel to a membrane (called a Southern blot). A single-stranded, labeled DNA probe complementary to the repeating sequence is hybridized with the DNA on the membrane. The probe base-pairs with its complementary sequences on the membrane. This labeled probe allows the VNTR regions to be detected among all the DNA in the genome. The size of the fragment detected varies depending on the number of tandem repeats the individual has. This is length polymophism—length variation from individual to individual.

Samples of blood, semen, saliva, or other biological materials are often collected at crime scenes for later DNA analysis. As such a sample ages, dries, or is subjected to high temperatures, the DNA may degrade (break into smaller pieces). To use RFLPs, intact DNA of 20,000 to 25,000 base pairs is required. If DNA degraded to smaller sizes than this is used, a restriction fragment might not be generated, which could cause the false exclusion of a suspect. The minimum amount of DNA that is needed for detection using a radioactive or chemiluminescent probe is 10 to 50 nanograms.

RFLPs were used in the first forensic DNA profiling. As many as fifteen different loci could be examined. The Combined DNA Index System (CODIS), the system developed by the Federal Bureau of Investigation (FBI) for tracking DNA profiles, keeps DNA information from convicted felons for five RFLP loci.

The use of RFLPs for DNA fingerprinting is increasingly being replaced by polymerase chain reaction (PCR) methods, which amplify DNA. With PCR, many copies of short pieces of DNA can be made rapidly, and variations in sequences copied can be used to create a DNA profile. Because PCR can be done on degraded DNA, this newer method has widely replaced RFLPs in forensic applications.

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Further Reading

Fisher, Barry A. J. *Techniques of Crime Scene Investigation*. 7th ed. Boca Raton, Fla.: CRC Press, 2004.

Gill, Peter, Alec J. Jeffreys, and David J. Werrett. "Forensic Application of DNA 'Fingerprints.'" *Nature* 318 (1985): 577-579.

Jones, Phillip. "DNA Forensics: From RFLP to PCR-STR and Beyond." *Forensic Magazine*, Fall, 2004.

Rudin, Norah, and Keith Inman. *An Introduction to Forensic DNA Analysis*. 2d ed. Boca Raton, Fla.: CRC Press, 2002.

See also: DNA analysis; DNA database controversies; DNA extraction from hair, bodily fluids, and tissues; DNA fingerprinting; DNA isolation methods; DNA typing; Electrophoresis; Ethics of DNA analysis; Paternity testing; Polymerase chain reaction; Short tandem repeat analysis; Soil.

RFLPs. *See* Restriction fragment length polymorphisms

Ricin

Definition: Poisonous protein extracted from beans of the plant with the botanical name *Ricinus communis* and the common name castor bean.

Significance: Given that the plant source for the highly toxic substance ricin is easy to obtain, concerns have arisen among law-enforcement and national security agencies that terrorists might attempt to use this toxin in attacks. Such fears are exacerbated by the fact that no antidote to ricin poisoning has been developed.

More than one million tons of castor beans are processed every year for their oil, and the poison ricin can be prepared from the waste created in this processing. Near the end of World War I, the U.S. Chemical Warfare Service extracted ricin from castor beans as part of a plan to produce a toxic weapon. The possession of ricin is illegal in the United States; ricin is listed as a restricted substance (select agent) in the U.S. Biological Weapons Anti-Terrorism Act of 1989.

Preparations of ricin generally appear as gray, off-white, or white powders. Ricin is a heat-resistant protein that consists of two protein subunits, an A chain and a B chain. The B chain is a lectin (carbohydrate-binding protein) and enables ricin binding and internalization by cells; the A chain is the lethal component. To be toxic, ricin has to enter cells, where the A chain enzymatically inactivates ribosomes, the protein-synthesizing machines of cells. The toxic dose of ricin for humans is approximately 500 micrograms; ricin is more toxic on a weight basis than most common nerve gases or chemical weapons. Ricin would be most dangerous as a weapon of terrorism in aerosolized form—that is, in the form of a fine powder that does not clump—as this form would enable the dispersion of the substance over a wide area.

Signs and Symptoms of Ricin Poisoning

The effects of ricin vary depending on how the poison enters the body. If ricin is inhaled, symptoms usually appear within a few hours to eight hours. These include difficulty breathing, fever, cough, nausea, profuse sweating, accumulation of fluid in the lungs, low blood pressure, and respiratory failure. If ricin is ingested with food or liquids, symptoms usually appear in less than six hours and include diarrhea, vomiting, severe dehydration, hallucinations, blood in urine, and seizures. Over the course of several days, liver, kidney, and spleen failure may result.

Time to death from ricin exposure depends on the dose and method of exposure; death may take place from thirty-six to seventy-two hours after initial exposure. Victims who survive past seventy-two hours often recover. Treatment consists of supportive care based on the route of entry of the ricin; for example, for ingested ricin, activated charcoal is administered orally. Other therapy includes provision of intravenous fluids, help in breathing, and medications for low blood pressure and seizures.

Criminal Cases Involving Ricin

Perhaps the most famous case of the use of ricin as a weapon is that of the assassination of Bulgarian dissident and exile Georgi Markov in London in 1978. Markov was a writer who worked for various Western European radio stations and was a persistent critic of the communist Bulgarian government. Agents of the Bulgarian government made three attempts on his life, and the third was successful. At a bus stop, Markov was reportedly stabbed in the thigh with an umbrella that had been specially fabricated to inject a small metal pellet that was designed to release ricin. He died a few days later. Because of Markov's verbalized suspicions about the incident, an autopsy was requested by Scotland Yard. The examination recovered a small metal sphere the size of a pinhead from Markov's body. The artifact, which was composed of expensive and finely machined metals, contained traces of ricin in an inner chamber.

Confirming Ricin Poisoning

In its fact sheet on ricin, the U.S. Centers for Disease Control and Prevention describes how authorities confirm cases of suspected ricin poisoning.

- If we suspect that people have inhaled ricin, a potential clue would be that a large number of people who had been close to each other suddenly developed fever, cough, and excess fluid in their lungs. These symptoms could be followed by severe breathing problems and possibly death.
- If in suspected situations where ricin may have been disseminated, preliminary environmental testing by public health or law enforcement authorities may detect ricin in powders or materials released into the immediate environment. Persons occupying such areas may initially be observed for signs of ricin poisoning.
- No widely available, reliable medical test exists to confirm that a person has been exposed to ricin.

Ricin is derived from the beans of the castor-oil plant, shown here at top right along with the leaf and flower head of the plant. *(© iStock-photo.com/Alex Bramwell)*

Less than two weeks before the attack on Markov, another Bulgarian dissident, Vladimir Kostov, was shot in Paris with a bullet carrying the same kind of pellet that killed Markov. The attempt on Kostov failed because the pellet did not lodge deeply in his body and was removed before it could deliver a lethal dose of ricin. The crimes against Markov and Kostov remain unsolved, but KGB defectors have claimed that the KGB provided technical assistance to the perpetrators.

In 1994 and 1995, members of a domestic American terrorist group, the Minnesota Patriots Council, were convicted of possession of ricin and of conspiring to kill law-enforcement officers. They had responded to an advertisement in a radical right-wing magazine offering the materials necessary to make ricin and instructions on how to make the toxin.

In February, 2004, ricin was detected in materials in the Washington, D.C., mail office of U.S. Senate Majority Leader Bill Frist. Three buildings were closed while investigations and tests for contamination were completed, and no human poisonings occurred. The case remains unsolved. Other cases involving small amounts of apparently homemade ricin made the news in the United States in 2006 and 2008, illustrating the relative ease with which this substance can be produced.

Forensic Detection of Ricin

Forensic techniques for the detection of ricin include the use of lateral-flow immunochromatographic devices for on-site detection as well as enzyme-linked immunosorbent assays in the laboratory. Other methods that have been employed for ricin detection and quantification, as it is a protein, include conventional amino acid sequencing and extremely sensitive and specific mass spectrometry techniques.

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Further Reading

Audi, Jennifer, et al. "Ricin Poisoning; A Comprehensive Review." *Journal of the American Medical Association* 294, no. 18 (2005): 2342-2351. Focuses on the medical treatment of ricin poisoning.

Bullock, Jane, and George Haddow. *Introduction to Homeland Security*. 2d ed. Boston: Butterworth-Heinemann, 2006. Provides an informative overview of security measures, including coverage of issues relevant to protection against biological and chemical warfare agents.

Cook, David, Jonathan David, and Gareth Griffiths. "Retrospective Identification of Ricin in Animal Tissues Following Administration by Pulmonary and Oral Routes." *Toxicology* 223 (2006): 61-70. Discusses techniques used during death investigations for detecting ricin in different body fluids and organs.

Greenberg, Michael I. *Encyclopedia of Terrorist, Natural, and Man-Made Disasters*. Sudbury, Mass.: Jones & Bartlett, 2006. Presents examples of criminal uses of biological and chemical weapons.

Keyes, Daniel C., ed. *Medical Response to Terrorism: Preparedness and Clinical Practice*. Philadelphia: Lippincott Williams & Wilkins, 2005. Provides a review of clinical treatments for exposure to biological and chemical agents. Also discusses health care organizations' readiness for responding to terrorist attacks.

Lorberboum-Galski, Haya, and Philip Lazarovici. *Chimeric Toxins: Mechanisms of Action and Therapeutic Applications*. New York: Taylor & Francis. Reviews the research on ricin and many other poisonous substances in the context of their use as parts of medical therapies.

Rappuoli, Rino, and Cesare Montecucco, eds. *Guidebook to Protein Toxins and Their Use in Cell Biology*. New York: Oxford University Press, 1997. Technical handbook describes toxins similar to ricin as well as other classes of poisons derived from biological sources.

See also: Biodetectors; Biological terrorism; Biological weapon identification; Biological Weapons Convention of 1972; Biotoxins; Centers for Disease Control and Prevention; Forensic toxicology; Markov murder; Poisons and antidotes; Toxicological analysis.

Rigor mortis

Definition: Temporary stiffening of the cardiac and skeletal muscles that ensues shortly after death as the result of chemical changes within the muscular tissue. The limbs of the deceased may lock into position and become difficult to manipulate.

Significance: Together with algor mortis (cooling of body temperature) and livor mortis (discoloration from gravitational blood seepage), rigor mortis provides information that is useful in the assessment of time of death. In some cases, rigor mortis may be also useful for helping investigators determine whether bodies have been moved after death.

Rigor mortis (a Latin term meaning "the stiffness of death") was first studied systematically in the nineteenth century. Immediately after a human being dies, the body's muscles become limp, or flaccid. The circular sphincter muscles of the anus, for example, may relax to the point that defecation occurs. After a few hours, however (in some instances after a few minutes), the muscles grow rigid, locking the body into a fixed position. This stiffening occurs when, in the absence of oxygen and nutrients, the body's adenophine triphosphate (ATP) is depleted. This complex chemical energy source is critical for muscular contraction; without it, muscular fibers remain interlocked.

In a temperate climate with an ambient temperature of 70 degrees Fahrenheit, the rigidity of a body ideally proceeds, with some variations, according to chronological parameters. It generally progresses downward following Nysten's law (named for a nineteenth century researcher): It appears first in the small facial muscles (such as the muscles of the eyelids and jaws), then in the upper extremities, and then in the lower extremities. The facial muscles stiffen within thirty minutes to three hours after death; the entire body stiffens within six to twelve hours. After thirty-six hours (again in a temperate climate), rigor mortis tends to disappear in the same downward progression as the body begins to putrefy.

Although this multistaged biochemical process would seem to allow some precision in determining time of death, in fact no competent investigator would use information about rigor mortis in isolation to estimate time of death because the progression of rigor is subject to too many variables. Contrary to popular misconceptions fostered by films and television, observation of rigor mortis stages is one of the least reliable means of determining the postmortem interval; further, such observation is at all useful only before decomposition begins. When investigators base estimations of time of death on the progress of rigor mortis, they do not furnish specific times; rather, they make statements regarding probable intervals.

Cool ambient temperatures retard the progress of rigor mortis, and high temperatures accelerate it. How an individual died can also affect the progress of rigor. For example, if a person kicked at an attacker before dying, the ATP in the legs might be depleted first. Strychnine poisoning induces violent physical convulsions that would quickly deplete the supply of ATP and shorten the time for onset of rigor. Elevated body temperature caused by an infection would also accelerate the process.

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Further Reading

DiMaio, Vincent J., and Dominick DiMaio. *Forensic Pathology*. 2d ed. Boca Raton, Fla.: CRC Press, 2001.

Innes, Brian. *Bodies of Evidence*. Pleasantville, N.Y.: Reader's Digest Association, 2000.

Nickell, Joe, and John F. Fischer. *Crime Science: Methods of Forensic Detection*. Lexington: University Press of Kentucky, 1999.

See also: Adipocere; Algor mortis; Autopsies; Decomposition of bodies; Forensic pathology; Livor mortis; Misconceptions fostered by media; Taphonomy.

Ritual killing

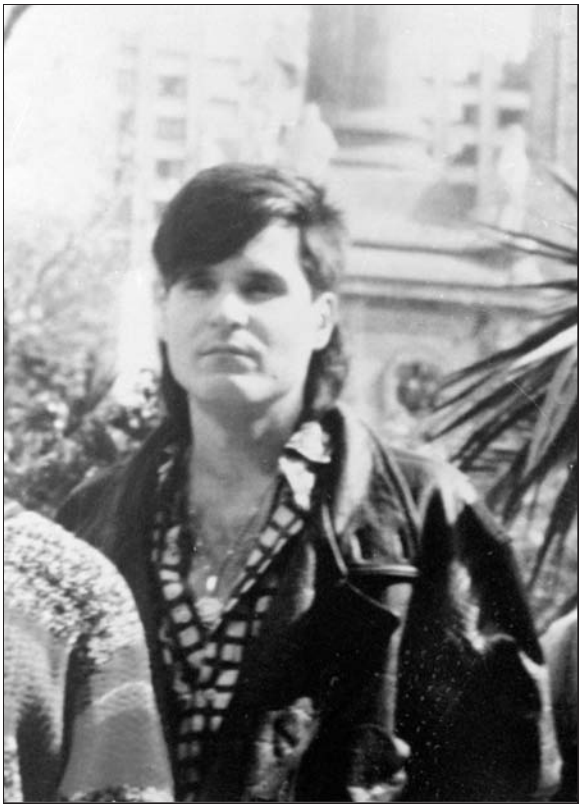
Definition: Murder of a human being as part of a religious, spiritual, or medicinal rite.

Significance: Although ritual killings are rare in the developed nations of the modern world, some traditional medicinal practices in the developing world still call for such practices, and occasional cases related to new religious movements are seen in developed nations. Behavioral profiling is a vital tool to aid investigators in the identification and classification of ritual killing cases. Through the analysis of patterned behaviors and common characteristics found among victims and offenders, law-enforcement investigators can better understand the features of the ritual killing phenomenon.

Ritual killing has been practiced by members of diverse civilizations for thousands of years. Various cultures throughout history have called for human sacrifices as ways to appease deities or ancestral spirits, to attain the support of supernatural forces for worldly gains, or to achieve spiritual transcendence. Such homicides are symbolic acts, and they are carried out in particular ways prescribed by cultural traditions.

Mexico's Aztec people are most infamous for engaging in ritual slaughter, but numerous other ancient cultures prescribed homicide rites to attain material or spiritual ends. In precolonial Borneo, headhunting was believed to ensure fertility and bountiful harvests. In Scandinavia, slave women were occasionally killed so that they could become the wives of recently deceased Viking warriors in the afterlife of Valhalla. Although the Old Testament itself contains numerous references to ancient forms of human sacrifice, the Abrahamic religions' condemnation of human sacrifice has been an important element in the widespread decline of the practice.

In modern times, nearly all religions and cultures have renounced human sacrifice. The few religious adherents who have remained faithful to or recently adopted human sacrifice are con-



Adolfo de Jesús Constanzo, a drug dealer and the leader of a black magic cult in Matamoros, Mexico. He and his followers committed at least twelve ritual murders intended to enable them to become invincible and to evade law-enforcement authorities. *(AP/Wide World Photos)*

sidered marginal and not representative of their larger communities.

African Medical Murder

Throughout much of southern and western Africa, a type of ritual killing occurs that adherents believe to be medicinal, although the practice is maintained and perpetuated by traditional religious beliefs. *Muti* killing, a term derived from the Zulu word for medicine, is ritual murder in which the vital organs of live victims are removed to be used in sacred medicines created by traditional healers.

Various traditional African medicines are made from animal organs or plants, but the most powerful medicine is considered to be that made from human remains, as the luck of others can be taken and transferred. Adherents believe that such medicine will bring wealth, success, power, or fertility and ward off drought, illness, and myriad other evils. It is desirable for the organs to be removed from conscious victims, as screams of pain are thought to strengthen the potency of the medicine. As they are necessary for the removal of organs from live individuals, knives are the exclusive weapon of choice. The most common body parts removed are the eyes, head, tongue, genitalia, hands, heart, and breasts. As the explicit purpose is merely to obtain the organs, murder is not a necessary part of the ritual, although the victims nearly always die as a result. Rarely is any effort made to conceal these homicides; the bodies of victims are typically left out in the open near sources of running water.

The most desirable victims are healthy and young, as this is thought to create the most potency. They are most frequently poor, young, indigenous males. Typically, at least three parties are involved in the ritual: the traditional healer, the client seeking assistance from the healer, and the assassin. The killing is set in motion when the client, usually a member of a traditional community, visits a healer for help in achieving some type of personal gain. The client is usually not involved in the murder and purchases the medicine afterward for a substantial fee. The healer prescribes a specific medicine and approaches a third party or parties to commit the crime; the murder is almost never carried out by the healer. Assassins are most likely to be males over thirty years old from lower socioeconomic backgrounds; they typically work together in small teams. The killers, motivated by profit, dedication to tradition, or both, often know their victims and may even be related to them.

Ritual Killing in Developed Nations

Law-enforcement personnel in developed nations are often unfamiliar with the practices of ritual killing and thus do not know how to go about investigating crimes that appear to include elements of ritual. In some cases, the nature of bodily dismemberment may allow investigators to determine whether or not a ritual killing has taken place, and offender profiling and victimology (study of victims' behavior) may be instrumental in their assessment of possible suspects.

Although ritual homicide and suicide are rare in developed nations, some marginal religious movements have engaged in these practices in order to accomplish material or spiritual ends. In 1997, for example, thirty-nine members of the Heaven's Gate religious cult committed mass suicide because they believed that they would be transported to a "level beyond human" as a result. It may be argued that the 1978 deaths of more than nine hundred members of Jim Jones's People's Temple in Jonestown, Guyana, constituted a form of ritual killing, as some of those who died committed suicide willingly by ingesting a poisoned fruit-flavored drink and others were forced to drink the liquid or were shot.

Ritual killings in the name of demoniac spirits have also occurred in the West. One such case involved murders committed by a drug-dealing so-called black magic cult in Matamoros, Mexico, in 1989. Charismatic leader Adolfo de Jesús Constanzo and his followers committed numerous ritual murders intended to enable them to become invincible and evade law-enforcement authorities. Body parts of the group's victims were found floating in a ceremonial pot along with dead spiders and scorpions.

In the United States, the concept of ritual killing is perhaps most commonly associated with satanic cults, which have been alleged to have established organized networks that engage in ceremonies in which victims (often children) are brainwashed, abused, and killed. Claims of such widespread ritual abuse remain unsubstantiated, however, and most authorities believe that descriptions of so-called satanic cults have been greatly exaggerated. Although an organization known as the Church of Satan exists, its theology rejects both animal and human sacrifice.

Eric Madfis

Further Reading

Adinkrah, Mensah. "Ritual Homicides in Contemporary Ghana." *International Journal of Comparative Criminology* 5 (2005): 29-59. Examines twenty-four cases of ritual murder committed in Ghana between 1990 and 2000 and discusses socioeconomic influences, demographics, motivations, and general patterns of the crimes.

Green, Miranda. *Dying for the Gods: Human Sacrifice in Iron Age and Roman Europe*. Charleston, S.C.: Tempus, 2002. Analyzes the reasons for and functions of human sacrifice throughout much of ancient history. Includes descriptive case studies.

Labuschagne, Gerard. "Features and Investigative Implications of *Muti* Murder in South Africa." *Journal of Investigative Psychology and Offender Profiling* 1 (2004): 191-206. A South African police commander details the offender and victim characteristics associated with *muti* murder and provides guidelines for investigating this crime.

Richardson, James T., Joel Best, and David G. Bromley, eds. *The Satanism Scare*. New York: Aldine de Gruyter, 1991. Excellent reader presents discussion of the social construction of the fear of Satanism and satanic ritual abuse in the United States.

See also: Child abduction and kidnapping; Crime scene investigation; Homicide; Suicide; Victimology.

S

Sacco and Vanzetti case

Dates: Murder committed April 15, 1920; Sacco and Vanzetti executed August 23, 1927

The Event: After two Italian immigrants were charged with murder, ballistics evidence played an important role in their prosecution.

Significance: The guilt or innocence of Nicola Sacco and Bartolomeo Vanzetti continues to be a subject of ongoing discussion, as is the forensic evidence presented at their trial and retested several times thereafter.

On April 15, 1920, in a small town near Boston, the paymaster and a security guard at a shoe factory were shot and robbed of more than $15,000. On May 5, 1920, two Italian immigrants, Nicola Sacco and Bartolomeo Vanzetti, were arrested for the crime; the two were carrying guns. When they were eventually indicted for the murder of the guard, Alessandro Berardelli, twentieth century America's most notorious political trial was set in motion. The trial of Sacco and Vanzetti took place in the midst of the Red Scare, when federal and state authorities in the United States moved aggressively against any signs of radical political activity.

The Trial

Sacco and Vanzetti's trial opened in Dedham, Massachusetts, on May 31, 1921. By far the most controversial evidence presented in the case was that dealing with guns and bullets; the trial became a battle of the experts as testimony was presented on both sides about the new field of forensics encompassing ballistics and firearms identification.

The prosecution presented expert testimony concerning one of the four bullets (designated bullet III) found in the body of Berardelli. No one disputed that the bullet had been fired from a Colt automatic or that Sacco was arrested carrying a Colt automatic. The prosecution's key witness, Captain William Proctor, testified that bullet III was "consistent with being fired from that [Sacco's] pistol." (Two years later, however, after he allegedly had a dispute with the prosecutor, Proctor provided an affidavit to the defense stating that he found no evidence that bullet III had actually been fired from Sacco's gun.) The defense presented testimony from two ballistics experts who challenged the prosecution's expert's testimony. (Years later, however, one of the defense experts changed his testimony and said that a shell casing found at the scene was fired from Sacco's gun.)

The Verdict

On July 14, 1921, after five and one-half hours of deliberations, the jury returned guilty verdicts against both defendants, and Sacco and Vanzetti were subsequently sentenced to death. The convictions immediately prompted protests in the United States as well as in France and Italy, and posttrial legal motions and appeals continued for years.

A key defense motion for a new trial alleged that Captain Proctor, by arrangement with the prosecution, had given intentionally misleading testimony. The defense claimed that despite Proctor's testimony that bullet III was "consistent" with having been fired from Sacco's Colt, Proctor had confided earlier to the district attorney that he did not believe the bullet came from the defendant's gun. The trial judge denied this motion, and his ruling was upheld by the Massachusetts Supreme Court in 1926.

After being overwhelmed by pleas for clemency for Sacco and Vanzetti, Massachusetts governor Alvan T. Fuller appointed a three-person advisory commission to investigate the case. The commission hired Colonel Calvin Goddard, a pioneer in the field of ballistics who had written a seminal article titled "Forensic Ballistics" in which he described a new method of firearms investigation. This technique employed the comparison microscope developed by Goddard's colleague Philip O. Gravelle, which allowed for simultaneous microscopic side-by-side comparisons of two objects.

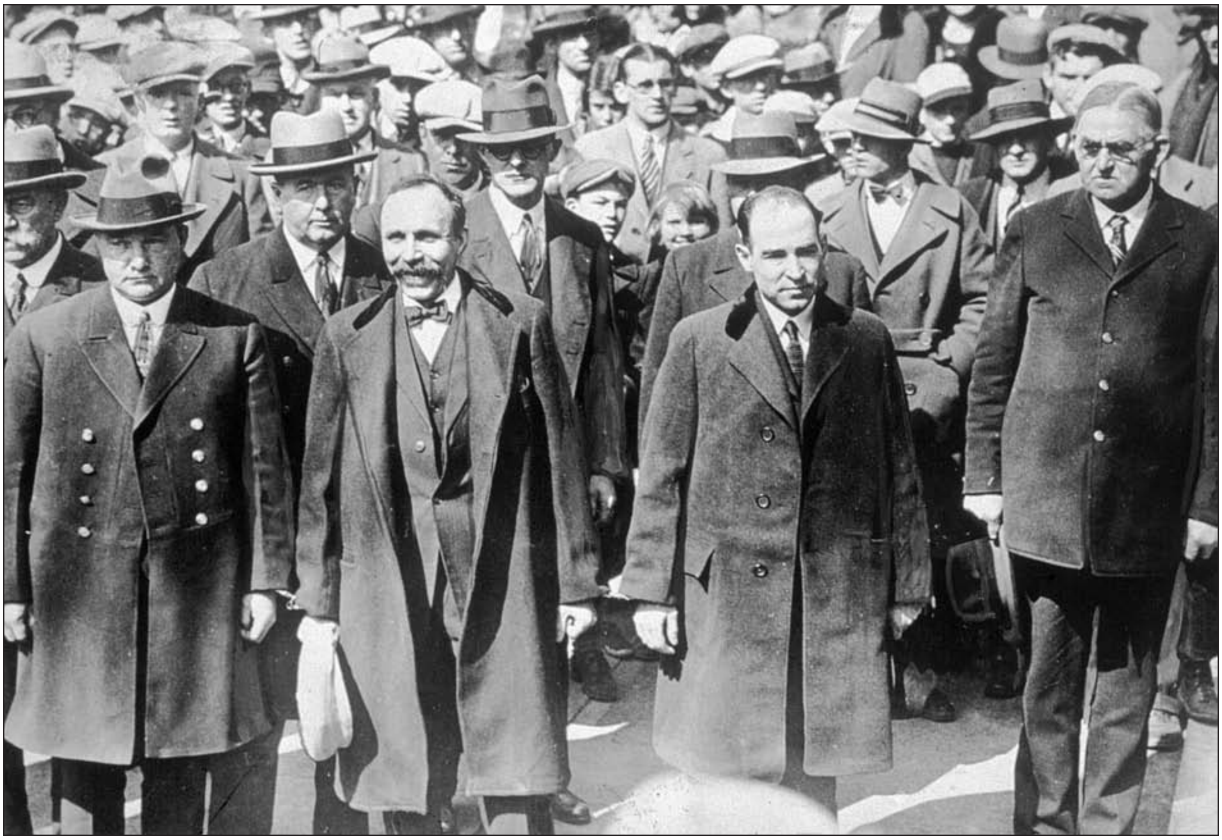
In the presence of one of the ballistics experts who had testified for the defense, Goddard fired a bullet from Sacco's gun and then used a comparison microscope to examine the ejected casing next to each of the casings found at the scene of the crime. The first two casings from the crime scene did not match Sacco's gun, but the third one did. Both of the defense experts agreed that the two cartridges had been fired from the same gun.

When the commission concluded that Sacco and Vanzetti were guilty beyond a reasonable doubt, Governor Fuller denied them clemency. Last-ditch appeals to the Massachusetts and U.S. Supreme Courts failed, and on August 23, 1927, the two men were executed. Both continued to proclaim their innocence to the very end.

The Aftermath

In October, 1961, forty years after Sacco and Vanzetti's trial, the Massachusetts State Police Laboratory examined the ballistics evidence using techniques much improved over those available earlier and concluded that bullet III was in fact fired from Sacco's Colt automatic. Critics, however, noted that these results meant nothing if bullet III was substituted years before to frame the defendants.

In 1982, Professor Regis Pelloux of the Massachusetts Institute of Technology conducted new tests in which he compared bullet III with the other three bullets found in Berardelli's body. He found both differences and similarities but concluded that the differences could be explained by deformation that occurred as the bullets entered the victim's body. In 1983, renowned forensic scientist Henry C. Lee demon-



Bartolomeo Vanzetti (left) and Nicola Sacco, manacled together and surrounded by guards and onlookers, approaching the Massachusetts courthouse where they were sentenced to death in 1921. Appeals challenging the validity of the expert testimony used against them delayed their executions until 1927. *(Library of Congress)* strated that the six Peters cartridges taken from Sacco when he was arrested were made on the same machine that made the two Peters fired cartridge cases found at the crime scene. In 1988, a reporter for the *Boston Globe* newspaper disclosed that a police sergeant had admitted that the prosecution's ballistics experts had switched the murder weapon.

Some scholars have continued to dispute the conclusiveness of the ballistics evidence in this case, asserting that bullet III might have been planted by prosecutors. Others have pointed out that bullet III matched perfectly with the autopsy report on the victim. Those who believe the defendants were correctly convicted have argued that if the prosecution witnesses had been part of a conspiracy to frame Sacco, they would not have been so restrained in their testimony; some have also asserted that the prosecutor would have been highly unlikely to jeopardize his entire career by falsifying evidence in the case.

Stephen F. Rohde

Further Reading

Frankfurter, Felix. *The Case of Sacco and Vanzetti: A Critical Analysis for Lawyers and Laymen*. 1927. Reprint. Buffalo, N.Y.: William S. Hein, 2003. Classic work by the future U.S. Supreme Court justice makes the case for a new trial by carefully marshaling evidence of unfairness at the trial and pointing to others as possible perpetrators of the crime.

Russell, Francis. *Sacco and Vanzetti: The Case Resolved*. New York: Harper & Row, 1986. Updated examination of the case defends the author's first book (cited below) against the onslaught of criticism it received from supporters of the defendants. Argues that Vanzetti was an accessory after the fact.

_______. *Tragedy in Dedham: The Story of the Sacco-Vanzetti Case*. New York: McGraw-Hill, 1962. Initial work of one of the preeminent proponents of the view that Sacco was guilty but Vanzetti was either innocent or marginally involved.

Topp, Michael M. *The Sacco and Vanzetti Case: A Brief History with Documents*. New York: Palgrave Macmillan, 2005. Places the case in its historical context by providing documents from the time. Includes an informative introduction and a chronology of the case.

Young, William and David E. Kaiser. *Postmortem: New Evidence in the Case of Sacco and Vanzetti*. Amherst: University of Massachusetts Press, 1985. Comprehensive critique of the evidence against Sacco and Vanzetti takes full advantage of the forensic techniques developed in the years after the case. Advances the theory that bullet III was fraudulently substituted to frame the defendants.

See also: Ballistic fingerprints; Ballistics; Chain of custody; Firearms analysis; Microscopes.

Saliva

Definition: Complex fluid mixture secreted from the salivary glands into the mouth or oral cavity.

Significance: Saliva is an extremely useful tool in many forensic applications, in part because collection of saliva samples is relatively simple and noninvasive. Even small samples of saliva will yield the blood types of the donors as well as DNA for comparative purposes.

Saliva contains water, electrolytes, mucus (consisting of mucopolysaccharides and glycoproteins), various enzymes, and opiorphin, a painkilling substance. Saliva has many functions in the human body. It aids digestion by moistening food, binding it together so that it may be more effectively chewed. It also lubricates food, permitting swallowing and easy passage of food down the esophagus, thereby minimizing irritation of the lining of the oral cavity. The salivary enzyme amylase initiates digestion of carbohydrates such as starch, and the mix of saliva with molecules in food and liquid aids tasting, as the molecules more readily interact with taste buds located on the tongue.

Saliva aids oral hygiene by flushing food debris from the mouth. It contains the enzyme lysozyme, which destroys many bacteria, thereby acting as a disinfectant; however, many pathogenic bacteria can thrive in the mouths of humans and other animals. Saliva also functions as a protective barrier, as when nausea reflexively triggers saliva flow, which coats the oral lining and teeth before vomiting occurs so that acidity is minimized.

The amount and type of saliva secretion is controlled by the autonomic nervous system. Increased stimulation leads to increased blood flow to the salivary glands, which stimulates production and release of saliva. Sympathetic stimulation results in an increased amount of mucus in the saliva, and parasympathetic stimulation results in increased volume of watery saliva production (serous saliva).

Saliva samples are often important in criminal investigations. Collection of saliva is relatively simple and noninvasive, and only a small amount is needed for determination of an individual's blood type and for extraction of DNA (deoxyribonucleic acid) for comparisons. Saliva can also reveal the drugs an individual has taken; in some cases, even simple contact with certain drugs can be detected through analysis of saliva.

Saliva samples also permit evaluation of general health, and saliva tests have been developed for the detection of certain medical ailments, such as human immunodeficiency virus (HIV), and other health problems. Saliva samples that reveal the presence of viral, bacterial, or systematic diseases may link their donors to crime scenes or to objects.

Dwight G. Smith

Further Reading

Idowu, O. R., and B. Caddy. "A Review of the Use of Saliva in the Forensic Detection of Drugs and Other Chemicals. *Journal of the Forensic Science Society* 22 (1982): 123-135.

Mandel, I. D. "The Diagnostic Uses of Saliva." *Journal of Oral Pathology and Medicine* 19 (1990): 119-125.

Sweet, D., and D. Hildebrand. "Saliva from Cheese Bite Yields DNA Profile of Burglar: A Case Report." *International Journal of Legal Medicine* 112 (April, 1999): 201-203.

Walsh, D. J., et al. "Isolation of Deoxyribonucleic Acid (DNA) from Saliva and Forensic Science Samples Containing Saliva." *Journal of Forensic Sciences* 37 (1992): 387-395.

See also: Bite-mark analysis; DNA analysis; DNA extraction from hair, bodily fluids, and tissues; DNA isolation methods; DNA recognition instruments; Evidence processing; Hantavirus; Oral autopsy; Serology.

Sarin

Definition: Highly toxic liquid substance used as a chemical weapon.

Significance: Concerns that terrorists could employ sarin in chemical attacks have increased law-enforcement agencies' attention to this substance. The United Nations classifies sarin as a weapon of mass destruction.

Sarin was discovered in the 1930's during a search for new insecticides. Its extreme toxicity to humans led to its development as a chemical weapon by Nazi Germany and other nations, and huge quantities were manufactured and stored. In the 1980's and later, sarin was used several times in warfare and in terrorist attacks. The United Nations Chemical Weapons Convention of 1993 bans the manufacture and storage of chemical weapons including sarin, which is also known as isopropyl methylphosphonofluoridate or GB. Various nations—including the United States and Russia—have been gradually destroying stockpiles of munitions with sarin in accordance with the Chemical Weapons Convention. The United States has taken significant steps to provide members of its armed forces with means of protection from sarin attacks.

Toxic Effects

A so-called nerve gas, sarin is one of several chemical agents that exert toxic effects through the ability to bind to and inactivate the vital enzyme acetylcholinesterase (AChE). AChE exists in nerves and acts as a catalyst for hydrolysis of acetylcholine, the chemical that is released at nerve endings and that causes muscle contraction. Only a small amount of AChE is present in nerves, but it is very effective in catalyzing the destruction of acetylcholine.

When AChE is inactivated by sarin or a similar nerve agent, the acetylcholine builds up and causes uncontrolled muscle contractions. Symptoms of poisoning by sarin include pain in the eyes, blurred vision, runny nose, incontinence, respiratory failure, convulsions, coma, and death. The eyes are particularly sensitive; the pupils react to sarin by shrinking to pinpoints (meiosis). Sarin absorbed through the skin or inhaled as vapor or aerosol is toxic to different degrees, depending on exposure.

Dispersal

Sarin may be dispersed as a vapor or as an aerosol. The volatility of sarin permits a significant concentration of vapor at ambient temperatures, but this volatility also means that it may not persist in the environment. Toxic concentrations are more effectively achieved in confined spaces.

Aerosol dispersal of sarin, which requires some type of sprayer, can achieve higher concentrations than vapor dispersal. All types of dispersal tend to leave traces of sarin or its degradation products on surfaces, including clothing, from which forensic samples may be obtained for identification.

Detection and Treatment

Methods for the detection of sarin in military situations include test papers, test kits, and electronic devices. The M8 test paper for soldiers is impregnated with three dyes and responds with three color changes characteristic of different classes of chemical warfare agent. The M256A1 test kit contains a simple apparatus for sampling and applying chemical tests. Among more sophisticated methods are those that use small mass spectrometers, about the size of a brick; these devices can sample the ambient air directly and detect individual compounds. Also under development are even smaller detectors that use AchE on a silicon chip or compounds with fluorescence that reacts to nerve agents.

Treatment of sarin poisoning follows removal of the victim from contaminated clothing and all other contact with the toxic substance. Atropine may be given by injection to provide some relief from symptoms, as it inhibits binding of excess acetylcholine at some receptors. Diazepam may be administered to control the muscular spasms caused by the nerve agent, and pralidoxime methanesulfonate (P2S) is helpful in removing it from AChE.

Prophylaxis consists of drugs administered before sarin exposure occurs to increase resistance and reduce

Terror Attacks in Japan

In November, 1994, members of the religious movement Aum Shinrikyo sprayed sarin aerosol near a pond in a park in the city of Matsumoto in Japan. Sarin's precursor chemicals, such as isopropanol, trimethylphosphite, methyl iodide, and sodium fluoride, have legitimate industrial uses, and in 1994 it was possible for individuals to purchase these materials openly (access to many has since been restricted). The cult members had obtained chemicals sufficient to prepare sarin in quantity. In the Matsumoto attack, 5 people were killed and 274 were injured. The police were initially unsure what had happened, but eventually forensic investigators detected sarin in the water of the pond.

A few months later, on March 20, 1995, Aum Shinrikyo carried out a sarin attack on three major lines of the Tokyo subway system; the terrorists boarded subway trains and punctured plastic bags of impure sarin. This time it took police investigators only two hours to collect a sample and identify sarin using the method of gas chromatography-mass spectrometry (GC-MS). The attack killed 12 people and injured thousands. The dead exhibited extreme lividity, bronchial congestion, meiosis, and pulmonary edema. Some victims showed reduced cholinesterase activity in the blood. This attack stimulated research on forensic methods for detecting nerve agents and on possible courses of treatment for poisoning by such agents.

Tokyo subway passengers arrive at a hospital after being injured by sarin gas that was released in the subway system by members of the Aum Shinrikyo cult on March 20, 1995. The attack killed twelve and injured thousands. *(AP/Wide World Photos)*

the severity of possible symptoms. Among the drugs used are atropine and pyridostigmine bromide.

John R. Phillips

Further Reading

Croddy, Eric A., with Clarisa Perez-Armendariz and John Hart. *Chemical and Biological Warfare: A Comprehensive Survey for the Concerned Citizen*. New York: Copernicus Books, 2002. Addresses the uses of sarin and other nerve agents as weapons.

Marrs, Timothy C., Robert L. Maynard, and Frederick R. Sidell, eds. *Chemical Warfare Agents: Toxicology and Treatment*. 2d ed. Hoboken, N.J.: John Wiley & Sons, 2007. Presents a technical discussion of the factors affecting the toxicity of agents. Includes description of tests done with sarin on volunteers.

Mauroni, Al. *Chemical and Biological Warfare: A Reference Handbook*. 2d ed. Santa Barbara, Calif.: ABC-CLIO, 2007. Comprehensive survey of chemical and biological weapons includes a valuable annotated bibliography that includes citations to Internet sites.

Suzuki, Osamu, and Kanako Watanabe, eds. *Drugs and Poisons in Humans: A Handbook of Practical Analysis*. New York: Springer, 2005. Collection of highly technical articles discusses analytic techniques. Includes information on procedures for the analysis of sarin and its degradation products through gas chromatography and mass spectrometry.

Tucker, Jonathan B., ed. *Toxic Terror: Assessing Terrorist Use of Chemical and Biological Weapons*. Cambridge, Mass.: MIT Press, 2000. Presents twelve case studies of the use of chemical and biological agents by terrorist groups, identifying terrorists' patterns of behavior and strategies to combat them.

White, Peter, ed. *Crime Scene to Court: The Es-*

sentials of Forensic Science. 2d ed. Cambridge, England: Royal Society of Chemistry, 2004. General work provides good discussion of forensic science principles.

See also: Analytical instrumentation; Chemical agents; Chemical terrorism; Chemical warfare; Chemical Weapons Convention of 1993; Nerve agents; Nervous system; Soman.

Satellite surveillance technology

Definition: Commercially owned and operated Earth-orbiting satellites capable of producing high-resolution photographs of the ground from space.

Significance: Most surveillance requires either the person doing the surveillance or the equipment used to be in proximity to the target being watched, so there is risk that the target will become aware of the surveillance. The use of satellite technology, however, enables law-enforcement and other agencies to conduct surveillance that is undetectable by the targets.

Shortly after the first artificial satellites were placed into Earth orbit, plans were made for surveillance satellites. Such spy satellites were used by the military and intelligence agencies of national governments to monitor the activities of other nations from space. Commercial uses for imaging satellites eventually led to the development of remote-sensing satellites capable of monitoring land usage. With advances in technology, commercial satellites have been created with capabilities far in excess of those held by military satellites of only several years ago. Modern commercial satellites are capable of capturing images with resolutions of one meter (a little more than three feet) or less, meaning that they are capable of distinguishing between objects at least one meter apart.

The proliferation of high-resolution commercial satellites has led to a market for the data they collect. Several police agencies in the United States have contracted to use DigitalGlobe's QuickBird satellites to acquire high-resolution images. This type of surveillance can provide police with information such as the approximate numbers of people involved in suspected gang or drug-trafficking activities and their patterns of movement. Satellite-captured images can also provide law-enforcement agencies with information on the locations of fences, walls, trees, vehicles, and other obstacles in particular areas, which can be very useful, for example, when special weapons and tactics (SWAT) teams are preparing for raids. Alternative methods of surveillance, such as by aircraft, could alert suspects to police activity and potentially put officers at risk. Satellite surveillance also enables federal authorities to monitor national borders in remote regions that are difficult to monitor in other ways.

Commercial satellite technology began as remote sensing to monitor land usage, and law-enforcement agencies still use satellites for this purpose: to look for cultivated fields of marijuana or other controlled substances. Such surveillance can also be done by aircraft, but a single satellite can cover more area in more locations than a small fleet of aircraft. Also, satellites offer complete stealth surveillance, whereas aircraft can often be heard or spotted by persons on the ground. In addition, unlike aircraft, which must be fueled and flown on specific missions, satellites are always on duty. All that authorities need is to access the images.

Some privacy advocates have challenged law-enforcement agencies' uses of satellite surveillance as violations of the right to protection from unlawful searches guaranteed in the Fourth Amendment to the U.S. Constitution. Most law-enforcement agencies, however, argue that surveillance through satellite images does not require warrants. So far, the courts have permitted warrantless satellite surveillance.

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Further Reading

Bamford, James. "Big Brother Is Tracking You. Without a Warrant." *The New York Times*, May 18, 2003, p. 140.

Jasani, Bhupendra, and Gotthard Stein, eds. *Commercial Satellite Imagery: A Tactic in Nuclear Weapon Deterrence*. New York: Springer, 2002.

Peterson, Julie K. *Understanding Surveillance Technologies: Spy Devices, Their Origins, and Applications*. Boca Raton, Fla.: CRC Press, 2001.

See also: Closed-circuit television surveillance; Federal Rules of Evidence; Flight data recorders; Forensic photography; Geographic information system technology; Imaging; Night vision devices.

Scanning electron microscopy

Definition: Technique in which a high-powered scanning electron beam is used to achieve high-resolution imaging of microscopic samples.

Significance: Forensic scientists are often asked to compare various kinds of materials to determine whether the materials have a common origin. Scanning electron microscopy allows analysts to view samples at high magnification so that they can compare the surface characteristics of the samples to see if they are consistent with each other.

The scanning electron microscope was invented in 1938 by Manfred von Ardenne. The instrument is capable of distinguishing objects that are 3 nanometers apart, compared with 200 nanometers for simple light microscopes. Because of this, scanning electron microscopy (SEM) can be used for imaging and comparing very small surface characteristics.

In forensic science, SEM is typically used for comparing known samples to unknown samples recovered from crime scenes. SEM can be used to compare virtually any kind of materials, but in forensic laboratories it is most commonly used for imaging tool marks, fibers, minerals, soil samples, and gunshot residue.

The scanning electron microscope consists of an electron gun mounted atop a series of electromagnetic lenses and scanning coils, a sample holder, and a detector. The electron gun produces a high-powered electron beam that is focused by condenser lenses and scanned back and forth across the sample being imaged. The beam penetrates into the sample and causes the

A technician uses a scanning electron microscope to examine a sample. *(Custom Medical Stock Photo)* production of four things: low-energy secondary electrons (SEs), backscatter electrons (BSEs), X rays, and heat. The SEs are ejected from just under the surface of the sample, enter the detector, and are converted electronically to an image of the sample surface. Flat areas of the sample appear dark, and elevated areas appear lighter.

Some instruments also contain backscatter detectors that produce images using BSEs. These images have lower resolution than SE images but they are unique in that in these images heavier compounds appear brighter than lighter compounds. For example, a mixture of calcium carbonate and magnesium carbonate would appear simply as small grains when viewed in SE mode, but when viewed in BSE mode, the grains of calcium carbonate would appear brighter because calcium is a heavier element than magnesium.

SEM is often coupled with energy-dispersive spectroscopy (EDS), which provides an elemental profile of the section of the sample being viewed. This is especially useful for comparisons of items that look the same under SE mode, such as two pieces of paper. An analyst who is trying to determine whether two pieces of paper are consistent with each other may first view the two samples under SEM. If they appear different, the samples can be said to be inconsistent. If the samples appear similar, the analyst could perform EDS to see if the samples contain all the same trace elements. It may be found, for example, that one piece of paper has trace amounts of copper in it and the other does not. In that case, the two samples may be determined inconsistent even if they appear similar under SEM.

Lisa LaGoo

Further Reading

Flegler, Stanley S., John S. Heckman, and Karen L. Klomparens. *Scanning and Transmission Microscopy: An Introduction*. New York: Oxford University Press, 1993.

Goldstein, Joseph, et al. *Scanning Electron Microscopy and X-Ray Microanalysis*. 3d ed. New York: Kluwer Academic/Plenum, 2003.

Li, Zhigang R. *Industrial Applications of Electron Microscopy*. New York: Marcel Dekker, 2003.

See also: Analytical instrumentation; Document examination; Energy-dispersive spectroscopy; Fax machine, copier, and printer analysis; Fibers and filaments; Geological materials; Gunshot residue; Imaging; Microscopes; Paint; Paper; Tool marks; Trace and transfer evidence.

Scent identification

Definition: Use of specially trained dogs to identify particular persons by their unique odors.

Significance: In some cases, criminal investigators use trained scent identification dogs to connect crime scene evidence with suspects.

The canine sense of smell can be as much as ten thousand times more sensitive than the human sense of smell, and dogs' ability to discriminate among odors is sometimes useful during criminal investigations. Traditionally, police have used canines' olfactory skills to track or trail criminal suspects as well as missing persons. Dogs can track a person by following indicators of a fresh track, such as the odors of crushed vegetation and disturbed ground. To trail an individual, a dog needs a scent sample of the quarry.

A trailing dog uses the scent of a known person to identify that person's location. If presented with the scent of an unknown person, a trained dog can identify that person in a crowd. This is the basis of scent identification.

Human Scent

Research has shown that humans have stable and unique odor profiles and that dogs can be trained to recognize unique scents in mixtures of other odors. Studies with bloodhounds indicate that genetics plays a key role in determining the uniqueness of a person's scent. Although dogs can discriminate among members of human families, identical twins, who essentially have the same genes, pose a problem for dogs. It has been suggested that a human's scent profile, or "odortype," may be determined by the expression of genes in the major histocompatibility complex, the genes that also control immune responses through recognition of "self" and "nonself."

Other elements that may contribute to the uniqueness of an individual's scent include nutrition, hygiene, and state of health. Such secondary factors may become significant if a dog must distinguish between identical twins.

Studies with Dutch and German scent identification dogs have found that the age of a scent sample affects a dog's performance. Dogs faultlessly matched odors collected on the same day of the testing, but they made mistakes when presented with scent samples that had been stored for two weeks. After this initial drop in performance level, the dogs' accuracy remained steady even with scent evidence up to six months old. These results show that scent has a volatile component.

Using gas chromatography-mass spectrometry, scientists have analyzed the volatile components of human odor signatures. They have found that the distinctiveness of humans' scents arises from a combination of common compounds that differ in amounts from person to person. In addition, they have discovered that some compounds are unique to certain people.

The Federal Bureau of Investigation (FBI) has supported bloodhound research workshops in which the durability of human scent has been examined. One study showed that a dog could use the scent of a mailed letter to locate the letter writer's house six months after the person had moved out of the house. Another study found that bloodhounds could detect human scent on bomb fragments and identify the individual who had handled the bomb before it exploded.

The Scent Identification Lineup

The durability of human scent can combine with the sensitivity of the canine nose to allow criminal investigators to link a suspect and crime scene evidence in a scent identification lineup. This technique is relatively new to law-enforcement agencies in the United States, but it has become established in Europe. The Netherlands National Police Agency, for example, has formulated a protocol for the scent lineup that is accepted by the Dutch courts.

The basic Dutch police scent lineup proceeds as follows. A scent identification dog and its handler enter a test room that contains six stainless-steel scent-carrier tubes, each 10 centimeters (about 4 inches) long, clamped to platforms; one of these tubes has been handled by a suspect, and the other five have been handled by adults who are not associated with the suspect. After several quality-assurance tests are conducted, the suspect identification stage begins with the dog sniffing a scent evidence object collected from the scene of the crime. The dog then smells the scent-carrier tubes. If the dog picks the scent-carrier tube handled by the suspect in two tests, the police conclude that the scent evidence object and the suspect share an "odor similarity."

The scent lineup protocol requires that the dog's handler be unaware of who touched the scent-carrier tubes. This protects the findings from being invalidated by the possibility that the handler gave any nonverbal, or even unconscious, suggestion to the dog.

Scent Identification Evidence in U.S. Courts

The identification of a person by scent has an important limitation: Scent can be transferred from one person or object to another. Although scent identification can establish a direct or indirect link between an individual and crime scene evidence, it cannot prove that the individual participated in a crime.

In the United States, scent identification is usually not considered to be enough evidence to justify an arrest. Rather, a scent identification is viewed as one indicator of reasonable suspicion. Investigators must seek corroboration of a scent identification to meet the standard of probable cause before they can arrest the identified person.

Judges in the United States have expressed different opinions about the admissibility of scent lineup evidence. In some jurisdictions, judges view scent identification as sufficiently reliable to be presented during trial, whereas judges in other jurisdictions require the presentation of scientific evidence that every person has a scent so unique that it provides an accurate basis for identification. Although judges disagree about the scientific proof of reliability, scent identification offers a valuable tool for criminal investigation.

Phill Jones

Further Reading

Harvey, Lisa M., et al. "The Use of Bloodhounds in Determining the Impact of Genetics and the Environment on the Expression of Human Odortype." *Journal of Forensic Sciences* 51, no. 5 (2006): 1109-1114. Reports on research findings that indicate bloodhounds rely primarily on genetically determined cues when differentiating among humans.

Harvey, Lisa M., and Jeffrey W. Harvey. "Reliability of Bloodhounds in Criminal Investigations." *Journal of Forensic Sciences* 48, no. 4 (2003): 811-816. Examines the bloodhound's ability to trail and to discriminate among the scents of different humans.

Schoon, Adee, and Ruud Haak. *K9 Suspect Discrimination*. Calgary, Alta.: Detselig Enterprises, 2002. Discusses methods for training scent identification dogs and presents a history of canine scent detection in police investigations.

Syrotuck, William G. *Scent and the Scenting Dog*. 4th ed. Mechanicsburg, Pa.: Barkleigh Productions, 2000. Explores the canine sense of smell and discusses the challenges faced by scent identification dogs.

Tomaszewski, Tadeusz, and Piotr Girdwoyn. "Scent Identification Evidence in Jurisdiction." *Forensic Science International* 162, nos. 1-3 (2006): 191-195. Presents a survey of scent identification practices in the United States, the Netherlands, Germany, and Poland.

See also: Buried body locating; Cadaver dogs; Canine substance detection; Cross-contamination of evidence; Physical evidence.

Secret Service, U.S.

Date: Established on July 5, 1865

Identification: Federal agency created to combat counterfeit currency throughout the United States after the Civil War. After 1902, the agency's expanded mission included protective details for U.S. presidents and vice presidents and their families; it later began to offer protection to U.S. presidential candidates as well as to foreign dignitaries.

Significance: One of the oldest federal law-enforcement agencies in the United States, the Secret Service has shut down many illegal money operations and has investigated numerous other forms of fraud in addition to carrying out its widely known function of protecting past and current presidents, vice presidents, and their families.

The U.S. Secret Service was founded on July 5, 1865, as a law-enforcement bureau of the U.S. Department of the Treasury with the mission of combating counterfeiting and the distribution of fake treasury notes and currencies. During the nineteenth century, the federal government's systems for creating, distributing, and tracking currency were in disarray, inviting fraud and other illegal activities. Throughout the early nineteenth century, each U.S. state had at least one version of its own exclusive coin and paper currencies. In fact, during this time, it was rumored that more than one-third of all paper currency in circulation in the United States was counterfeit.

During its first thirty years, the Secret Service investigated and closed down countless illegal money operations throughout the continental United States. Aside from targeting numerous counterfeiting scandals, the agency began to investigate various cases that fell outside the duties outlined in its initial charter. Throughout the history of the Secret Service, numerous U.S. presidents have ordered the agency to investigate both individuals and groups suspected of involvement with many kinds of fraud and other activities deemed threatening to the government or the general public; the subjects of such investigations have ranged from members of the U.S. government to individual American citizens. Among those most frequently investigated by the Secret Service have been groups known for their antigovernment rhetoric; the Ku Klux Klan is a notable example.

Investigation

The primary investigative mission of the Secret Service continues to be focused on crimes that deal specifically with counterfeiting; these include crimes involving nonfinancial federal documents as well as money and finance-related documents. Since the early 1980's, however, Congress has expanded the investigative responsibilities of the Secret Service, which now include the investigation of credit card fraud, crimes involving forgery, various forms of cybercrime, crimes related to American financial institutions, money laundering (both domestic and international), and major cases of identity theft. The Secret Service is the only federal agency that Congress has explicitly designated as having investigative jurisdiction over major identity theft cases.

In 2000, following the Columbine High School massacre in 1999, the Secret Service added the investigation of major incidents of school violence in the United States to its traditional duties of fighting counterfeiting and other financially related crimes. The assess-

Forensic Services of the Secret Service

The U.S. Secret Service provides the following information about the agency's forensic services.

The U.S. Secret Service is home to an advanced forensic laboratory, which includes the world's largest ink library. Secret Service forensic analysts examine evidence, develop investigative leads and provide expert courtroom testimony. . . .

Forensic examiners analyze questioned documents, fingerprints, false identification documents, credit cards, and other related forensic science areas. Examiners also are responsible for coordinating photographic and graphic production, as well as video, audio, and image enhancement services. Much of the technology and techniques utilized by examiners is exclusive to the U.S. Secret Service. . . .

The forensic services utilized by the Secret Service include a number of specialties:

- **Identification:** The Secret Service has access to a full range of fingerprint-related services using the most up-to-date chemical and physical methods, including the utilization of state-of-the-art equipment for the development of latent prints. Specialists provide technical expertise and training in all fingerprint-related matters to the Secret Service field offices and other law enforcement agencies. They also provide expert testimony in federal, state, and local courts.
- **Forensic Automation:** Forensic automation analysts provide advanced automated/computer support to all U.S. Secret Service protective and investigative elements, as well as for outside requests that have originated within Secret Service field offices. This responsibility is computer intensive and utilizes internal and external networks to identify fingerprints, handwriting, counterfeit identity documents, and financial documents. . . .
- **Polygraph:** The Secret Service has distinguished itself as having one of the premier polygraph programs in existence. Highly trained personnel use their skills and the latest technology available to enhance U.S. Secret Service protective missions, criminal investigations, and hiring needs. The examiners assigned to the program are considered experts in the psychology of deception and provide investigative expertise for all cases under the agency's jurisdiction. . . .
- **Questioned Documents:** The Secret Service has long been recognized as one of the foremost questioned document laboratories in the world. The primary goal of analysts is to support field investigations by providing expert forensic analyses of evidence developed during investigations, writing reports of the scientific findings, and providing subsequent expert testimony in court proceedings. . . .
- **Visual Information:** The Secret Service utilizes a unique blend of technologies providing expertise in forensic photography, graphic arts, multimedia operations, audio/image enhancement, voice identification, and 3-D modeling and simulation.

ment of threats of school violence also became a high priority for the Secret Service.

Protection

In 1901, after William McKinley became the victim of the third presidential assassination in U.S. history, Congress made an informal request for Secret Service agents to provide protection for U.S. presidents, and in 1902 the agency took on the full-time responsibility of protecting the president. It was not until 1906, however, that Congress passed a federal law that made protection of the president of the United States a major duty of the Secret Service and provided funds for that purpose. In 1917, another law added Secret Service protection for the president's immediate family and made it a federal offense for anyone to make verbal or written threats against a president or any member of the president's family.

The protective role of the Secret Service has grown a great deal since its inauguration. Two divisions of Secret Service personnel are responsible for various protective assignments. One of these is made up of special nonuniformed agents who act as bodyguards for various government officials. These agents all train for years before they are handpicked to receive this duty assignment. The second group consists of uniformed officers who carry out their duties much as do regular police officers. Established in 1922, this uniformed force is a noticeable presence as its members provide security at federal facilities, foreign embassies, the vice president's home, and the White House.

Among those persons for whom the Secret Service provides protection details are the current president and vice president and their immediate families, former presidents (and their spouses) who have been out of office for no more than ten years, all presidential and vice presidential candidates and their families up to 120 days before the general election, U.S. dignitaries acting on behalf of the United States in foreign countries, and foreign ambassadors who are visiting the United States. In addition, the Secret Service provides protection to any other individuals the president considers to be in need of such protection.

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Further Reading

Johnson, David R. *Illegal Tender: Counterfeiting and the Secret Service in Nineteenth Century America*. Washington, D.C.: Smithsonian Institution Press, 1995. Provides a history of the Secret Service with a focus on the agency's war on counterfeiting.

Melanson, Philip H. *The Secret Service: The Hidden History of an Enigmatic Agency*. Rev. ed. New York: Carroll & Graf, 2005. Revealing and candid history presents an interesting perspective on the Secret Service.

Neal, Harry Edward. *The Secret Service in Action*. New York: Elsevier/Nelson Books, 1980. Provides a detailed look at the role of the Secret Service and how that role changed over the course of the agency's first one hundred years.

Petro, Joseph, with Jeffrey Robinson. *Standing Next to History: An Agent's Life Inside the Secret Service*. New York: Thomas Dunne Books, 2005. Memoir by a former agent allows an interesting glimpse into the workings of the agency.

U.S. Secret Service. *Moments in History, 1865-1990*. Washington, D.C.: Department of the Treasury, 1990. Offers a unique look at the important role of the secret service agent over the years.

See also: Computer crimes; Counterfeit-detection pens; Counterfeiting; Document examination; Forgery; Identity theft; National Crime Information Center.

Semen and sperm

Definitions: Semen is a viscous fluid that results from a combination of secretions from the seminiferous tubules and glands such as the prostate, seminal vesicles, and Cowper's glands. Spermatozoa (sperm) are reproductive cells carrying male genetic material; they are uniquely found in the fluid of semen.

Significance: Semen is one of the most commonly analyzed types of biological evidence collected during criminal investigations, particularly cases involving sexual assault. DNA analysis of semen samples can link suspects to crimes or eliminate innocent persons from suspicion.

In 1677, Dutch scientist Antoni van Leeuwenhoek became the first person to report the observation of spermatozoa under a microscope. Sperm, the reproductive cells that carry male genetic material, are morphologically distinctive in that they are characteristically elongated cells divided into regions called head, midpiece, and tail. The sizes of spermatozoa and shapes of the heads vary among species; in human spermatozoa, the heads are oval in shape.

Composition of Semen

General ranges are known for how many spermatozoa are found in a given volume of semen and the amount of semen typically produced. This information can be applicable in the strategies used for testing biological evidence and for reconstructing events at a crime scene. It can also influence the approach taken to extract and analyze DNA (deoxyribonucleic acid) from a semen stain.

Other cells in semen are epithelial cells from the linings of the male reproductive tract. Although these make up less than 1 percent of the volume of semen, they can be sufficient to make DNA typing possible for semen lacking spermatozoa due to congenital conditions or vasectomy. The spermatozoa are usually the main source of DNA in semen that is tested forensically to provide evidence for the source of the semen. It is of forensic importance that spermatozoa DNA can be extracted under conditions different from those used for other types of cells, because this means that a semen component of DNA can be separated from female DNA, thus making it easier to identify the origin of the semen.

The liquid portion of semen is called seminal plasma; it contains certain organic substances in relatively high concentrations, including ascorbic acid, citric acid, fructose, prostaglandins, phosphoryl choline, spermine, and spermidine. Zinc is an element present in particularly high concentrations in semen relative to other body fluids. Certain proteins are found in higher concentrations in semen than in other sources; the most useful of these in terms of forensic testing are prostatic acid phosphatase, prostate-specific antigen (PSA), and semenogelin.

Detection of Semen and Sperm

As a biological stain, semen survives as evidence detectable by biochemical and DNA typing techniques for several years. The survival of DNA in semen stains has allowed for the analysis of evidence in items more than ten years old. Under a forensic lamp that emits blue light, semen stains and some other body fluids fluoresce, which is helpful in their detection at crime scenes or on evidence such as clothing. Additional tests may then be performed to determine whether given stains are semen.

A commonly used presumptive, or screening, test for semen looks for activity of the enzyme acid phosphatase in stains. Acid phosphatase is found at levels four hundred times higher in semen than in other body fluids. In the presence of acid phosphatase, an acid solution of fast blue and alpha-naphthyl phosphate will turn blue-purple. An investigator may sample a stain by rubbing it with a swab or moist piece of filter paper and then adding a drop of the acid solution to the swab or paper; a positive result produces a blue or purplish color within thirty seconds. Where no stains are visually apparent, an area containing a suspected semen stain can be divided into sectors for systematic searching using the acid phosphatase detection technique. This method is not a conclusive indication of the presence of semen, however; other approaches must be used to identify semen definitively for a court of law.

One confirmatory test for semen relies on the special staining and microscopic observation of spermatozoa. The sample can be taken from a crime victim or from a stain on material such as cloth that has been extracted in water after gentle stirring. A drop of the extract is placed on a microscope slide, processed to cause adherence of any cells to the slide, and stained with picroindigocarmine and fast red. This procedure characteristically stains spermatozoa heads red and midpieces a green to yellow color, leading to the name "Christmas tree stain."

A forensic scientist in the DNA section of the Seattle crime laboratory of the Washington State Patrol tests a shirt for semen. As a biological stain, semen survives as evidence detectable by biochemical and DNA typing techniques for several years. *(AP/Wide World Photos)*

Spermatozoa can remain alive and moving for four to six hours in the living female body. Intact nonmotile spermatozoa may still be found in the female body up to six days after deposition.

After certain periods of time, nonmicroscopic techniques are not useful in the identification of stains as semen. Another limitation of microscopic techniques is that they do not detect semen that does not contain sperm, such as the semen produced by vasectomized males. In cases where semen stains are aged or suspected to be from vasectomized males, immunological techniques may be used that detect substances that are highly abundant or relatively unique to semen and present in semen from both vasectomized and nonvasectomized males. The most widely used confirmatory immunological test for semen uses antibodies that are specific for PSA. The test format is a type of cassette called a lateral flow immunochromatographic assay. PSA is found in highest abundance in semen, so that at levels detectable in semen, other body fluids are apparently negative for PSA content.

Another immunological test that works by the same principles detects the presence of a protein called semenogelin, which has not been found in any other biological fluids and tissues tested. Semenogelin also appears to be unique to humans and perhaps other higher primates and therefore is potentially the most specific immunological test for semen available.

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Further Reading

Baechtel, F. S. "The Identification and Individualization of Semen Stains." In *Forensic Science Handbook*, edited by Richard Saferstein. Vol. 2. Englewood Cliffs, N.J.: Prentice Hall, 1988. Discusses semen identification and the use of classical serological techniques for analyzing whether a semen stain originated from a given person.

Gaensslen, R. E. *Sourcebook in Forensic Serology, Immunology, and Biochemistry*. Washington, D.C.: National Institute of Justice, 1983. Presents a comprehensive review of the fundamentals and practice of forensic serology relevant to semen evidence.

Jones, Edward L. "The Identification of Semen and Other Body Fluids." In *Forensic Science Handbook*, edited by Richard Saferstein. 2d ed. Vol. 2. Upper Saddle River, N.J.: Prentice Hall, 2005. Discusses the forensic science techniques used in relation to semen evidence.

Nash, Jay Robert. *Forensic Serology*. New York: Chelsea House, 2006. Provides background information on the use of serology in the forensic sciences and discusses various techniques used in the handling of semen evidence.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007. Introductory textbook includes a chapter that provides a general introduction to serology and discusses semen analysis.

See also: Biohazard bags; Crime scene screening tests; DNA extraction from hair, bodily fluids, and tissues; DNA isolation methods; DNA recognition instruments; Evidence processing; Immune system; Lasers; Locard's exchange principle; Paternity testing; Postconviction DNA analysis; Rape; Rape kit; Serology; Y chromosome analysis.

Separation tests

Definition: Techniques used to separate the chemical components in sample mixtures so that they can be identified.

Significance: Forensic scientists often need to separate evidence sample mixtures into their individual chemical components to determine precisely what the substances are and to distinguish among samples that may initially look very similar.

Forensic laboratories use a number of different techniques to separate samples into their individual chemical components. These include filtering methods, extraction methods, and thin-layer chromatography. Filtering is a simple and rapid method of separating the components that make up sample mixtures. A solid sample is placed in a filter funnel lined with filter paper that is positioned over a beaker. A solvent is poured over the sample and collected in the beaker after it passes over the sample. Sample components that are soluble in the solvent pass through the filter paper in the solvent and are collected with the solvent in the beaker. Components that are insoluble remain in the filter paper. Although this method is simple to perform, the success of filtering depends on the solubility of sample components in the solvent.

Another procedure used to separate sample components is extraction. One of the most routinely used of the many different extraction methods is liquid-liquid extraction. In this case, the sample is in solution form and an extraction solvent is added. The extraction solvent is chosen based on the chemistry of the target component; the component should be soluble in the extraction solvent and should prefer to exist in that solvent. In addition, the extraction solvent should not mix with the original solvent; that is, the solvents should form two separate layers. With the correct choice of extraction solvent, the target component moves from the sample solution into the extraction solvent, which is then removed. The component has thus been extracted into this solvent and can be analyzed further.

Thin-layer chromatography (TLC) provides another means to separate complex samples that contain numerous components of interest. As with all chromatography techniques, separation is achieved based on differences in the interaction of sample components with a mobile and a stationary phase. In TLC, the stationary phase is typically a solid adsorbent coated onto a thin plate of silica, and the mobile phase is a liquid. The sample is applied to the TLC plate, which is then introduced into a small volume of the mobile phase. The mobile phase travels up the plate by capillary action, dissolving the sample and hence carrying the sample up the plate.

Separation of components occurs because of differences in attraction for the stationary and mobile phases. Components that have stronger attraction for the stationary phase spend more time in that phase and therefore do not travel as quickly as components with less attraction for the same phase. In TLC, this is seen as component spots on the plate—spots close to the bottom of the plate indicate components that did not travel far and hence had greater attraction for the stationary phase. The plate is removed from the mobile phase and dried, and then the distance that the components have traveled is determined. The numbers of components present in a known standard and in the questioned sample are compared, as are the distances corresponding components in both samples traveled.

TLC can be used in the analysis of a variety of different types of evidence. For example, two inks or two fibers may both appear blue to the naked eye when in fact they are composed of different dyes. Using TLC, dyes in the inks or fibers may be separated into the individual dye components and compared. Illicit drug samples may contain cutting agents that may or may not be illegal. TLC can be used to separate the illegal drug from these other substances before further analysis is performed to confirm the identity of the drug.

Ruth Waddell Smith

Further Reading

Bell, Suzanne. *Forensic Chemistry*. Upper Saddle River, N.J.: Pearson Prentice Hall, 2006.

Bogusz, M. J., ed. *Handbook of Analytical Separations*. Vol. 6 in *Forensic Science*, edited by Roger M. Smith. 2d ed. New York: Elsevier, 2007.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007.

Sherma, Joseph, and Bernard Fried, eds. *Handbook of Thin-Layer Chromatography*. New York: Marcel Dekker, 2003.

See also: Analytical instrumentation; Chromatography; Document examination; Fibers and filaments; Microcrystalline tests; Presumptive tests for blood; Serology; Thin-layer chromatography.

September 11, 2001, victim identification

Date: Terrorist attacks occurred on September 11, 2001

The Event: Following the devastation caused by terrorist attacks on the World Trade Center in New York City and the Pentagon in Arlington, Virginia, experts used several forensic techniques to identify the dead.

Significance: This investigation was unique in that it involved a very high number of deaths at three very different scenes separated by great distances. The contributions of forensic science to the recovery and identification of the victims were important both because they aided in the investigation of these crimes and because they made it possible for the family members of victims to lay their loved ones' remains to rest.

In the aftermath of the four plane crashes that took place on the morning of September 11, 2001, authorities had to create a plan quickly to manage victim identification. Because the deaths were caused by acts of terrorism, jurisdiction over the bodies went to the Office of the Armed Forces Medical Examiner (OAFME), a division of the Armed Forces Institute of Pathology. The OAFME, however, did not have sufficient human resources to deal with so many separate incidents of such great magnitude all at once. A decision was thus made to honor the request made by authorities in New York City and allow the New York medical examiner's office to handle the victims who died at the World Trade Center. The OAFME would handle the remains at the Pentagon as well as those at the site of the crash in a field near Shanksville, Pennsylvania.

Search and Recovery

At any death scene, no matter what the details or the scope, the most important, and therefore first, step taken by first responders is always to check for and treat survivors. Any loss of evidence that occurs because medical personnel enter a scene to treat victims is considered acceptable. Immediately after the attacks, massive searches began for any possible survivors at the Pentagon and at the World Trade Center site (later referred to as Ground Zero); it was clear that United Airlines Flight 93, which crashed in Pennsylvania, had no survivors.

A rescue operation is very different from a scene search, as time is of the essence. At both the Pentagon and Ground Zero, search efforts had to be stopped often because of fires in the buildings and fears of continued structural collapses. All rescue workers had to leave these scenes every time the areas were deemed too dangerous; after the risks had subsided, they resumed their previous positions. The initial searches in both areas were thus extremely slow and time-consuming.

The OAFME conducts autopsies at a mortuary located on Dover Air Force Base in Delaware, approximately one hundred miles east of the Pentagon, but the first bodies from the crash sites did not arrive at the OAFME facility until two days after the attacks, on September 13, 2001. The remains varied in condition from full-bodied corpses to fragments of muscle and bone. Some remains were burned; some were crushed. Many were commingled; that is, parts from two or more bodies were mixed together. The victim remains recovered from Ground Zero were much more fragmented than those recovered at the Pentagon, as they had been subjected to the tremendous forces of the collapse of the World Trade Center buildings.

The Events of September 11, 2001

Within approximately ninety minutes on the morning of September 11, 2001, four hijacked U.S. airline jets were crashed, resulting in approximately 3,000 deaths. At 8:46 A.M., American Airlines Flight 11 was flown into the north side of the north tower of the World Trade Center, striking between the ninety-fourth and ninety-eighth floors of the 110-story building. At 9:02 A.M., United Airlines Flight 175 crashed into the south side of the south tower of the World Trade Center, hitting between the seventy-eighth and eighty-fourth floors. Three buildings in the World Trade Center complex eventually collapsed as the result of the structural failure caused by these collisions. At 9:59 A.M. the south tower, designated as 2 World Trade Center, fell, followed by the north tower, named 1 World Trade Center, at 10:28 A.M. These collapses eventually caused the third building, 7 World Trade Center, to fall at approximately 5:20 P.M. Including the passengers on the two planes, approximately 2,750 victims died at the World Trade Center on that day.

Shortly after the first two planes struck the twin towers of the World Trade Center, at 9:37 A.M. American Airlines Flight 77 was flown into the western side of the Pentagon in Arlington, Virginia. If many sections of that side of the building had not been empty because of a scheduled renovation, the loss of life could have been much worse; as it was, 184 people in the building and on the plane that struck it died at the Pentagon.

A passenger uprising aboard United Airlines Flight 93 prevented the hijackers of that flight from reaching their designated target. Instead, at 10:03 A.M. the plane crashed in a field outside of Shanksville, Pennsylvania. All 40 passengers and crew members were killed.

Methods of Identification

Even when bodies in need of identification are relatively fresh and complete, visual identification is not considered accurate enough for official purposes. Following the September 11 attacks, most of the remains recovered were in pieces, and visual identification was of no use at all. The purpose of the autopsies performed on the remains was victim identification.

Three main forensic methods produce results that are accepted as positively identifying deceased persons: fingerprint analysis, forensic odontology (analysis of teeth and dentistry), and DNA (deoxyribonucleic acid) analysis. Each on its own is sufficient for identification, and each involves a process of comparing elements of remains with antemortem (prior to death) documents or records of persons who could possibly be the deceased. For every piece of remains that was brought into the Dover mortuary, all three methods were conducted whenever possible.

Managing the Remains

All remains that arrived at Dover Air Force Base followed the same flow and were seen by workers at the same stations. When each body bag arrived, its paperwork was reviewed; the paperwork noted where the remains were from, how they were found, and any identifying numbers given to them. The remains were then renumbered using an OAFME system, so they could be tracked through the stations. A checklist that accompanied the remains throughout the process was annotated with the OAFME number to ensure that no station was missed and to document the reason any given station may not have been able to work on the remains (such as the fingerprint station explaining that the remains included no hands).

The first station was a security scanning machine much like the kind used at airports. The body bag was placed on the conveyor belt, and the X-ray machine allowed for an initial look inside the bag. This preliminary step allowed the workers to check for any hazards in a bag, such as sharp metal objects, before they opened it. After the remains were taken off the belt, pictures were taken of the closed bag to document how it arrived. The bag was then opened and pictures were taken of the body or parts inside.

Steps in the Identification Process

The next station was the first of the identification process, the anthropology station. Forensic anthropologists examine skeletal remains to determine the sex, age, and race of the deceased. In this particular case, the anthropology station's function was to characterize and document the remains in each bag. If, for example, a bag was found to contain two right arms, this was noted so that the workers at the rest of the stations would know that the bag contained commingled remains. If a bag contained only a hip and upper leg bone, then it could skip the fingerprint and forensic odontology stations.

A forensic scientist opens a freezer containing the remains of victims of the September 11 terrorist attacks at a facility in Springfield, Virginia, in August, 2002. Above his head and on the rear wall are the names of the World Trade Center victims that he and other scientists were working to identify through DNA samples. *(AP/Wide World Photos)*

The fingerprinting station was next. Fingerprints were taken of every recoverable finger, and analysts from the Federal Bureau of Investigation (FBI) later compared the prints with the antemortem fingerprint records available for those on the list of possible victims. Many of those who died at the Pentagon on September 11 were in the military, and thus their fingerprints were on file and accessible. The FBI also conducted searches for fingerprint records that may have existed for all of the nonmilitary victims.

The remains next moved to the forensic odontology station. Forensic odontologists compare oral X rays and castings of the teeth of decedents with antemortem dental records. Tooth enamel is one of the hardest substances produced by the human body; it can survive when the rest of the body is crushed, decomposed, or severely burned. Elements such as the positions of teeth in the jaw, the shapes of fillings, and the lengths of the roots of teeth can all contribute to the identification process.

The next step was to X-ray the remains. Although the primary purpose of the X rays taken was to assist the pathologists with their work in performing the autopsies that followed, comparisons of X rays were also sometimes used in the identification process. For victims with X rays in their medical records, radiologists could compare antemortem and postmortem X-ray images. Unique injuries, healing mechanisms, or medical procedures revealed in X rays could help to identify individuals.

The third method of positively identifying remains, DNA analysis, was begun when the remains were brought into autopsy. Nuclear DNA is found in cells that contain nuclei, such as the cells in blood, skin, and saliva. Nuclear DNA is

Victims of the 9/11 Terrorist Attacks

Place	*Male*	*Female*	*Unknown*	*Total*
World Trade Center	2,128	621	—	2,749
Pentagon	108	71	5	184
Somerset County, Pennsylvania	20	20	—	40
Totals	2,256	712	5	2,973

Source: Federal Bureau of Investigation, *Crime in the United States*, 2002.

the most common type used for DNA testing, but it is somewhat fragile and can easily be damaged, especially by decomposition. Another type of DNA, mitochondrial DNA, can be used in a different test comparison that can also identify remains. Unlike nuclear DNA, the offspring receives mitochondrial DNA only from the mother, and since there is no mixing with the father's mitochondrial DNA, usually little change is seen from generation to generation. Mitochondrial DNA is much sturdier than nuclear DNA and can withstand decomposition changes. It can be recovered from both bone and teeth even after hundreds of years. Because mitochondrial DNA is maternal in its delivery, mitochondrial DNA from a decedent must be compared with mitochondrial DNA from a family member on the decedent's mother's side to make a match.

Success Rate

Following the unprecedented national tragedy of the September 11 attacks, identifying the victims was an extremely high priority. The OAFME was able to identify positively all 184 victims from the Pentagon scene as well as each of the 40 victims from the Pennsylvania field. The New York medical examiner's office had similar success with the remains recovered from the World Trade Center site.

The volume of the remains examined, the number of agencies involved, and the number of volunteer workers who helped with the identification process went beyond anything either of the medical examiners' offices had ever before experienced. By using established forensic methods for positively identifying remains, they were able to give the victims' families a sense of resolution by returning the remains of their loved ones to them for burial.

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Further Reading

DiMaio, Vincent J., and Dominick DiMaio. *Forensic Pathology*. 2d ed. Boca Raton, Fla.: CRC Press, 2001. One of the best reference sources available in the field of forensic pathology. Covers autopsies, types of death, and body decomposition, and also provides good explanations of the methods used to identify remains.

Grant, Nancy, David Hoover, Anne-Marie Scarisbrick-Hause, and Stacy Muffet. "The Crash of United Flight 93 in Shanksville, Pennsylvania." In *Beyond September 11th: An Account of Post-disaster Research*. Boulder: Natural Hazards Center, University of Colorado, 2003. Focuses specifically on the crash in Pennsylvania. Discusses jurisdictional issues and the problems that arose regarding the search for and recovery of the remains to be identified.

Keiser-Nielsen, Søren. "Dental Identification: Certainty v. Probability." *Forensic Science* 9, no. 2 (1977): 87-97. Somewhat dated article nevertheless provides a very good overview of the field of forensic odontology and the procedures used.

Lowe, Seana, and Alice Fothergill. "A Need to Help: Emergent Volunteer Behavior After September 11th." In *Beyond September 11th: An Account of Post-disaster Research*. Boulder: Natural Hazards Center, University of Colorado, 2003. Conveys well the chaos created by this tragedy, as the sheer numbers of people who wanted to help made some processes (including the identification of victims) difficult.

Ritter, Nancy. "Identifying Remains: Lessons Learned from 9/11." *NIJ Journal* 256 (January, 2007) 20-25. Reviews the techniques used to identify human remains in the aftermath of the September 11 attacks. Expresses clearly the difficulties associated with handling large numbers of both victims and volunteers.

Rubinoff, Daniel, Stephen Cameron, and Kipling Will. "A Genomic Perspective on the Shortcomings of Mitochondrial DNA for 'Barcoding' Identification." *Journal of Heredity* 97, no. 6 (2006): 581-594. Argues against some of the identification powers of mitochondrial DNA when attempting to trace heritage back through generations. While technical, it does give a good explanation of the mitochondrial DNA process.

Simpson, David M., and Steven D. Stehr. "Victim Management and Identification After the World Trade Center Collapse." In *Beyond September 11th: An Account of Post-disaster Research*. Boulder: Natural Hazards Center, University of Colorado, 2003. Good overview addresses the processes used to identify the victims at the World Trade Center. Compares the work with other identification cases.

See also: Airport security; Anthrax letter attacks; Asian tsunami victim identification; DNA analysis; Fingerprints; Forensic anthropology; Forensic odontology; Mitochondrial DNA analysis and typing; Oral autopsy; World Trade Center bombing.

Serology

Definition: Study of the properties and components of biological fluids such as blood, saliva, cerebrospinal fluid, and semen.

Significance: Much of the physical evidence analyzed by forensic scientists in criminal investigations is biological in nature, and serological methods are used on this biological evidence. Forensic serologists use antibodies or separation techniques to identify and measure biological molecules and materials for legal purposes.

In forensic science, serology is typically used to identify biological evidence related to crimes such as sexual or physical assault, homicide, kidnapping, and robbery. Contact between victims and offenders as well as between people and objects during crimes can lead to the transfer of biological materials, as noted by Locard's exchange principle. Serological evidence may prove or disprove statements by suspects, victims, or witnesses and may associate evidence with suspects or victims. The types of biological evidence most often subjected to serological analysis include the biological fluids blood, saliva, and semen.

Composition and Markers of Biological Fluids

Different types of biological evidence analyzed by serology have distinctive cellular and molecular compositions. Blood contains cells as well as both biological and inorganic molecules and ions. Blood cells are divided into two major groups: red blood cells (erythrocytes), which are major sources of blood group antigens but contain no DNA (deoxyribonucleic acid), and white blood cells, which contain DNA and B-lymphocyte subpopulations that produce antibodies that are widely used tools in serology.

Hemoglobin is a substance specific to red blood cells and absent from other body cells. Reactivity with hemoglobin forms the basis of most forensic tests for blood. Blood contains a great variety of proteins, some of which display inherited variations in structure and therefore were historically used in forensic serology to exclude or associate bloodstains with individuals before the rise of DNA typing. Certain of these proteins are also found in other biological fluids.

Spermatozoa are a unique cellular component used to identify semen in biological evidence. Spermatozoa exhibit unique morphology in that each has a compact region or "head" containing most of the organelles, a short cylindrical region or midpiece, and an elongated whiplike appendage or "tail." Proteins specific for semen include prostate-specific antigen (PSA) and semenogelin. Certain other biological molecules, however, including various proteins, oligosaccharides, prostaglandins, and basic compounds, are relatively specific or abundant in this biological fluid.

Saliva is a viscous fluid that contains buccal cells from the lining of the mouth, which are the main source of DNA in saliva. Substances in saliva include many proteins, such as alpha amylase, mucins, and proline-rich proteins, as well as other biological molecules and inorganic compounds. The enzyme alpha amylase is uniquely abundant in saliva.

Tests for Biological Fluids

Most tests for the detection and identification of blood are based on reactions with hemoglobin from erythrocytes. Several screening tests are color tests that rely on the ability of hemoglobin to transfer oxygen from hydrogen peroxide to another substance that either changes color (for example, pink for phenolphthalein, green for tetramethylbenzidine) or causes the production of light (chemiluminescence), as in the case of luminol. To identify stain material as blood conclusively after one of these presumptive tests, a forensic scientist may perform a microcrystalline test. In such a test, a trace scraping of the stain is gently heated with particular chemicals; if blood is present, microscopic examination will reveal the formation of crystals of characteristic shapes and sizes.

Immunology-based methods are used to identify the species of origin of bloodstains. Some methods, such as lateral-flow immunoassay, use monoclonal antibodies against human hemoglobin to identify human blood. Another method uses immunoprecipitation of human blood proteins by antibodies against human blood (serum) proteins on extracts of the stain evidence in an agarose medium.

A presumptive test for semen relies on detection of the enzyme acid phosphatase, which is more abundant in semen than in other biological fluids. One confirmatory test for semen involves microscopic examination of material after treatment with the “Christmas tree” (picroindigocarmine) stain, which marks intact spermatozoa with characteristic green, yellow, and red colors in specific regions. Other specific semen tests are immunochromatographic ones that use monoclonal antibodies to PSA or to semenogelin, an apparently human/primate- and sperm-specific protein.

Until 2006, only presumptive tests were available for detection of saliva, and these relied on the detection of alpha amylase enzyme activity on colored starch or other colorimetric substrates. An immunochromatographic test became available in 2006 that appears to be confirmatory and uses a monoclonal antibody specific for the salivary form of alpha amylase.

Blood Group Typing

Human blood groups were the first genetically based systems used by forensic scientists to gain information on who might or might not be the sources of biological evidence. Identification of blood groups from evidence samples involves the use of defined antibodies to agglutinate (clump together) erythrocytes based on the type of inherited blood group carbohydrates on the erythrocyte. ABO and Rh blood group antigens are the major systems used. Several other types of blood groups (such as Lewis and MN antigens), involving other genetically inherited structures, have been used in forensic serology. Blood group typing of dried bloodstains and other body fluids is achieved through various methods of extracting stains and testing the extracts for their ability to inhibit agglutination.

Inherited differences (polymorphisms) exist in proteins found in blood and other biological fluids. By using serological techniques to identify which variants of proteins are present in biological evidence, scientists can help to associate victims or suspects with particular items of evidence or exclude victims or suspects from consideration. Electrophoretic analyses identify protein variants based on the differing degrees to which they move in an electric field while in a medium such as agarose or polyacrylamide. Some polymorphic blood proteins include transferrin, Gc (group-specific component), phosphoglucomutase, and haptoglobin. Better testing is achieved when the serologist analyzes several polymorphic proteins in a sample to arrive at a statistical calculation of a probability that the stain did or did not originate from a particular individual.

Oluseyi A. Vanderpuye

Further Reading

Baechtel, F. S. "The Identification and Individualization of Semen Stains." In *Forensic Science Handbook*, edited by Richard Saferstein. Vol. 2. Englewood Cliffs, N.J.: Prentice Hall, 1988. Discusses semen identification and the use of classical serological techniques for analyzing whether a semen stain originated from a given person.

Gaensslen, R. E. *Sourcebook in Forensic Serology, Immunology, and Biochemistry*. Washington, D.C.: National Institute of Justice, 1983. Presents a comprehensive review of the fundamentals and practice of forensic serology.

Houck, Max M., and Jay A. Siegel. *Fundamentals of Forensic Science*. Burlington, Mass.: Elsevier Academic Press, 2006. Good general textbook includes a chapter that succinctly describes the field of forensic serology and its relevance.

Nash, Jay Robert. *Forensic Serology*. New York: Chelsea House, 2006. Provides background information on the use of serology in the forensic sciences and discusses various techniques of forensic serology.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007. Introductory textbook includes a chapter that covers immunology basics and the history and methods of forensic serology.

Whitehead, P. H. "A Historical Review of the Characterization of Blood and Secretion Stains in the Forensic Laboratory, Part One: Bloodstains." *Forensic Science Review* 5 (June, 1993): 35-40. Discusses the development and application of serological techniques over time.

See also: Blood residue and bloodstains; Blood spatter analysis; DNA typing; Electrophoresis; Epidemiology; Immune system; Kidd blood grouping system; Multisystem method; Paternity evidence; Paternity testing; Physical evidence; Saliva; Semen and sperm.

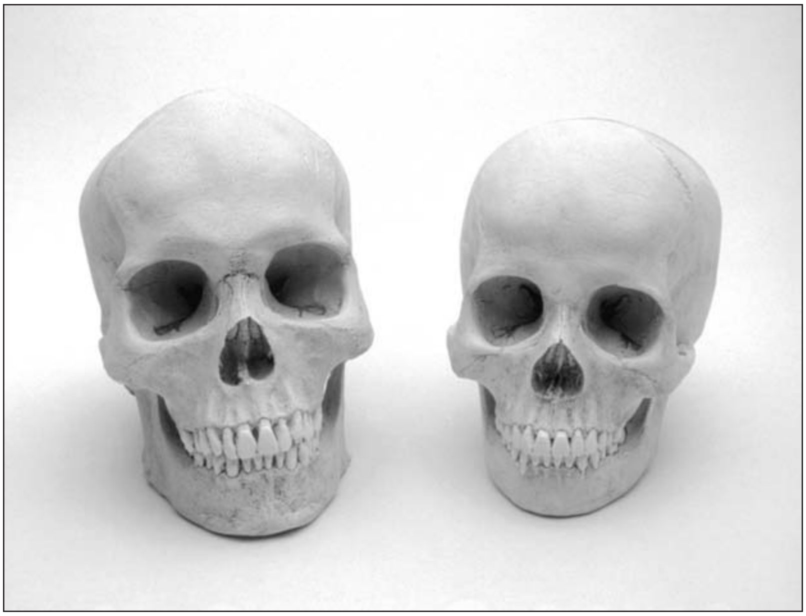
Sex determination of remains

Definition: Process of discerning the sex of a decomposed human body based on knowledge of the physiological and behavioral differences between the sexes.

Significance: The sexual dimorphism of human beings allows forensic scientists to accomplish one of the most important initial steps in ascertaining the identity of unknown human remains—the determination of sex.

Male and female human beings exhibit significant anatomical and behavioral differences. For example, male humans are on average larger and stronger than female humans, and female humans gestate, bear, and nurse the young. For forensic investigators, challenges in determining the sex of human remains occur primarily when bodies are badly decomposed. Remaining tissues may contain DNA (deoxyribonucleic acid) that is not too degraded to allow for analysis; in such cases, routine forensic DNA analysis to determine the identity of the remains based on short tandem repeat (STR) markers includes a marker for sex determination such as the one within the gene for dental enamel (amelogenin).

When sufficient skeletal remains are available, forensic scientists may determine sex by using methods that exploit the structural differences associated with muscularity and size in men and with childbearing in women. Teeth are not sufficiently different between the sexes for forensic purposes. Sex differences in skeletal remains are relatively trivial at birth, and using such remains to determine the sex of juveniles is difficult at best. Some early differences between boys and girls do occur in the pelvis, but reliable sex differentiation is not possible until after the anatomical changes associated with puberty. The methods that forensic scientists use to assess sex differences in skeletal remains fall into two categories: anthroposcopic or qualitative characteristics (eyeball) and metric traits (quantification). Metric measures have more influence in court because they allow more accurate specification of degrees of reliability.



Male (left) and female human skulls. After the pelvis, skulls are the second-most-useful parts of human skeletal systems for determining sex. However, ethnic ancestry complicates such determinations because male and female skull characteristics vary among the world's major ethnic divisions. *(Digital Stock)*

Sexually Dimorphic Regions of the Skeleton

Accuracy at determining sex is from 90 to 100 percent with the entire skeleton but declines to 90-95 percent, 80-90 percent, and about 80 percent, respectively, with only the pelvis, only the skull, and only the long bones. The impact of giving birth on the shape of the pelvis makes it the most reliable bone for differentiating the sexes. Most of the sex-specific features reflect how a woman's pelvis is designed to permit the fetus to exit the woman's body within the constraints of bipedal walking. The inferior bony pelvis must be angled out of the way, and these pressures result in different morphologies (structures) and angles that for some features, in combination or alone, can be as accurate as 96 percent. The pelvis is also the best bone for use in any attempt to determine the sex of the remains of a juvenile.

The skull is the second most useful structure for determining sex, but some traits vary depending on the ancestral origins of the individual. Some features typical of European-derived female skulls, such as relatively high forehead and smaller size, are shared with some Asian male skulls. Some overlap also exists between male and female skull traits within populations, although typically male skulls are not only larger but also more rugged in appearance. These average differences are partly a function of age. Young male skulls look more feminine because of less developed muscle attachments, and older female skulls can look more masculine after menopause. More reliable is the use of computer software that determines sex based on discriminant function analysis of a series of measures between points on a skull.

Postcranial bones can also be used to determine sex, although with less success. Overlap exists in skeletal characteristics of men and women, less so in the shoulders and feet than in the lower limbs, but, again, measures can vary depending on the population. Differences are dependent in part on genetic differences among ancestral populations and in part on environmental influences, particularly nutrition. Malnourished individuals can be smaller and less muscular than those who are better nourished, so poor nutrition can sometimes increase the overlap between male and female skeletal characteristics, because men are often more sensitive to this kind of stress.

Limitations of Metric Methods

Metric methods for determining sex from skeletal remains involve measuring between points on a structure, such as the skull, and then entering the measures into a software program that performs discriminant function analysis and predicts the sex of the unknown individual based on the resulting value. Formulas vary in terms of which measurements are necessary; this provides flexibility in the case of incomplete bones.

The data used in these discriminant function analyses have been generated from skeletal collections for which the sexes of individuals are known; most have been derived from studies on the Hamann-Todd Human Osteological Collection at the Cleveland Museum of Natural History and the Robert J. Terry Anatomical Skeletal Collection at the National Museum of Natural History in Washington, D.C. The specimens in both of these collections were gathered in the Midwest during the first half of the twentieth century; thus the individuals represented experienced diets and disease ecologies significantly different from those of modern Americans. In addition, the collections do not represent the diversity of ancestral origins found in the population of the United States in the twenty-first century.

Because the functions derived from these collections are losing their utility, the University of Tennessee at Knoxville set up the Forensic Anthropology Data Bank in 1986 to centralize the growing amounts of information available on skeletal remains in modern populations. Most forensic anthropologists compare unknown individuals to populations in this database with the help of FORDISC, a forensic anthropology software program.

Joan C. Stevenson

Further Reading

Burns, Karen R. *Forensic Anthropology Training Manual*. Upper Saddle River, N.J.: Prentice Hall, 2006. Comprehensive textbook includes discussion of sex differences for each region of the human skeleton.

Butler, John M. *Forensic DNA Typing: Biology, Technology, and Genetics of STR Markers*. 2d ed. Burlington, Mass.: Elsevier Academic Press, 2005. Very readable textbook introduces this complex subject to novices.

Byers, Steven N. *Introduction to Forensic Anthropology*. 3d ed. Boston: Pearson/Allyn & Bacon, 2008. Comprehensive, accessible textbook includes a chapter on sexing skeletons.

Klepinger, Linda L. *Fundamentals of Forensic Anthropology*. Hoboken, N.J.: John Wiley & Sons, 2006. Excellent textbook includes a chapter on sex identification of skeletal remains.

Scheuer, Louise, and Sue Black. *The Juvenile Skeleton*. Burlington, Mass.: Elsevier Academic Press, 2004. Describes the subtle sex differences that can be observed in juvenile skeletons.

White, Tim D., and Pieter A. Folkens. *The Human Bone Manual*. Burlington, Mass.: Elsevier Academic Press, 2005. Well-illustrated volume is the next best thing to studying an actual skeleton. Includes discussion of sex differences.

See also: Anthropometry; DNA analysis; DNA extraction from hair, bodily fluids, and tissues; Forensic anthropology; Forensic sculpture; Osteology and skeletal radiology; Short tandem repeat analysis; Skeletal analysis; University of Tennessee Anthropological Research Facility; Y chromosome analysis.

Sexual predation characteristics

Definition: Characteristics of criminal offenders who exhibit a pattern of pursuing nonconsenting persons for the purpose of acting out aggressive sexual fantasies that commonly include themes of domination, control, and revenge.

Significance: The behaviors of sexual predators range along a continuum from coercive sexual acts, such as rape, to sadistic torture and homicide. These individuals prey on victims they perceive as weak and vulnerable, such as women and children. Law-enforcement investigations of cases involving sexual predators must take into account the compulsive and deep-seated nature of such offenders' sexual urges and fantasies.

Sexual predators derive intense sexual pleasure from pursuing, overpowering, and forcing their victims to comply with their deviant fantasies. Sexually violent predators make up a subgroup of sexual offenders. These individuals engage in violent and sometimes deadly sexual activities with their victims. Over time, the severity of their deviant fantasies may escalate as these perpetrators require increasing degrees of control or victim suffering to achieve sexual gratification. Over the courses of their criminal careers, some sexual predators perfect their patterns so that they gain access to many victims while eluding capture by the authorities.

Sexually violent predators tend to share a number of characteristics. For example, research has found that many of these offenders have experienced severely troubled childhoods, often including verbal, physical, and sexual abuse. Most are Caucasian males who typically began their offending in early to mid-adolescence, if not before, and have experienced problems with substance abuse.

The crimes of sexual predators are often motivated by the sexual gratification they receive from inflicting pain, mutilating, and displaying the bodies of their victims in sexually suggestive positions. These acts often lead to or involve the death of the victims; however, sexual stimulation, not murder, is the perpetrators' primary goal. Victims may be sexually penetrated, but it is not uncommon for these offenders to use penetration with foreign objects in place of or in addition to penetration with penis or fingers. Sexual penetration does not always occur during such crimes, however; at times, this can make it difficult for investigators to determine that the crimes were sexually motivated.

Types of Sexual Predators

Research into sexual predation has identified two broad types of offenders, distinguished according to the offender's level of social adjustment, the amount of planning that goes into each crime, and the offender's behavior with the victims. Those classified as "organized" sexual predators consciously plan their crimes and choose their victims in order to have significant control. These offenders spend a considerable amount of time trying to conceal their crimes so that they avoid being caught and often travel significant distances to find their victims and commit their crimes. They are socially adept and able to function in intimate sexual relationships.

The sexual predators classified as "disorganized" are typically socially inadequate and engage in their crimes impulsively, typically in response to particular stressors. They are opportunistic, so they are not selective when choosing their victims and rarely expend much effort in concealing their crimes. Their behavior is often erratic or haphazard because of their lack of planning; if they need weapons, they are likely to use whatever weapon is available at the scenes of their crimes.

Research regarding sexual predation has typically focused on male sex offenders because perpetrators of violent crimes, particularly sexual crimes, are typically male adults. Female sex offenders do exist, however; for the most part, their offenses occur with children under the age of six. It has been suggested that the rate of sexual offending by women is higher than crime reports indicate because such crimes by women often go unreported or unnoticed owing to societal views on sexual offenses.

Managing Sexual Predators

"Sexually violent predator" is a legal term assigned to certain sex offenders. In most U.S. states, in order to be labeled a sexually violent predator, a person must be convicted of committing sexually violent acts on at least two victims. Additionally, the individual must be diagnosed with a mental disorder that places that person at risk of committing additional sexually violent acts. In some states, those convicted offenders who are labeled as sexually violent predators may be incarcerated in state mental facilities for some period of time after they have completed their court-mandated sentences in correctional facilities. Forensic psychologists or psychiatrists then assess the mental status of such offenders and testify in court on the results of their assessments and on their opinions concerning the level of treatment the offenders should receive.

Jocelyn M. Brineman and
Richard D. McAnulty

Further Reading

Hudson, Kirsty. *Offending Identities: Sex Offenders' Perspectives on Their Treatment and Management*. Portland, Oreg.: Willan, 2005. Reports on a study in which the author interviewed convicted sex offenders about their experiences in one of three treatment groups and their perceptions of their treatment. Includes discussion of the offenders' perspectives on their crimes.

Purcell, Catherine E., and Bruce A. Arrigo. *The Psychology of Lust Murder: Paraphilia, Sexual Killing, and Serial Homicide*. Boston: Elsevier/Academic Press, 2006. Discusses sexually motivated murder by examining theories ranging from developmental issues to behavioral motivations. Specific accounts involving Jeffrey Dahmer are offered to enable comparisons of the validity of a number of models.

Ressler, Robert K., Ann W. Burgess, and John E. Douglas. *Sexual Homicide: Patterns and Motives*. Lexington, Mass.: Lexington Books, 1988. Gathers information on sexually motivated crimes in relation to the backgrounds of the criminals in support of the motivational model of sexual homicide.

Salter, Anna C. *Predators: Pedophiles, Rapists, and Other Sex Offenders—Who They Are, How They Operate, and How We Can Protect Ourselves and Our Children*. New York: Basic Books, 2003. Based on interviews with both sex offenders and their victims, examines how the offenders operated and how the victims were deceived. Also discusses prevalence and incarceration rates.

Schlank, Anita, ed. *The Sexual Predator: Legal Issues, Clinical Issues, Special Populations*. Kingston, N.J.: Civic Research Institute, 2001. Collection of essays by both prosecutors and defense attorneys focuses on the issues surrounding civil commitment cases involving sexually violent predators.

Schlesinger, Louis B. *Sexual Murder: Catathymic and Compulsive Homicides*. Boca Raton, Fla.: CRC Press, 2004. Discusses the historical background of sexual homicide and the difficulties in the identification and classification of sexual murders and their perpetrators.

See also: Actuarial risk assessment; Competency evaluation and assessment instruments; Cyberstalking; Expert witnesses; Forensic psychiatry; Forensic psychology; Internet tracking and tracing; Megan's Law; Psychopathic personality disorder; Rape; Victimology; Violent sexual predator statutes.

Shaken baby syndrome

Definition: Signs and symptoms in an infant or young child resulting from violent shaking, including subdural hematomas, cerebral edema, and retinal hemorrhages.

Significance: The incidence of shaken baby syndrome in the United States has been estimated to range between six hundred and fourteen hundred cases a year. The actual number may be much higher, however, as many cases may not be brought to the attention of medical professionals. In addition, it is easy to miss the diagnosis of shaken baby syndrome, as generally no external injuries are visible. Forensic scientists must be aware of the signs and symptoms associated with the syndrome so that cases of child injury and death caused by abuse do not go unnoticed.

In the early 1970's, John Caffey used the term "whiplash shaken infant syndrome" to describe the injuries caused in young children by violent shaking that are now commonly known as shaken baby syndrome (SBS). Others have used terms such as "shaken impact syndrome" and "shaken/slammed baby syndrome" to emphasize that impact of the child's head against a hard or soft surface—such as a floor, wall, or mattress—often occurs in addition to the shaking.

Infliction of Injuries

In a typical scenario leading to SBS, an infant or toddler's caretaker, irritated by the child's incessant crying, grabs the small victim by the shoulders or chest and shakes the child forcefully back and forth. The child's relatively large head, which is poorly supported by weak neck muscles, rolls around repeatedly. At the same time, the brain is exposed to acceleration, deceleration, and rotational forces that cause the bridging veins to shear, leading to the formation of subdural hematomas and swelling of the brain.

In milder cases, the baby becomes drowsy and ceases to cry. The abuser, having obtained the desired result, is likely to repeat the shaking on other occasions when again the irritable infant cannot be consoled. More severe manifestations of SBS, which tend to lead to contact with physicians, include vomiting, apnea, seizures, loss of consciousness, and death. Survivors of SBS require long-term follow-up, as they frequently face behavioral, learning, and developmental challenges later in life.

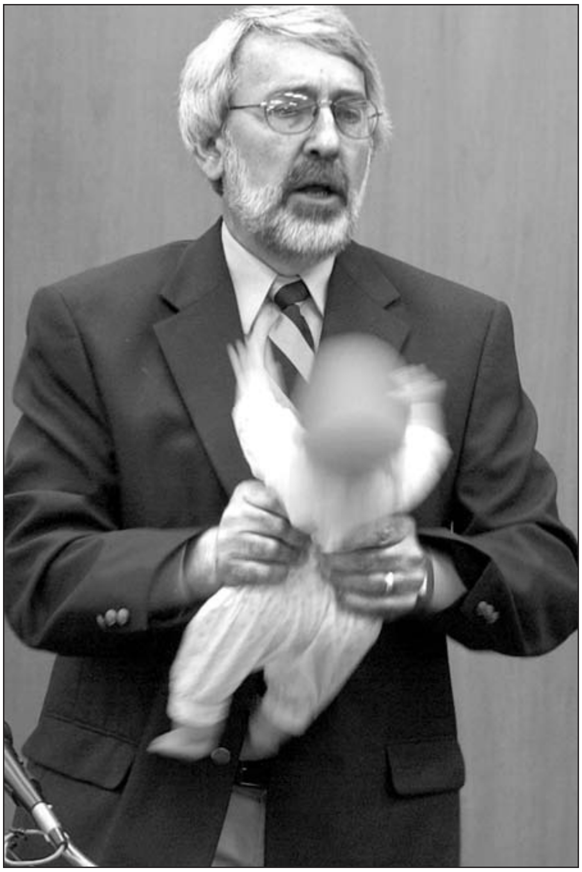
Forensic Evaluation

The collection and preservation of evidence and the notification of appropriate authorities are necessary steps toward the successful prosecution of child abusers. In cases in which SBS is suspected, examining physicians need to search purposefully for clinical signs of maltreatment. When a small child has been shaken violently, retinal hemorrhages are generally present in both eyes. Accuracy in diagnosing retinal hemorrhages demands that an ophthalmologist evaluate the patient. A detailed description of the findings accompanied by drawings and photographs constitutes valuable evidence.

Another hallmark of SBS, subdural hematoma, is revealed only through imaging of the head, either by computed tomography (CT) or by magnetic resonance imaging (MRI). CT or MRI scanning will also help detect the presence of cerebral edema.

When SBS is suspected, examining physicians should obtain X rays to look for old and new fractures, specifically of the skull, ribs, collarbone, and long bones. On rare occasions when bruising, swelling, and lacerations are present, documentation with the help of body diagrams and appropriately dated and labeled forensic photographs can be helpful in court. Additionally, health care workers need to obtain and document detailed testimony from the caretakers of suspected victims of SBS. In cases of SBS, the severity of victims' injuries usually does not correlate with caretakers' descriptions of what happened to the children, and contradictory statements or changing stories are often given.

Health professionals should be aware of the caretaker-related risk factors associated with child maltreatment. Although female babysitters have been shown to be responsible for a high incidence of abuse, severe child abuse often occurs at the hands of male caretakers—the abused children's stepfathers or biological fathers or the boyfriends of the children's mothers. Perpetrators are often alone with the children at the time injuries occur. Other factors that have been found to be associated with child



Pediatrician Daryl Steiner, a noted champion of protecting children against parental abuse, testifying in a child abuse trial in Mansfield, Ohio, in 2005. Steiner used a doll to demonstrate to the jury how a baby can be shaken in a way that produces the brain damage associated with shaken baby syndrome. *(AP/Wide World Photos)* maltreatment include poverty, drug abuse, significant life stressors, spousal abuse, low-birth weight infants, and young, unmarried mothers.

Autopsies should be performed in cases of unexplained infant death. Ideally, the pathologists assigned to such cases should be trained in pediatric forensic science.

The Courts and SBS

All U.S. states mandate that suspected child abuse be reported to the appropriate authorities, but health care workers are often reluctant to report suspected cases. Most child abuse cases are heard in civil court, the main focus of which is child safety. Civil court requires only a "preponderance" of proof to decide that abuse has taken place. Criminal courts become involved when death or severe injury has occurred; for convictions, the criminal system requires proof beyond a reasonable doubt.

The American judicial system struggles with rulings in cases of SBS. Judges and prosecutors often lack extensive knowledge about child abuse, and juries are reluctant to believe the presented evidence. In addition, the laws are poorly tailored to deal with violent infant death. Frequently abusers are not convicted, and those that are often receive mild sentences. One highly publicized case involving SBS was that of the young British au pair Louise Woodward, whom a jury found guilty of second-degree murder in the death of the child who had been in her care, eight-month-old Matthew Eappen. The presiding judge later reduced the conviction to involuntary manslaughter.

Elisabeth Faase

Further Reading

Kellogg, Nancy, and the Committee on Child Abuse and Neglect. "Evaluation of Suspected Child Physical Abuse." *Pediatrics* 119 (2007): 1232-1241. Presents guidelines for medical professionals to use in the evaluation of suspected child abuse.

Monteleone, James A., and Armand E. Brodeur, eds. *Child Maltreatment*. 2d ed. St. Louis: G. W. Medical Publishing, 1998. Medical text presents analysis of the mechanism of brain injury in SBS. Includes images of subdural hematomas.

Morey, Ann-Janine. *What Happened to Christopher: An American Family's Story of Shaken Baby Syndrome*. Carbondale: Southern Illinois University Press, 1998. Narrative account of the case of an actual SBS victim and his family includes medical, social, and legal details pertaining to SBS.

Peinkofer, James. *Silenced Angels: The Medical, Legal, and Social Aspects of Shaken Baby Syndrome*. Westport, Conn.: Auburn House, 2001. Provides comprehensive discussion of SBS from the perspective of a clinical social worker.

Reece, Robert M., and Cindy Christian, eds. *Child Abuse: Medical Diagnosis and Management*. 3d ed. Elk Grove Village, Ill.: American Academy of Pediatrics, 2007. Medical text presents detailed description of retinal hemorrhages and the kinds of bone fractures seen in child abuse.

See also: Brain-wave scanners; Child abduction and kidnapping; Child abuse; Forensic pathology; Forensic photography; Living forensics; Medicine; Petechial hemorrhage.

Sherlock Holmes stories

Identification: A fictional consulting detective based in London, Sherlock Holmes first appeared in Sir Arthur Conan Doyle's *A Study in Scarlet*, published in 1887. By the time he made his last appearance in a work by Doyle in 1927, he was the most widely known fictional detective in the world.

Significance: With Sherlock Holmes, Doyle popularized the figure of the forensic investigator, introducing empirical investigative methods to a worldwide audience. In turn, Holmes offered a model for forensic scientists.

Sir Arthur Conan Doyle (1859-1930) began medical studies at the University of Edinburgh in 1876. Forensic medical investigation had been introduced there during the late eighteenth century, and a new kind of scientist was overturning the tradition-burdened medicine and law-enforcement practices of the past. Among these scientists was Dr. Joseph Bell, an eminent surgeon and occasional forensic investigator who became Doyle's mentor. Bell argued for the full use of the senses in the observation of evidence; he insisted that investigators should draw conclusions from evidence alone and reject unsupported theories. Earlier investigators had too frequently formed theories and then sought evidence to support them.

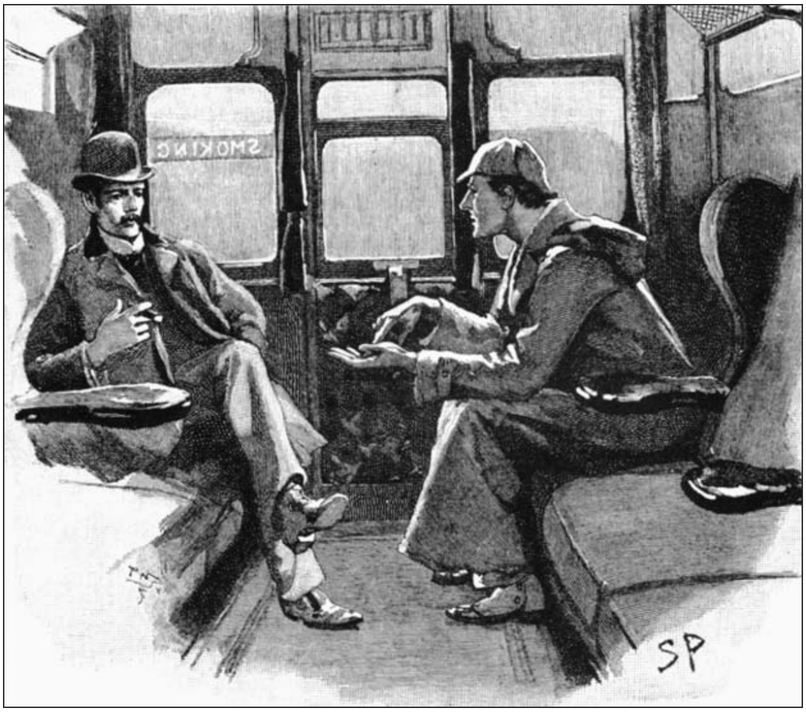


Illustration of Sherlock Holmes (right) and Dr. Watson drawn by Sidney Paget for *The Strand Magazine* in 1892.

Doyle several times acknowledged Holmes's debt to Bell, but whether Bell and Holmes were pioneers is doubtful. In the nineteenth century, forensic science was far more advanced in some parts of Europe than it was in England or the United States. Holmes, for example, often called on Bell's ability to identify a man's occupation from his appearance, but French forensic scientist Auguste Ambroise Tardieu had published on this subject as early as 1849, referring to similar work by earlier investigators. Holmes's interest in toxicology was similarly anticipated; Matthieu-Joseph-Bonaventure Orfila, a Spaniard, published a work in 1813 that is considered to be a founding document in the field of forensic toxicology. In 1891, Holmes stories began to appear regularly in *The Strand Magazine*. By 1893, Hans Gross's *System der Kriminalistik* (*Criminal Investigation*, 1906) had appeared. The Holmes stories nevertheless impressed scientists. Edmond Locard (1877-1966), the pioneer of forensic science who originated the dictum that came to be known as Locard's exchange principle, advised his students to read Doyle's detective fiction.

Through the Holmes stories, Doyle popularized scientific ideas. Sherlock Holmes first appeared at a time when the United States, England, and Europe were experiencing terrorist attacks, assassinations, and other social turmoil, and the stories offered hope that science and reason could find a path to social order and justice. When Doyle attempted to kill Holmes off in "The Adventure of the Final Problem" (1893), thousands dropped their subscriptions to *The Strand*; thousands more renewed when Holmes returned in *The Hound of the Baskervilles* (serialized in the magazine, 1901-1902). The Sherlock Holmes character, which went on from Doyle's original publications to be featured in countless plays and films, helped to create worldwide acceptance of the principles of forensic science.

Betty Richardson

Further Reading

Costello, Peter. *Conan Doyle Detective: True Crimes Investigated by the Creator of Sherlock Holmes*. New York: Carroll & Graf, 2006.

Stashower, Daniel. *Teller of Tales: The Life of Arthur Conan Doyle*. New York: Henry Holt, 1999.

Wagner, E. J. *The Science of Sherlock Holmes: From Baskerville Hall to the Valley of Fear, the Real Forensics Behind the Great Detective's Greatest Cases*. Hoboken, N.J.: John Wiley & Sons, 2006.

See also: Crime laboratories; Crime scene investigation; Forensic geoscience; Forensic toxicology; Literature and forensic science; Locard's exchange principle; Misconceptions fostered by media; *Silence of the Lambs, The*; Training and licensing of forensic professionals.

Short tandem repeat analysis

Definition: Determination of the number of repetitive DNA sequences two to seven base pairs in length that are found at particular locations on chromosomes in long arrays, the exact number of which typically varies among individuals in a population.

Significance: Short tandem repeat analysis represents a rapid and straightforward way to identify the persons to whom samples of DNA belong and is widely used for the identification of DNA samples collected at crime scenes, in paternity testing, and in the identification of human remains.

Since the 1990's, the analysis of short tandem repeats (STRs; also called microsatellites) as a method of DNA (deoxyribonucleic acid) identification has gained prominence over the original restriction fragment length polymorphism (RFLP) protocol developed in 1985. The original method required that a relatively large amount of nondegraded DNA (about 100 nanograms) be isolated from a forensic sample and took several days to process. It measured the variation in the number of repeating units of DNA that were typically fifteen to fifty base pairs in length, also called minisatellites. This process is also referred to as the analysis of variable number of tandem repeats (VNTRs).

STR analysis has several advantages over the RFLP protocol: It requires about one hundred times less DNA, it can be completed within a few hours, and it exhibits less sensitivity to DNA degradation. The first two advantages come about mainly because of the coupling of this procedure with the polymerase chain reaction (PCR), also developed during the 1980's. PCR allows for the rapid amplification of trace amounts of DNA using a set of DNA "primers" that bind to the sequence of interest and use it as a template to make millions of copies. The final advantage is the result of the decreased size of the DNA fragments that are analyzed, typically only a few hundred base pairs in length. It follows that, as the length of DNA being analyzed decreases, so does the probability that it has been degraded.

The short length of the fragments used in STR analysis does introduce one limitation. Because the variability in these shorter fragments within a population is less compared with RFLP analysis, more of them must be analyzed to provide the same assurances of an exact identification. This drawback has been circumvented by the development of "multiplex" systems for PCR. Here eight to sixteen pairs of PCR primers are combined in one reaction, each set labeled with a different fluorescent dye so that the products can be discriminated.

Another modification that has been made to improve STR analysis is the use of capillary gel electrophoresis, instead of the traditional "slab" gels, to separate out the resulting DNA fragments. This technique, developed in conjunction with the Human Genome Project, is much faster than slab gels and particularly amenable to the use of fluorescently labeled primers.

James S. Godde

Further Reading

Griffiths, Anthony J. F., et al. *Introduction to Genetic Analysis*. 9th ed. New York: W. H. Freeman, 2008.

Strachan, Tom, and Andrew P. Read. *Human Molecular Genetics 3*. New York: Garland Press, 2004.

See also: Anastasia remains identification; Bacterial biology; CODIS; DNA analysis; DNA extraction from hair, bodily fluids, and tissues; DNA fingerprinting; DNA profiling; DNA typing; Electrophoresis; Paternity testing; Polymerase chain reaction; Restriction fragment length polymorphisms; Y chromosome analysis.

The Silence of the Lambs

Date: Premiered on January 30, 1991

Identification: Motion-picture thriller about investigators' pursuit of a serial killer that presents an iconic portrayal of criminal personality profiling.

Significance: The success of *The Silence of the Lambs*, a film based on Thomas Harris's best-selling novel of the same title, led many people, particularly women, to pursue careers in federal law enforcement and forensic psychology. The film's portrayal of criminal personality profiling influenced public ideas about the criminally insane and heightened interest in the law-enforcement tactics used to apprehend such offenders.

The Silence of the Lambs, directed by Jonathan Demme, pits Clarice Starling (played by Jodie Foster), a Federal Bureau of Investigation (FBI) special agent in training, against "Buffalo Bill," a serial killer (the character, portrayed by Ted Levine, is an amalgamation of three real-life serial killers). The FBI's apprehension of Buffalo Bill hinges on the assistance of incarcerated killer—and brilliant psychiatrist—Hannibal Lecter (played by Anthony Hopkins).

With little physical evidence available except for the discovery of a death's-head moth in the throat of one of Buffalo Bill's dead victims, the federal agents investigating the case rely on criminal personality profiling in attempting to determine the identity of the killer. Although Lecter is a master of con games and psychological sadism and Starling is still in training, the FBI sends Starling, alone, to gather information from Lecter, who is being held in an insane asylum.

During the 1990's, numerous books were published about criminal personality profiling. Many were written by FBI agents who were central to developing the FBI's Behavioral Science Unit (later renamed the Behavioral Analysis Unit) and established methods for using criminal profiling as an investigative tool. Thomas Harris routinely consulted with FBI agents when creating the characters for his novels, including *The Silence of the Lambs*. Similarly, for added credibility, the makers of the book's film adaptation sought consultation from retired FBI special agent John Douglas.

The Silence of the Lambs has nevertheless been criticized as a rather unrealistic portrayal of the conditions under which FBI agents, and specifically criminal profilers, work. In fact, Robert K. Ressler, former director of the FBI's acclaimed Violent Criminal Apprehension Program (Vi-CAP), objected to the movie's script because he perceived it as an unrealistic portrayal of the bureau's agents. Ressler pointed out that profilers for the FBI are highly experienced, trained investigators, not new recruits. They are not "supersleuths," he said, adding that profiling is not a magical or mystical process. Rather, it requires the systematic, objective analysis of crime scenes. This analysis involves psychological principles and is conducted by experienced investigators who ultimately derive lists of personality and behavioral characteristics of the offenders. Local law-enforcement personnel then use this information in the detection and apprehension of the offenders.

Despite the implausibility of the "go it alone" investigative style into which Clarice Starling is thrust in *The Silence of the Lambs*, as well as the questionable efficacy of criminal profiling generally, the film has inspired many potential law-enforcement agents and remains a virtual recruitment tool for the FBI's Behavioral Analysis Unit.

Nickie D. Phillips

Further Reading

Douglas, John. *Mindhunter: Inside the FBI's Elite Serial Crime Unit*. New York: Pocket Books, 1995.

Nathan, Gregory. "Offender Profiling: A Review of the Literature." *British Journal of Forensic Practice* 7 (August, 2005).

Ressler, Robert K., and Tom Shachtman. *Whoever Fights Monsters: My Twenty Years Tracking Serial Killers for the FBI*. New York: St. Martin's Press, 1992.

See also: Criminal personality profiling; Forensic psychiatry; Forensic psychology; Literature and forensic science; Misconceptions fostered by media; Sherlock Holmes stories.

Silencers for firearms

Definition: Devices that reduce the peak sound pressure levels of gunshots.

Significance: By using silencers on firearms, criminals can substantially reduce the sounds of gunfire and thus reduce the likelihood that those sounds will reveal their locations or the types of guns being fired.

The term "silencer" is something of a misnomer, as many silencers reduce but hardly eliminate the sound of gunshots. "Sound suppressor" is a more accurate term. First developed during the twentieth century, sound suppressors are widely used by firearms owners in a number of nations, including Finland, France, Sweden, and the United Kingdom. They are often used to protect neighbors from unnecessary noise in locations where guns are fired on a regular basis (such as target ranges).

Sound suppressors are less commonly used in the United States, in part because the federal National Firearms Act of 1934 required owners to register the devices with the federal government and to pay a hefty tax. The motive for stringent regulation of sound suppressors at that time may have been fear that sound suppressors could facilitate the poaching of animals during a period when hunger and malnutrition were widespread in the nation. According to U.S. law, any device that reduces the sound of a firearm by at least three decibels is considered a "silencer." Most U.S. states allow their residents to possess silencers in accordance with federal law, and the criminal use of lawfully owned silencers by ordinary citizens in the United States is essentially nil.

A silencer may be attached to a gun's barrel (muzzle silencer) or may be built into the barrel itself (integral silencer). Silencers achieve sound suppression in a variety of ways. "Wet" suppressors contain grease or other liquid coolants; "dry" suppressors may use baffles to contain sound energy.

Sound suppressors typically reduce gunshot sounds by about fifteen to twenty decibels. Contrary to many media portrayals, the suppressed sound can still be more than four times louder than a chainsaw. When used in conjunction with simultaneous sounds in the surrounding area (such as traffic noise), however, silencers can be effective in masking the sound of gunshots.

In a heavily silenced firearm, the sound of the bullet flight may be louder than the sound of the gunshot, thereby making it more difficult for a

A handgun with a muzzle silencer. *(© Vadim Kozlovsky/Dreamstime.com)* witness to identify the origin of the gunshot. Snipers find silencers useful in that they help to maintain the snipers' concealed positions by reducing the visible muzzle flash of gunshots and by reducing recoil.

David B. Kopel

Further Reading

Paulson, Alan C. *Sporting and Tactical Silencers*. Vol. 1 in *Silencer: History and Performance*. Boulder, Colo: Paladin Press, 1996.

Paulson, Alan C., N. R. Parker, and Peter G. Kokalis. *CQB, Assault Rifle, and Sniper Technology*. Vol. 2 in *Silencer: History and Performance*. Boulder, Colo: Paladin Press, 2002.

See also: Assassination; Ballistics; Bureau of Alcohol, Tobacco, Firearms and Explosives; Firearms analysis; Misconceptions fostered by media.

Silicone breast implant cases

Date: 1977-1999

The Event: Women throughout the United States filed individual and class-action lawsuits against the manufacturers of silicone gel-filled breast implants, alleging that injuries and illnesses resulted when the products ruptured or leaked. Suits filed during the 1990's led to huge monetary awards for damages to women who claimed injury from silicone breast implants, often because the manufacturers had concealed safety information from implant recipients.

Significance: Numerous scientific studies of silicone breast implants have shown that there is no significant link between such implants and the diseases experienced by the plaintiffs who brought lawsuits against the manufacturers, but these cases nonetheless resulted in the largest proposed product liability settlement in American legal history. In addition, the beginning of federal regulation of medical devices in the United States may be attributed to the silicone breast implant cases.

The first silicone gel-filled breast implant was introduced in 1962. By 1964, Dow Corning Corporation, the largest manufacturer of such implants, had established its Medical Products Division in order to market silicone breast implant products. Between 1962 and 1991, nearly two million women had received silicone breast implants in North America alone. Of these women, 80 percent received the implants for cosmetic reasons; the remaining 20 percent received the implants as part of breast reconstruction surgery following mastectomies.

As increasing numbers of breast augmentation surgeries were performed, problems with silicone implants began to become evident, including hardening and occasional rupture; cases of enlargement of the lymph nodes in implant sites were also observed. At the same time, some recipients of silicone implants began to develop an array of more serious disorders that they suspected were related to the implants. Some recipients developed systemic connective-tissue diseases, including scleroderma, systemic lupus erythematosus, rheumatoid arthritis, and other nonspecific autoimmune ailments. The silicone breast implant lawsuits focused on the alleged link between the silicone implants and connective-tissue diseases.

Background

The first suit, which was filed in 1977, resulted in a $170,000 settlement against Dow Corning. In *Hopkins v. Dow Corning Corporation* (1991), a jury found that the plaintiff's mixed connective-tissue disease was linked to her ruptured silicone breast implants and awarded the plaintiff $7.3 million. The bulk of that award ($6.5 million) can be attributed to the jury's desire to punish the conduct of Dow Corning, which had concealed its knowledge that its silicone implants could leak and failed to disclose the adverse results of animal testing the company had conducted.

In response to *Hopkins* and other cases, certain manufacturers of breast implants and their suppliers set aside funds of $4.25 billon to deal with potential legal suits. The fund was used as the basis for a global settlement whereby women who had received implants were given a deadline to decide whether they would join a class-action suit that guaranteed a settlement of $200,000 to $2 million if they agreed not to litigate or would litigate separately. Despite the settlement offer, 12,359 individual lawsuits were filed against Dow Corning by the end of 1993. In 1995, Dow Corning filed for Chapter 11 bankruptcy protection, which halted all pending litigation.

In 1997, a jury in the first class-action suit against Dow Chemical, which owned half of Dow Corning, found that the company had fraudulently concealed the dangers of silicone and failed to investigate properly the health risks associated with silicone implants. Facing the bankruptcy of Dow Corning, the plaintiffs agreed in 1998 to an offer of $3.2 billion to settle numerous injury claims; this step allowed Dow Corning to emerge from bankruptcy proceedings. Given the scientific evidence, most silicone breast implant cases after 1998 did not result in awards of punitive damages, but juries still concluded that the manufacturers were liable for concealing evidence and failing to warn recipients.

The Scientific Evidence Presented

To establish that silicone breast implants constitute a risk factor for the development of immune system-related disorders, epidemiological studies must show that recipients of these implants as a distinct group develop these disorders at a higher rate than do women without implants or any normal population of women. The first such study, the results of which were published in 1994, failed to demonstrate any such heightened risk or increased development of disorders, and statistical analyses continue to demonstrate that no evidence exists of any causal link or association between breast implants and any of the individual connective-tissue diseases, all connective-tissue diseases combined, or any other autoimmune conditions.

As most commentators have observed, insufficient scientific evidence exists to support the conclusion that the silicone breast implants caused the alleged injuries. Evidence is too sparse even to support the argument that the implants increased the likelihood of the recipients' developing these conditions. For example, one study noted that patients with insulin-dependent diabetes and those who depend on dialysis have increased exposure to silicone because silicone accumulates in their bodies. In these individuals, no systemic illnesses or any illnesses similar to those experienced by women with the silicone implants developed; thus, these illnesses are probably not attributable to silicone.

It is extremely difficult to establish a causal link involving illnesses and a product. In *Livshits v. Natural Y Surgical Specialties, Incorporated* (1991), the plaintiff was initially able to demonstrate a "cause-and-effect" link, but later the court substantially reduced the award of damages when the testimony of the plaintiff's expert witness was disqualified. The expert had testified that the plaintiff's silicone implant had caused an acceleration of the cancer that occurred in the plaintiff's breast. A study published in June, 1992, however, revealed that silicone was linked only to connective-tissue sarcomas that appeared in limited numbers in rodent species susceptible to cancer. The court found this study to be clear evidence that the silicone implant did not cause the acceleration of the plaintiff's cancer and therefore reduced the plaintiff's award.

Some commentators still adhere to their belief that the implants caused the disorders sustained by these women. They argue that scientific evidence may show no link between silicone breast implants and specific classic autoimmune diseases, but the research has not addressed possible connections of the implants to atypical autoimmune diseases or the severe complications that arise locally at the sites of implants.

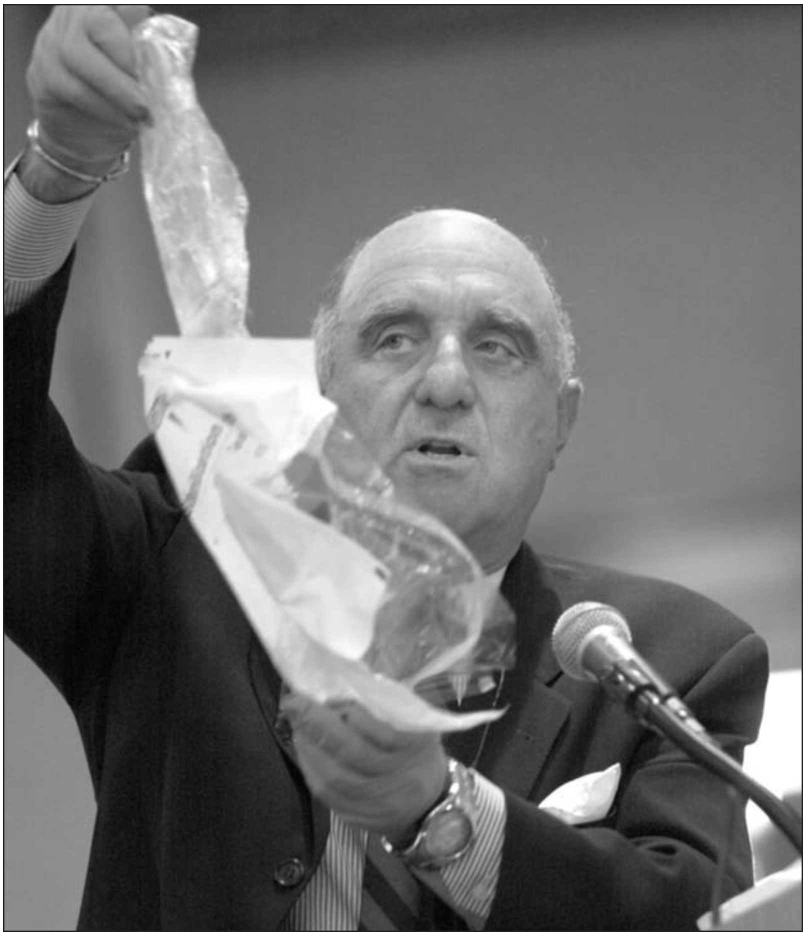
No definitive scientific evidence has shown whether removing silicone breast implants changes the course of connective-tissue diseases. One study found some improvement in seven of twelve patients after the removal of implants, but no firm conclusions can be drawn from this small sample.

The Food and Drug Administration's Response

In 1976, in response to public pressures regarding the lack of safety testing of silicone breast implants, the Medical Devices Amendment was added to the Federal Food, Drug, and Cosmetic Act. This amendment required the U.S. Food and Drug Administration (FDA) to review and approve new medical devices for safety. It had no effect on silicone breast implants, however, as they had already been on the market for almost fifteen years.

For years, the FDA failed to act on growing concerns related to breast implants, allowing manufacturers, in essence, to regulate themselves. In 1988, the FDA classified the implants as Class III devices, which meant that manufacturers were required to provide detailed data as to product safety and design. The data, however, were not due until 1991, at which point the FDA concluded that many manufacturers had submitted insufficient safety data and requested more. In 1992, after hearings before two independent advisory committees, the FDA placed a moratorium on the use of silicone gel-filled breast implants other than in research because of inadequate data on their safety. In 2006, silicone implants received FDA approval for use in breast reconstruction in women of any age and in breast augmentation (often cosmetic) in women twenty-two years or older.

Vivian Bodey



Dr. Edward Mehmed, testifying before a federal advisory panel in October, 2003, shows the remains of a silicone gel breast implant that he removed from one of his patients. *(AP/Wide World Photos)*

Further Reading

Angell, Marcia. *Science on Trial: The Clash of Medical Evidence and the Law in the Breast Implant Case*. New York: W. W. Norton, 1997. Argues that there was no medical consensus or evidence to support the contention that implants could cause widespread illness and that the courts should have relied on scientific evidence instead of awarding such large sums of money. Intended for a general audience.

Bar-Meir, Eran, Michael Eherenfeld, and Yehuda Shoenfeld. "Silicone Gel Breast Implants and Connective Tissue Disease: A Comprehensive Review." *Autoimmunity* 36 (June, 2003): 193-197. Presents an in-depth discussion of epidemiological studies that have been unable to establish an association between silicone gel breast implants and autoimmune disease.

Janowsky, Esther C., Lawrence L. Kupper, and Barbara S. Hulka. "Meta-analyses of the Relation Between Silicone Breast Implants and the Risk of Connective-Tissue Diseases." *New England Journal of Medicine* 342, no. 11 (2000): 781-790. Presents a detailed statistical analysis of several studies of the relationship between silicone breast implants and the risk of connective-tissue and autoimmune diseases to determine whether there was some statistical basis in alleging the relationship.

Stewart, Mary White. *Silicone Spills: Breast Implants on Trial*. Westport, Conn.: Praeger, 1998. Focuses on the stories of specific women while also providing good accounts of some of the cases as they wound their way through the courts. Nontechnical work intended for a general audience.

U.S. Food and Drug Administration. "Silicone Gel-Filled Breast Implants Approved." *FDA Consumer Magazine*, January/February, 2007. Presents a concise summary of the history of silicone breast implants and concludes that no convincing evidence exists to show that breast implants are associated with connective-tissue disease or cancer.

See also: *Daubert v. Merrell Dow Pharmaceuticals*; Epidemiology; Expert witnesses; Food and Drug Administration, U.S.; Immune system; Product liability cases.

Silkwood/Kerr-McGee case

Date: Silkwood died on November 13, 1974

Identification: An employee of the Kerr-McGee plutonium fuel-rod processing plant, Karen Silkwood was a union activist who gained notoriety after she died under mysterious circumstances while actively engaged in a campaign to publicize serious worker safety violations in her employer's plant near Crescent, Oklahoma.

Significance: Silkwood's dramatic and unexplained death, which was apparently connected to the safety hazards she was investigating, drew national attention to dangers in the nuclear power industry. Investigations established that Kerr-McGee had committed serious safety infractions that contributed to Silkwood's poor health and possibly even her death.

A divorced mother of three, Karen Silkwood (1946-1974) began working at the Kerr-McGee Corporation's new nuclear reactor fuel-rod processing plant near Crescent, Oklahoma, in August, 1972. There, she helped to produce plutonium pellets. Among the tasks she performed in the plant's metallography laboratory were quality-control checks on plutonium pellets that she held up to unexposed X-ray film. Pellets in which plutonium was distributed evenly throughout produced no "hot spots" on the film and passed the quality-control checks. Silkwood also polished fuel-rod welds to check for cracks and inclusions.

As an employee of the Kerr-McGee plant, Silkwood belonged to the Oil, Chemical, and Atomic Workers Union (OCAW). In November, 1972, only a few months after she had been hired, her union's contract with Kerr-McGee expired. The local union branch then went on strike, demanding higher wages and improved training and health and safety programs. After ten weeks, the strike ended when Kerr-McGee issued a sign-or-be-fired ultimatum. Meanwhile, the strike had strengthened Silkwood's bonds to her union, and she was developing concerns regarding worker safety in her plant.

The Trouble Begins

During the spring of 1974, Kerr-McGee fell so far behind in production that it initiated twelve-hour shifts and seven-day workweeks to catch up. The accelerated work pace caused a dramatic increase in accidental contaminations and spills, and Silkwood's worries about worker safety heightened. On July 31, 1974, Silkwood herself was accidentally contaminated while working in the emission spectroscopy lab. Tests using Atomic Energy Commission (AEC) standards showed a slight air-filter contamination in the lab. However, results of the test seemed confusing because the contamination occurred only on Silkwood's shift, not on the shifts before or after hers.

In August, 1974, Silkwood was elected to the local union's bargaining committee and assigned to address the topics of health and safety for the impending contract negotiations. Taking her new responsibilities seriously, she began studying work conditions at Kerr-McGee carefully. In September, she and two other local union officials met with officials of the national union and the AEC to discuss evidence of the dangerous conditions in the plant that she had observed. She also revealed her suspicions that company officials were altering the plant's quality-control records to make sure production levels remained high. She specifically faulted Kerr-McGee for falsifying inspection records to hide the improper handling of fuel rods and the improper assignment of poorly trained workers to perform tasks during a production speedup. If her charges could be proven to be true, Kerr-McGee would have been found to be guilty of fraud. Silkwood was then advised to gather more documentation at the plant secretly. At that same meeting, she learned for the first time that plutonium is carcinogenic.

Silkwood's Contamination

Several months later, Silkwood discovered that she herself had become contaminated with nearly forty times the legal limit for plutonium contamination. Curiously, the plutonium contamination did not seem to come from any holes in the protective gloves she had used and was greater on a day when she had only been doing office work and had no contact with nuclear materials. When she arrived for work on November 7, plant inspectors found Silkwood so dangerously contaminated that she was even exhaling contaminated air. A health team accompanied her to her home, where traces of plutonium were found in her bathroom, her refrigerator, and other places. Silkwood and her housemate were then sent to Los Alamos National Laboratory for more extensive examinations, and their house was thoroughly decontaminated.

The Forensic Mystery

The important question for forensic investigators to answer was how Silkwood could have become so seriously contaminated within such a short period. Silkwood herself charged that Kerr-McGee operatives were conducting a smear campaign to discredit her criticisms of safety conditions at their plant by putting plutonium in the urine and feces sample jars they gave her. That, she claimed, accounted for the plutonium contamination found in her bathroom that occurred when she spilled a urine sample there on the morning of November 7. She pointed out that samples taken at her home showed dramatically higher levels of contamination than those taken in "fresh" jars either at the Kerr-McGee plant or at Los Alamos.

Kerr-McGee responded by accusing Silkwood of deliberately contaminating herself in order to discredit the company. Making such an accusation was a dangerous strategy for the company to pursue, as it suggested that the company's security procedures were so lax that employees could smuggle nuclear material out of the plant. To complicate the issue, forensic investigators later determined that the soluble plutonium to which Silkwood had been exposed was not the same kind to which she could have had any kind of access in the plant for several months. The plant stored the type of plutonium with which she had been contaminated in a vault to which only Kerr-McGee managers had access.

Silkwood's Death

At the time Silkwood was contaminated by plutonium, Silkwood claimed to have assembled a large file of documents that supported her charges of irregularities in the Kerr-McGee plant. She was scheduled to meet with a *New York Times* reporter and a national union official to publicize her findings. On November 13, 1974, she showed a binder and packet of documents to attendees at a union meeting in Crescent, Oklahoma. Afterward, she left the meeting alone, intending to drive to Oklahoma City, thirty miles away, to present the documents to the *Times* reporter and union official.

Silkwood never reached Oklahoma City. Later that evening, her dead body was found in her car, which had apparently run off the road and hit a culvert. Police on the scene concluded that her death resulted from a single-car crash caused by her falling asleep at the wheel. They claimed to find no glass or debris to indicate that any other vehicles were involved. They also claimed to find some methaqualone (quaaludes) and marijuana in Silkwood's car, but none of the documents she was believed to be carrying. A coroner found enough traces of methaqualone in her blood to cause her to become drowsy.

Despite a lack of hard evidence, many people believed that Silkwood was murdered to keep her from publicizing her charges against Kerr-McGee. Independent investigators argued that another vehicle could have forced her car off the road without leaving any evidence of its involvement in the accident. They also dispute the suggestion that Silkwood was asleep at the time of the accident by pointing out that the position in which her steering wheel was bent indicated that she must have been awake and alert, trying to control her car.

Investigation and Trial

Both the AEC and the Oklahoma state medical examiner requested that the Los Alamos Tissue Analysis Program examine Silkwood's internal organs. Medical examiners found extensive plutonium contamination, with the greatest damage in her lungs and smaller amounts in her gastrointestinal organs. Such contamination was not consistent with the type of exposure to plutonium that Silkwood would have had during her normal tasks in the Kerr-McGee plant.

In November, 1976, Silkwood's father and children filed a wrongful-death civil suit against Kerr-McGee, seeking $160,000 in damages. The suit charged the corporation with negligence in handling plutonium and both Kerr-McGee and the FBI with a conspiracy to deprive Silkwood of her civil rights. Throughout the legal proceedings' discovery period, the Silkwood family's attorneys were impeded by insufficient funds and a lack of cooperation from the defendants. They dropped the conspiracy charges before the suit went to trial and shifted their focus to proving negligence. The plaintiffs also amended their complaint to $1.5 million in compensatory damages and $10 million in punitive damages.

The Silkwood case, through which the family sought to improve safety in the nuclear industry and to educate the public on the dangers of nuclear energy, was not only a civil trial but also a social movement. Under the direction of attorney Gerald Spence, the Silkwood legal team sought to prove several issues: that plutonium was ultrahazardous and that Kerr-McGee was responsible for its proper care, that Karen Silkwood had been contaminated with plutonium that originated at Kerr-McGee, that she had not contaminated herself, that her contamination injured her between November 5 and 13, 1974, and that Kerr-McGee was negligent in failing to protect its workers. The trial did not cover the details of Silkwood's death.

The trial began in March, 1979, and lasted ten weeks. The plaintiffs called nineteen witnesses to testify on the dangers of plutonium, working conditions at Kerr-McGee, and Karen Silkwood's character. The defense team called twenty-four witnesses to testify that Silkwood had deliberately contaminated herself with non-Kerr-McGee plutonium and that the contamination had not injured her. Moreover, the defense argued that her contamination fell under workers' compensation laws.

Aftermath of the Silkwood/Kerr-McGee Case

Despite a standing offer of a large cash reward for new information in the case, the full circumstances of Karen Silkwood's death remain unresolved. In December, 1983, Hollywood drew more attention to the case and to the dangers of nuclear energy with their version of the story in the film *Silkwood*, directed by Mike Nichols and starring Meryl Streep in the title role. The film earned five Academy Award nominations. One year later, a coalition of nuclear safety groups established the Karen Silkwood Awards to keep her memory alive by honoring safety crusaders in the nuclear industry. Silkwood may have lived an ordinary life, but her death initiated a social movement that not only changed the public perception of nuclear energy but also ultimately resulted in federal changes to the industry's regulation.

Jennifer Davis

In May, 1979, both sides rested. While meeting with the judge, Kerr-McGee conceded that Silkwood had, in fact, been contaminated by its own plutonium. The judge then set a precedent by defining plutonium as ultrahazardous. On May 18, 1979, after twenty-one hours of deliberation, the jury found Kerr-McGee negligent in an off-site contamination incident and awarded Silkwood's estate $500,000 in compensatory damages, $5,000 in property damages, and $10 million in punitive damages.

Kerr-McGee appealed the verdict to the Tenth Circuit Court of Appeals, contending that the first trial had violated federal and state regulations and that the first judge had erred in declaring plutonium ultrahazardous. On December 11, 1981, the appellate court concurred and lowered the award to only the $5,000 in property damages. Silkwood's team then appealed to the U.S. Supreme Court. On January 11, 1984, that Court ruled that victims of radiation injuries could sue nuclear power companies.

The Supreme Court's decision severely limited the federal monopoly on nuclear power by placing companies under state tort laws that could hold companies liable for punitive damages for gross negligence. The decision not only vindicated Karen Silkwood but also stood as a victory for states, which were given some regulatory control of the nuclear industry. In an out-of-court settlement in August, 1986, the Silkwood case finally ended with a $1.38 million agreement. Kerr-McGee contended that it settled to avoid more costly litigation.

Richard L. Wilson and Jennifer Davis

Further Reading

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005. Provides an excellent overview of the forensic sciences for general readers.

Kohn, Howard. "Malignant Giant." *Rolling Stone*, June 11, 1992, 92-97. Includes excerpts from the March 27, 1975, article that sparked an anti-nuclear power movement in the United States. Also discusses the impact of the case on the magazine.

_______. *Who Killed Karen Silkwood?* New York: Summit Books, 1981. Early compilation of *Rolling Stone* articles covers the struggles of Silkwood's family and supporters and theories about her death. Includes a discussion of the evidence against Kerr-McGee.

Raloff, Janet. "Silkwood: The Legal Fallout." *Science*, February 4, 1984, 74-79. Discusses the importance of the U.S. Supreme Court ruling in the Silkwood case for state regulation of the nuclear industry.

Rashke, Richard. *The Killing of Karen Silkwood: The Story Behind the Kerr-McGee Plutonium Case*. 2d ed. Ithaca, N.Y.: Cornell University Press, 2000. Provides a detailed look at the events surrounding Silkwood's death and the first trial. Based on information drawn from extensive interviews and available sources. A preface and three short chapters explore what has been learned about Silkwood since the book's initial publication.

See also: Courts and forensic evidence; Dosimetry; Environmental Measurements Laboratory; Forensic pathology; Forensic toxicology; Journalism; Nuclear detection devices; Quantitative and qualitative analysis of chemicals; Radiation damage to tissues.

Simpson murder trial

Date: January 24-October 3, 1995

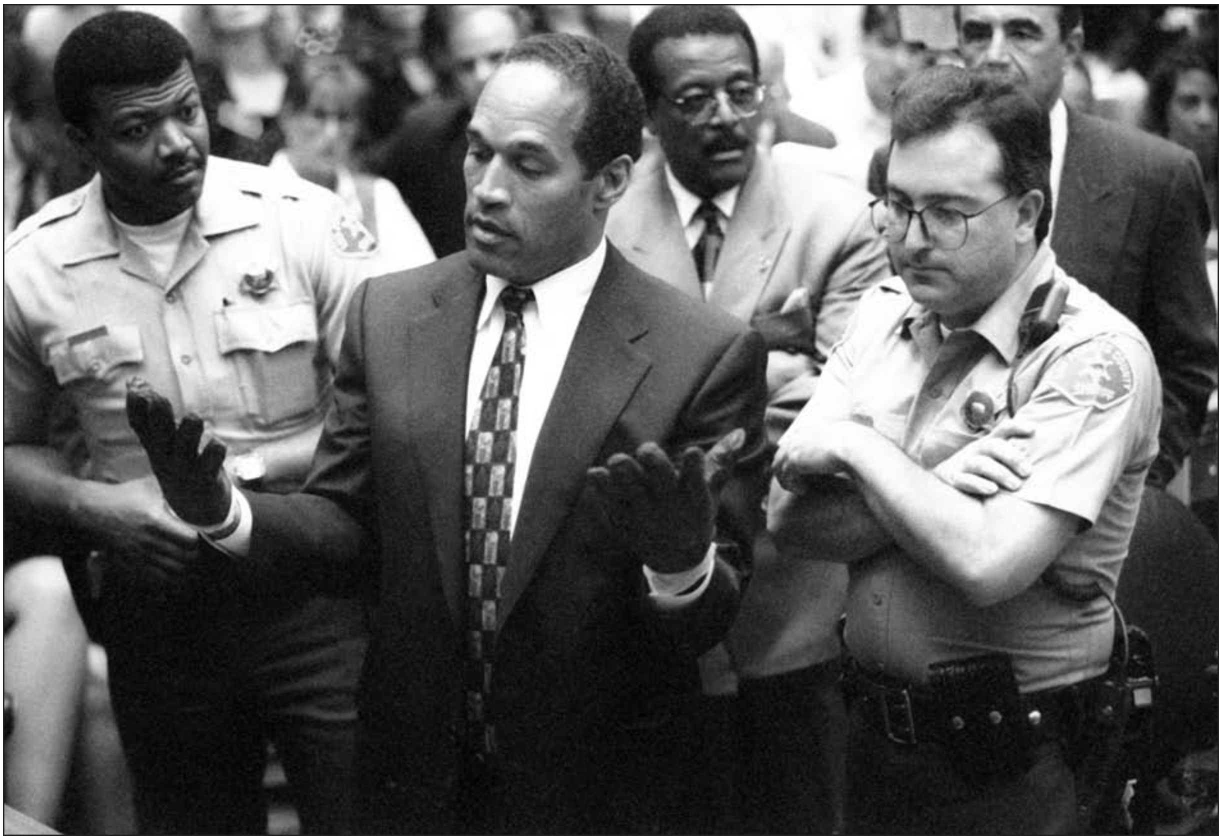
The Event: Indicted for the 1994 murders of his former wife Nicole Brown Simpson and her friend Ronald Goldman, O. J. Simpson used his wealth and celebrity to assemble a so-called dream team of defense lawyers. He was acquitted at trial after his attorneys successfully attacked much of the forensic evidence presented by the prosecution.

Significance: Simpson's televised murder trial brought issues of legal procedure and forensic investigation to the attention of millions of viewers on a daily basis for months, even as it exerted a distorting influence on the proceedings. His acquittal brought home to legal professionals the need for higher standards in the collection, interpretation, and presentation of forensic evidence, but it also revealed how legal processes can be influenced by celebrity and race. In addition, it highlighted the education gap between forensic professionals and the public from which juries are drawn.

During O. J. Simpson's murder trial, the prosecution produced what it called a "mountain" of evidence to demonstrate Simpson's guilt, and the defense explained the evidence away in terms of a police conspiracy to frame Simpson. Reporter Jeffrey Toobin may have been right when he observed that "the sheer number of associations between Simpson and the evidence made the evidence seem too complex when in fact it merely showed just how guilty Simpson was."

The Evidence

Evidence of Simpson's guilt included the victims' blood in his vehicle and on his socks, and his own blood at the murder scene and at his home. It included hair like Simpson's on Goldman's shirt and on a knit cap. It included fiber like the carpet in Simpson's Ford Bronco on the knit cap and on a glove. It included bloody shoe prints in Simpson's size, which were traced to a rare brand of shoes he denied owning. (Later, at Simpson's civil trial, photographs of him wearing such shoes materialized.) It included a bloody glove at the crime scene and the glove's mate at Simpson's estate. It included motive, opportunity, guilty behavior (the Bronco "escape," an apparent suicide note), and suspicious circumstances (unexplained wounds on Simpson's left hand). Some additional evidence—for example, Simpson's statements in an early interview



A key moment in O. J. Simpson's trial came when prosecutors asked him to put on a glove found at the murder scene and its mate. The obvious difficulty Simpson had in squeezing his hands into the gloves is believed to have damaged the prosecution's case severely. *(Sam Mircovich/Reuters/Landov)* with police—was not presented.

The prosecution emphasized how much evidence remained unrefuted by the defense's claims of police conspiracy, incompetence, and racism. The defense, intoning "garbage in, garbage out," insisted that things "didn't fit" and that there was "something wrong" with the prosecution's case. For those appalled by the verdict, the idea of a vast police conspiracy was absurd and the appeal to racism without foundation, and much evidence withstood even those suspicions. Those who celebrated the acquittal felt the "something wrong" with the prosecution's case tainted everything, even if exactly what was wrong had not been identified; enough had gone wrong with the investigation by the Los Angeles Police Department (LAPD), and with the prosecution's witnesses, to justify reasonable doubt about whether the prosecution had met its burden of proof, even if one supposed Simpson probably guilty.

California's Definition of "Reasonable Doubt"

It is not a mere possible doubt because everything relating to human affairs, and depending on moral evidence, is open to some possible or imaginary doubt. It is that state of the case which, after the entire comparison and consideration of all the evidence, leaves the minds of the jurors in that condition that they cannot say they feel an abiding conviction to a moral certainty of the truth of the charge.

Instructions to jurors in California courts

Reasonable Doubt

Opinions on the Simpson case divided largely along racial lines because the life experience of many African Americans made it seem reasonable, and that of many whites made it seem unreasonable, that racial motivations could lead authorities to trump up charges against a famous black man. It made sense to the prosecution to argue that LAPD detective Mark Fuhrman's lies about his use of racial epithets did not mean that he had planted evidence, although the law does suppose that a witness who lies about one matter may be willing to lie about others.

Some believed that the prosecution had not met its burden of demonstrating guilt beyond a reasonable doubt. As others viewed it, the evidence of guilt was overwhelming, so doubt could not be reasonable. If there could be no reasonable doubt, then the jury was willful or incompetent or both. This was the jury both sides had accepted, however.

After Simpson's acquittal, some commentators suggested that the jury system itself required amendment. A later jury, in the civil trial (October 23, 1996-February 4, 1997), found the evidence compelling and found Simpson "liable" for the attacks. Was this outcome the result of better (or worse) lawyering, stricter judging, absence of cameras, racial makeup of the jury, difference in standard of proof?

Not only did the two juries disagree, the experts continued to disagree. Critics such as attorneys Vincent Bugliosi and Daniel Petrocelli have expressed their beliefs that the specious doubts raised by the defense in the criminal trial have been dispelled. In contrast, forensic pathologist Michael Baden, who testified as an expert witness for the defense at the criminal trial, years later lamented that blood drops on Nicole Brown Simpson's back were not collected and suggested that "if the coroner's staff at the murders had not turned over Nicole's body, we might know beyond a reasonable doubt who killed those innocent people." Baden went on to plead for better protection of crime scenes and more careful collection, preservation, and testing of trace evidence. Renowned criminalist Henry C. Lee, whose expert testimony for the defense exerted immense influence on the jury, has continued, despite years of severe criticism, to view Simpson's acquittal as a victory for the objectivity of forensic science.

Edward Johnson

Further Reading

Baden, Michael, and Marion Roach. *Dead Reckoning: The New Science of Catching Killers*. New York: Simon & Schuster, 2001. Popular account of modern forensic advances makes several comments about the Simpson case.

Bugliosi, Vincent. *Outrage: The Five Reasons*

Why O. J. Simpson Got Away with Murder. New York: W. W. Norton, 1996. Presents a detailed argument for Simpson's guilt along with a scathing analysis of why the case was lost.

Erzinçlioglu, Zakaria. *Every Contact Leaves a Trace: Scientific Detection in the Twentieth Century*. London: Carlton Books, 2000. General discussion of forensics by a distinguished entomologist includes an oddly confused account of some of the evidence in the Simpson case.

Lange, Tom, and Philip Vannatter, as told to Dan E. Moldea. *Evidence Dismissed: The Inside Story of the Police Investigation of O. J. Simpson*. New York: Pocket Books, 1997. Two leading detectives in the case describe their investigation.

Lee, Henry C., with Thomas W. O'Neil. *Cracking Cases: The Science of Solving Crimes*. Amherst, N.Y.: Prometheus Books, 2002. Discusses the famous criminalist's thoughts on the Simpson case in chapter 3.

Petrocelli, Daniel, with Peter Knobler. *Triumph of Justice: The Final Judgment on the Simpson Saga*. New York: Crown, 1998. Definitive work on Simpson's civil trial highlights flaws in the criminal trial and explains how lead attorney Petrocelli was able to secure judgment against Simpson.

Toobin, Jeffrey. *The Run of His Life: The People v. O. J. Simpson*. New York: Random House, 1996. Account by the reporter whose story in *The New Yorker* first revealed the defense's strategy to "play the race card."

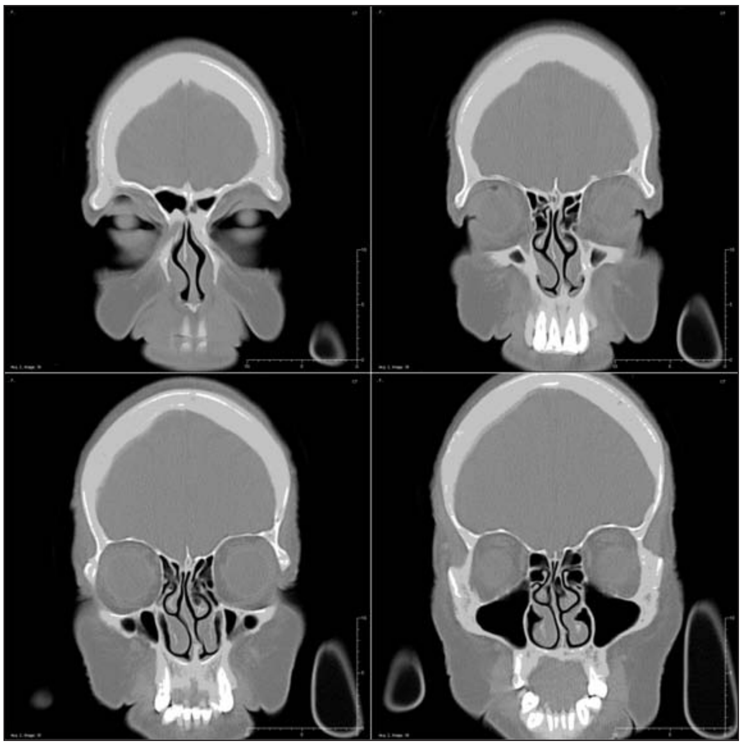
See also: Blood residue and bloodstains; Blood spatter analysis; Chain of custody; Cross-contamination of evidence; DNA analysis; DNA extraction from hair, bodily fluids, and tissues; Footprints and shoe prints; Hair analysis; Homicide; Journalism; Trace and transfer evidence.

Sinus prints

Definition: X rays of the bony ridges inside human skulls and the spaces they create.

Significance: Called "prints" because they resemble fingerprints in being unique to each human being, sinus prints are valuable both to medicine and to forensic anthropology, which uses them to identify bodies.

The uniqueness of the human sinus region was initially discovered by surgeons, who noticed in viewing preoperative X rays that the configuration of the sinus region varies from person to person, with no two exactly alike. Unlike other bones in the body, which are fairly standard across individuals, the sinus areas of different persons' skulls differ, and this can make surgery in this area difficult. For this reason, preoperative X rays are taken when patients undergo si-



Computed tomography images of human skulls showing their unique sinus cavity shapes. *(© Trout55/Dreamstime.com)* nus surgery so the surgeons can familiarize themselves with the patients' unique sinus cavities before surgery begins.

Forensic anthropologists sometimes use sinus prints to identify bodies. Other X rays may also assist with identification, particularly X rays of skeletal anomalies, such as broken bones. Even when bodies are not identified immediately, X rays can be used to help identify them years later.

Although each person's sinus print is unique, it can be difficult to identify a dead body from one postmortem sinus print alone. A sinus print made prior to death must also exist, and it must be accessible to law enforcement. For these reasons, sinus prints are used more often to confirm suspected identities than to identify individuals without other forms of identification.

Although sinus prints have been used for forensic identification since the early twentieth century, this technique is rarely mentioned, even in the forensic science literature. In one of the most famous instances of this method of identification, sinus prints were used to verify the identity of President John F. Kennedy after he was assassinated in 1963. A comparison of sinus prints made before and after Kennedy's death confirmed that the body subjected to autopsy was, indeed, that of the late president of the United States.

Ayn Embar-Seddon and
Allan D. Pass

Further Reading

Asherson, Nehemiah. *Identification by Frontal Sinus Prints: A Forensic Medical Pilot Survey*. London: Lewis, 1965.

Larheim, T. A., and P.-L. Westesson. *Maxillofacial Imaging*. New York: Springer, 2006.

See also: Autopsies; Class versus individual evidence; DNA fingerprinting; Ear prints; Fingerprints; Forensic anthropology; Osteology and skeletal radiology; September 11, 2001, victim identification; University of Tennessee Anthropological Research Facility.

Skeletal analysis

Definition: Examinations by forensic anthropologists of bones that are subjects of criminal investigations.

Significance: Because skeletons and teeth are the hardest and most durable parts of human bodies, they are often the only parts that investigators recover after victims of crimes have been dead for long periods of time. Forensic anthropologists are trained to identify skeletal remains and interpret the unique evidence they contain; they can often help identify homicide victims and reconstruct the circumstances of both their lives and their deaths.

Forensic anthropology is the application of physical anthropological knowledge to evidence used in the legal process. The field is one of the recognized subdisciplines of the American Academy of Forensic Science. Practitioners in the field are frequently called upon to identify skeletal, badly decomposed, or otherwise unidentified human remains. Often, their first task is to apply techniques developed within physical anthropology to determine whether unidentified remains are human. After confirming that remains are, in fact, those of human beings, they try to answer other questions about the identities of the decedents, the manner of their deaths, and whether they were victims of foul play.

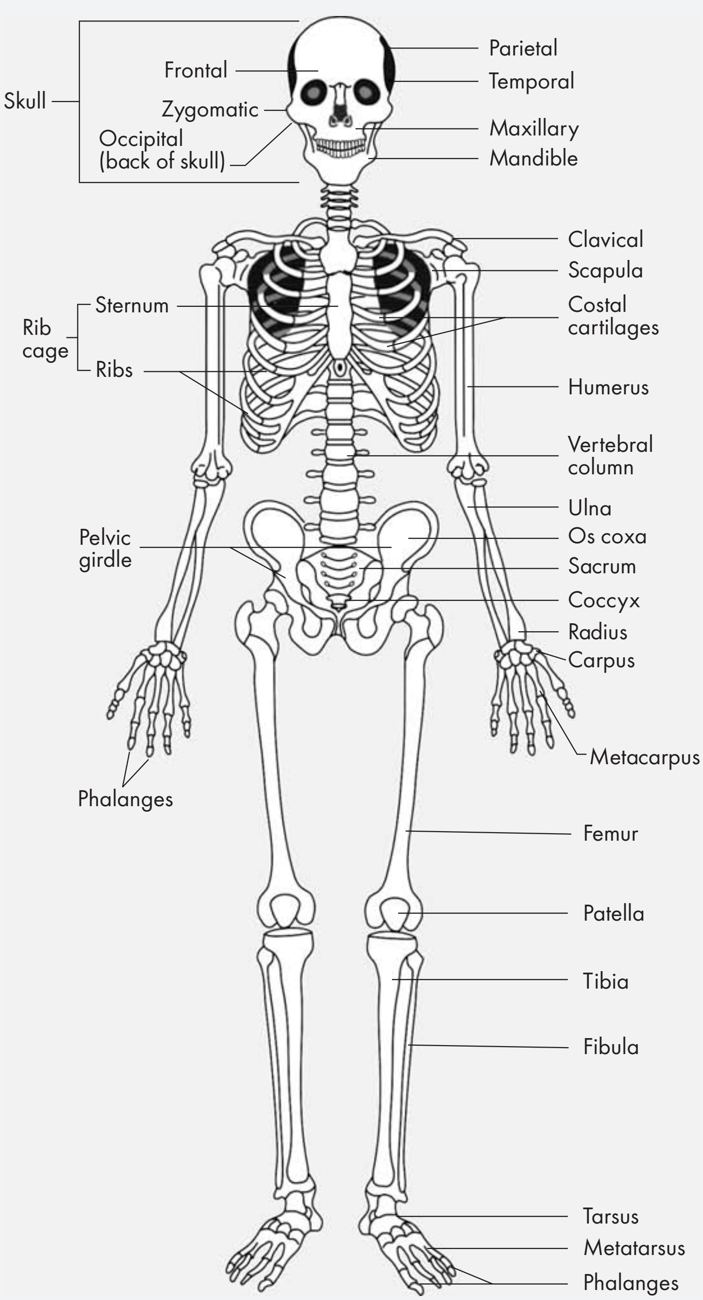
Forensic anthropologists frequently work alongside forensic pathologists, odontologists, and other investigators. They not only help identify decedents but also help determine their manner of death and how long they have been dead—the so-called postmortem interval. Although these professionals may initially be called upon to assist in locating and recovering suspicious human remains, they do most of their work on skeletons after they are recovered. Using the evidence they find in bones, they build decedents' biological profiles, which include their sex, age, ancestry, stature, and unique identifying features, such as former injuries.

Human Skeletons

The bone matter in skeletons is made up of two primary materials: a hard mineral salt known as hydroxyapatite and a more flexible organic material, collagen. Hydroxyapatite gives bones their structural support and torsion strength, and collagen gives them their elasticity and tensile strength. Bones in living bodies are also living matter. They are innervated and receive nutrients from the bodies' blood supplies. Like other living tissues, they produce waste from metabolic processes associated with their growth and development.

In addition to their structural support function, the muscles, ligaments, and tendons that are connected to the skeleton permit the body's animation. Skeletons also house the bone marrow that produces the vital red blood cells. Because living bones are replaced at a rate of about 10 percent per year and are constantly being re-formed by the mechanical forces exerted on them, they effectively record information about the body after an individual's death. The analytical techniques that forensic anthropologists use help bones speak for the dead.

The Major Bones of the Human Skeleton



Methods of Identifying Bones

Determining whether recovered bones belong to human beings requires a detailed knowledge not only of the morphology of all the bones in human skeletons but also of all types of animal bones with which human bones might be confused. Because there are only two sexes, one might expect that determination of a given decedent's sex should be correct approximately 50 percent of the time. However, given the critical functional differences between male pelvises and female pelvises, which are modified by childbirth, as well as general sexual differences in the muscle masses attached to bones, forensic experts should be able to identify the sex of unknown decedents from skeletal evidence in more than 95 percent of cases they investigate.

Methods of determining age from bones are more complex than those used for determining sex. Many criteria are employed to estimate the age of a decedent from a skeleton. Moreover, matching the estimated age at time of death of a body with the age of a long-missing person can be further complicated by uncertainty about the missing person's age at time of death. This latter complication is especially relevant to identifying the skeletal remains of children, whose bones change more quickly than those of adults. If the bones of what appears to have been a three-year-old child were recovered several years after a two-year-old child disappeared, those remains might belong to the missing child, but making such a match would pose special difficulties.

Age is best determined through the employment of multiple criteria. Among infants and children, for example, the numbers of bones, the presence or absence of specific bones, and the degree of bone development can all be important in estimating age at time of death. Infant humans have approximately four hundred bones; however, as the children grow older, the shapes and numbers of their bones change. Some of the bones fuse to others at growth plates, and the predictable timing of such events can be used to estimate age at time of death. The emergence of deciduous, or "baby," teeth and their gradual replacement by permanent teeth are also developmental events that occur at predictable ages.

The ages of middle-aged adults and older persons can be estimated based on changes in the appearance of the pubic bones of the pelvis, suture closures among their skull bones, the presence and degree of development of arthritis, and combinations of a host of degenerative changes that normally occur in human bones as individuals age. It is more difficult to estimate the ages of adult decedents than young decedents, however, because as human beings age, many other variables can affect their skeletal development. These variables include individual genetics, dietary differences, and exposure to disease and physical traumas.

Determining the ancestry of decedents from their skeletal remains is the most difficult aspect of creating biological profiles. Skulls must be present and in reasonably good condition to enable a host of measurements and observations to be collected. The data that are collected are then compared with measurements and other information gathered from large numbers of people of known ancestry and stored in databases. The results of multiple discriminant statistical procedures, along with researchers' experience and expertise in assessing the wide range of human skeletal variation, assist in identifying the ancestry of unknown decedents.

Estimating the stature of decedents from their skeletal remains is comparatively easy and involves the application of only basic mathematics. Forensic anthropologists simply measure the longest bones recovered in a set of skeletal remains and multiply the lengths by figures listed in the most relevant regression tables. The main challenge is in choosing which formulas to use from among the many available. Allowing for differences in sex, age, and ancestry, different formulas are used for the various long bones of the body.

Other unique skeletal features of decedents used to help identify remains include dental work, orthopedic prostheses, and records of fractures. In some cases, the cause of death itself or other injuries sustained around the time of death leave evidence on skeletons. Examples

Queen Hatshepsut

Skeletal remains can tell many stories about their owners' lives by providing information on age, health history, birth defects, and injuries. Skeletal analyses can even provide information on remains that are almost unimaginably old. A dramatic example is what has been learned from the bones of the legendary Queen Hatshepsut (c. 1525-c. 1482 B.C.E.), who ruled Egypt in her own right almost thirty-five hundred years ago. Inscriptions and written records chronicle her achievements as queen. Her bones chronicle the fact that she died at about the age of fifty from the ravages of metastatic bone cancer.

Dwight G. Smith

include perimortem injuries, evidence of sharp force or blunt force traumas, bullet wounds, and manual strangulation. For example, the recovered skull of a person known to have been shot through the head is likely to contain persuasive evidence of the decedent's cause of death.

Turhon A. Murad

Further Reading

Burns, Karen R. *Forensic Anthropology Training Manual*. Upper Saddle River, N.J.: Prentice Hall, 2006. General textbook on forensic anthropology includes discussion of sex differences for each region of the human skeleton.

Gill, George W., and Stanley Rhine. *Skeletal Attribution of Race: Methods for Forensic Anthropology*. Albuquerque: Maxwell Museum of Anthropology, University of New Mexico, 2004. Contains images of skull and face-form variations useful for determining ancestry.

Katzenberg, M. Anne, and Shelley R. Saunders, eds. *The Biological Anthropology of the Human Skeleton*. New York: John Wiley & Sons, 2000. Assortment of essays provides a comprehensive overview of issues relating to skeletal analysis. Includes a focused discussion of forensic science as applied to skeletal remains.

Krogman, Wilton Marion. "A Guide to the Identification of Human Skeletal Material." *FBI Law Enforcement Bulletin* 8, no. 8 (1939): 3-31. Classic essay on skeletal analysis that helped prompt the development of modern forensic anthropology. Krogman later wrote the standard textbook on skeletal analysis.

Krogman, Wilton Marion, and Mehmet Yasar Iscan. *The Human Skeleton in Forensic Medicine*. 2d ed. Springfield, Ill.: Charles C Thomas, 1986. Updated and expanded version of Krogman's standard textbook, which he first published in 1962.

Martini, Frederic H., Michael J. Timmons, and Robert B. Tallitsch. *Human Anatomy*. 6th ed. San Francisco: Pearson/Benjamin Cummings, 2008. Comprehensive anatomy text provides a detailed introduction to the skeletal system.

Scheuer, Louise, and Sue Black. *The Juvenile Skeleton*. Burlington, Mass.: Elsevier Academic Press, 2004. Focuses on the special characteristics of the skeletons of infants and children and includes explanations of subtle sex differences that can be observed.

Schwartz, Jeffrey H. *Skeleton Keys: An Introduction to Human Skeletal Morphology, Development, and Analysis*. New York: Oxford University Press, 2007. Presents an in-depth look at the skeletal system.

White, Tim D., and Pieter A. Folkens. *The Human Bone Manual*. Burlington, Mass.: Elsevier Academic Press, 2005. Compact volume offers essential information about skeletal identification for use by professional anthropologists, forensic scientists, and researchers. Contains hundreds of drawings and photographs.

See also: Anthropometry; Body farms; Decomposition of bodies; Forensic anthropology; Forensic sculpture; Gestational age determination; Mitochondrial DNA analysis and typing; Osteology and skeletal radiology; Sex determination of remains; Sinus prints.

Skeletal radiology. *See* Osteology and skeletal radiology

Sketch artists. *See* Composite drawing

Smallpox

Definition: Contagious viral disease characterized by high fever and a pustular rash that may cover the body.

Significance: Given the severity of certain forms of smallpox and the present-day lack of immunity to it among the world's population, the disease has the potential to be used as a weapon for mass devastation.

Smallpox is caused by a viral agent, a member of a family known as the poxviruses. Other viruses in the family include a variety of agents with the surname "pox" (monkeypox, cowpox) and vaccinia, but smallpox is the only one that naturally infects humans and has the potential of causing the deaths of a significant number of its victims. The virus is highly transmissible through contact with infected persons, both through oral secretions and through objects contaminated with the virus.

History of Smallpox

Smallpox is among the most ancient of human diseases, dating back at least to the times of the pharoahs in twelfth century B.C.E. Egypt. Likewise, the disease was prevalent in Southeast Asia and China during this era. The first written description of a disease that was likely smallpox is found in the fourth century C.E., in the writings of Eusebius of Caesarea; the first recorded epidemic of the disease in the Middle East came a century later. Common in Europe by the sixteenth century, smallpox was transported to the Americas by Spanish explorer Hernán Cortéz (c. 1520); it wreaked havoc there on the native populations and opened the way for Spanish conquest.

Although the cause of smallpox was unknown in the eighteenth century, it was clear even to the casual observer that the illness was devastating to populations that had never been previously exposed; mortality could approach levels as high as 90 percent among such peoples. In Europe, where the disease had by then been known for centuries, mortality still remained at a level of 20-30 percent in the most severe outbreaks. Survivors generally exhibited severe scarring at the sites of "pocks" that had covered the body.

Two forms of the disease were apparent. The more severe type, referred to above, was known as *Variola major*. A less severe type, *Variola minor*, exhibited a much lower mortality rate, as low as 1-2 percent. The basis for the difference

Early twentieth century smallpox patient with an advanced case of the disease showing the pustules that characterize it. *(Library of Congress)*

between the two forms remains unknown, as scientists have been unable to find much to distinguish the viruses associated with the two forms.

Evidence that the disease could be prevented originated with the Chinese, who, sometime around the eleventh century C.E., carried out a practice called variolation, in which smallpox crusts prepared as powders were inhaled or swallowed. The procedure was not always successful, but in many cases it did provide a measure of protection against the disease.

The practice of variolation spread through Persia (present-day Iran) and across the Middle East and Eastern Europe with the growing Muslim empire. Mary Wortley Montagu, wife of the British ambassador to Turkey and herself disfigured by the disease, had her son variolated in 1718. The practice, brought back to London with her return, was eventually described in writings that became part of the proceedings of the Royal Society of London for the

Improvement of Natural Knowledge. These proceedings were read in Boston by the American physician Zabdiel Boylston as well as by the Reverend Cotton Mather, and variolation made its way into North America.

Variolation became a widespread practice in Western Europe during the eighteenth century, as published reports provided evidence for the efficacy of the procedure and physicians from the Continent traveled to London and learned of the practice. Although it never became completely safe, variolation was increasingly accepted as a means of protecting people from the devastation of smallpox.

Smallpox and Biological Warfare

Evidence for the intentional use of smallpox as a biological weapon is mainly anecdotal. The earliest example may have been the introduction of the disease among Native American populations during the French and Indian War (1754-1763). Devastation of the Aztecs by smallpox during Spain's sixteenth century conquest was likely the result of accidental infection (although it clearly benefited the conquerors), but it clearly demonstrated the lack of resistance within isolated populations. The disease had appeared periodically in other native populations, creating a fear among these peoples similar to their fear of European weapons.

The French in North America were cognizant of the effects of smallpox among their Native American enemies, and at least one leader, Charles le Moyne de Longueuil, suggested its use as a weapon in the 1750's. During the French and Indian War in North America, the Americans and their British allies had mixed success in fighting Native American warriors who were often allied with the French. In 1763, British commander Sir Jeffrey Amherst reportedly approved providing native tribes with blankets that had been contaminated with the smallpox agent. Whether the blankets were ever actually distributed is unknown, but the following year some of the tribes experienced a smallpox epidemic.

Debate Concerning Smallpox Vaccination

The World Health Organization (WHO) in 1980 declared that smallpox had been eradicated, and the world was now free of the disease. Unlike most other viruses, smallpox is maintained only within the human population, so with the absence of disease, vaccination of susceptible individuals was no longer required. The United States ended its own requirement to vaccinate children against smallpox in 1972, as the disease was no longer found in the Western Hemisphere by that time. Around the world, most persons born since the 1980's have no immunity against the disease.

In 1980, the World Health Assembly (the major decision-making body of the WHO) recommended the destruction of all stocks of the smallpox virus, with the exception of reference laboratories in the United States, Great Britain, the Soviet Union, and South Africa. South Africa subsequently destroyed its stocks voluntarily, and Great Britain transferred its stocks to the Centers for Disease Control and Prevention in Atlanta, leaving only two sites in the world with remaining samples of the virus.

With an increase of terrorism in the twenty-first century, fears that terrorist groups could gain access to smallpox virus stocks and use the disease as a weapon resulted in controversy over whether vaccination among the general population should resume. Vaccination of both military personnel and health care workers was resumed to a limited extent. The likelihood that a terrorist group could obtain access to smallpox viral stocks is unknown, but the rapid dissemination of the illness—even prior to the onset of symptoms—lends a level of justification for real concern over the use of smallpox as a weapon of terrorism.

In 2001, the American Medical Association (AMA) declared smallpox one of the diseases that might be exploited by terrorists. With the absence of actual disease, however, the danger of severe side effects associated with vaccination outweighs the likelihood of exposure to smallpox; the AMA has estimated that large-scale vaccination could result in three hundred deaths per year in the United States alone.

Despite the use of variolation, smallpox remained common in North America in the decades that followed. The beginning of the American Revolutionary War in 1775 provided another opportunity for smallpox to have an effect on the ability of armies to fight. The British army, with its common soldiers representing the lower echelons of English society, was largely immune to the disease, either through required variolation or natural exposure, whereas the Americans were largely susceptible. An outbreak of the disease among American troops who invaded Canada was significant in eliminating the Americans as an effective fighting force. Certainly the Americans' sheer fatigue and lack of training, as well as weather conditions, played their roles, but illness was an important element in reducing the numbers of American troops.

General George Washington several times had to decide whether to require variolation of his men. Smallpox was clearly deadly, but the side effects of variolation could include not only temporary incapacitation but also development of actual smallpox, and from there the disease could spread to others. No evidence exists that the British intentionally practiced biological warfare on the Americans, but military decisions throughout the war were often affected by either the presence or the fear of smallpox. Variolation had been banned in several of the American colonies prior to the revolution, largely because of fears that the practice could cause outbreaks of the disease; Washington reversed the ban and required the inoculation of his troops during the war to protect them against a disease to which his opponents were already immune. In particular, inoculation of the Americans during the Siege of Boston in 1775 may have played an important role in maintaining Washington's army as a fighting force.

Smallpox remained a problem in North America, and not only in the northeastern region. In the years after the American victory over the British at Yorktown in 1781, smallpox repeatedly spread from Central America into what is now Texas and the American Southwest, frequently devastating Native American tribes. The precise numbers of deaths are unknown, but the elimination of thousands of natives and their villages certainly played a role later in the ability of colonists to subdue those populations.

Eradication of Smallpox

Variolation was a useful tool for fighting smallpox, but it was far from safe. During the 1790's, the British country physician Edward Jenner began to test a new procedure, the use of material from a bovine form of the pox, cowpox, as a means to immunize persons against smallpox. Although Jenner has been given proper acknowledgment for the thorough testing and publicizing of the practice that became known as vaccination (from the Latin word for cow, *vacca*), his work was not unprecedented. As early as the 1770's, Jenner was informed of the protection associated with cowpox by English dairymaids who had developed lesions as a result of milking cows that had the infection on their udders. Jenner first tested the efficacy of vaccination on himself and his family, and then on local children—with the approval of their parents. He found that vaccination with material prepared from the pustules of cowpox provided effective immunization against smallpox. Although the subsequent widespread use of the practice revealed some small degree of danger from side effects, vaccination was far superior to variolation.

Jenner had his opponents, and vaccination was far from universally accepted. It became clear, however, that the incidence of smallpox was significantly reduced in populations that had been extensively vaccinated. Eventually, compulsory vaccination became the rule, not only in England but also in the Americas. By the 1940's, smallpox had largely disappeared from most of Europe and North America. The disruption of World War II slowed many nations' abilities to control the disease, but in the years following the war, eradication of smallpox became a goal of the newly created World Health Organization (WHO).

Unlike many viral diseases, smallpox in its "natural state" is found only in humans. The lack of any animal reservoir meant that with interruption of the spread of infection in the human population there was hope for actual elimination of the disease. In 1948, the WHO began a program aimed at eradication of the disease, the goal being to immunize anyone who had come into contact with a smallpox victim rather than relying on "simple" mass inoculation. The principle behind the decision was to prevent the spread of the illness beyond the focus of infection, thus breaking the chain and eliminating the local outbreak.

The final push to eradicate smallpox began in 1967; that year, 131,000 cases of the disease were reported worldwide. Over the next ten years, the numbers of reported cases continued to fall, and the last natural case of the disease was diagnosed in Somalia in October, 1977. Other than a single accidental infection owing to a laboratory accident in 1978, no cases of smallpox have occurred in the world since then, indicating the first eradication of a human disease.

With the elimination of smallpox, vaccination against the disease is no longer routinely practiced, and many among the world's population may very well lack any natural immunity to the disease. Although the smallpox virus is no longer available in the general population, viral stocks remain in laboratories in both the United States and Russia. No stores of smallpox virus are believed to be located anywhere else, but with increased attention to the possibility of terrorist threats, fears have grown that persons with malicious intent could somehow obtain samples from the existing stocks to create their own form of biological weapon.

The question of whether the smallpox viral stocks should be destroyed has been much debated and remains unresolved. Proponents of destruction argue that with the absence of widespread immunity, even an accidental infection started by a careless researcher could unleash the virus into a "virgin" population, with results that might be comparable to those experienced by Native Americans in earlier centuries. Opponents of stock elimination argue that further research on the DNA (deoxyribonucleic acid) of the virus may shed light on the mechanism by which the virus causes disease, perhaps even leading to the production of a safer means of vaccination.

Richard Adler

Further Reading

Allen, Arthur. *Vaccine: The Controversial Story of Medicine's Greatest Lifesaver*. New York: W. W. Norton, 2007. History of vaccination includes discussion of smallpox, as it was the first major human disease controlled through immunization of the population.

Behbehani, Abbas. "The Smallpox Story: Life and Death of an Old Disease." *Microbiological Reviews* 47 (December, 1983): 455-509. Provides a history of the disease and tells the story of its eradication.

Carrell, Jennifer Lee. *The Speckled Monster: A Historical Tale of Battling Smallpox*. New York: Dutton, 2003. Presents a partially fictionalized account of the roles played by the Reverend Cotton Mather and physician Zabdiel Boylston in the introduction of variolation as a means to control smallpox in early eighteenth century Boston.

Fenn, Elizabeth. *Pox Americana: The Great Smallpox Epidemic of 1775-1782*. New York: Hill & Wang, 2001. Discusses the role played by smallpox during the American War of Independence, including speculation regarding its possible use in biological warfare on the part of the British.

Glynn, Ian, and Jenifer Glynn. *The Life and Death of Smallpox*. New York: Cambridge University Press, 2004. Covers the history of the disease as well as the story of its eradication.

Hopkins, Donald. *The Greatest Killer: Smallpox in History*. Chicago: University of Chicago Press, 2002. Focuses on the effects of smallpox epidemics on the history of human civilization.

See also: Anthrax; Biodetectors; Biological terrorism; Biological weapon identification; Biotoxins; Bubonic plague; Centers for Disease Control and Prevention; Ebola virus; Epidemiology; Hantavirus; Medicine; Nipah virus; Pathogen transmission; Viral biology.

Smoke inhalation

Definition: Breathing in of gases, vapors, and particles created by combustion (burning) or pyrolysis (breakdown of material by heat in the absence of enough oxygen to support combustion).

Significance: By examining the airways of a person who has died in a fire, a forensic pathologist can determine the cause of death and whether the individual was dead before the fire started or died during the fire.

Smoke inhalation has been known to be potentially deadly for centuries. For example, the Roman writer and naturalist Pliny reported in the first century C.E. that prisoners were executed by being placed over a smoking fire. Of the people who die in fires, two to three times as many die from smoke inhalation as die from burns. When large numbers of people are killed in a fire, deaths most often occur because people are trapped in the building and succumb to smoke inhalation. For example, all eighty-seven deaths in the 1990 fire at the Happy Land social club in New York City were caused by smoke inhalation, and up to half of the one hundred people who died in the Station nightclub fire in West Warwick, Rhode Island, in 2003 were killed by smoke.

How Smoke Inhalation Causes Death

Smoke inhalation damages the body in multiple ways, all of which may cause or contribute to death. Inhaling hot smoke burns the tissues that line the airways. Thermal burns from smoke tend to occur only in the mouth and upper part of the trachea (windpipe). Nevertheless, if the smoke is hot enough, when it reaches the larynx (voice box), it can trigger a spasm that closes the windpipe and causes asphyxiation.

If the smoke contains toxic gases, it can also cause chemical burns. When a fire burns certain synthetic polymers, such as PVC (polyvinyl chloride) pipe, poisonous hydrogen chloride gas is created; burning wool, silk, nylon, and polyurethane create deadly hydrogen cyanide gas. Exposure to either of these gases can cause death. In addition, soot and particles in smoke can trigger a reaction in the airways similar to an asthma attack. The airways narrow, and the individual begins to wheeze in an attempt to get enough air.

One of the most common causes of smoke inhalation death is carbon monoxide (CO) poisoning. In a normally functioning lung, oxygen from the air is transferred to a molecule called hemoglobin that is found in red blood cells. Hemoglobin holds the oxygen as the red blood cell travels through the circulatory system. When the red blood cell reaches an oxygen-deficient cell, hemoglobin releases the oxygen molecule and picks up a molecule of carbon dioxide (CO_2). CO_2 is a normal cellular waste product. The red blood cell carries it to the lungs, where it is released and breathed out of the body. The hemoglobin molecule then picks up another oxygen molecule and the cycle repeats.

In a fire, a large amount of carbon monoxide, a colorless, odorless gas, is produced through incomplete combustion, or pyrolysis. Hemoglobin binds to CO two hundred times more easily than it binds to oxygen. When CO enters the lung, it rapidly binds to hemoglobin, making it impossible for the hemoglobin to pick up any oxygen molecules. Once the CO is bound to hemoglobin, it remains tightly attached, so that over time less and less oxygen can be picked up in the lungs and carried to cells, and little CO_2 is removed.

When the level of CO in a person's blood reaches about 30 percent, the person becomes confused; this state may contribute to the inability to escape from a fire. As the amount of CO increases (many victims of smoke inhalation have as much as 80 percent of their hemoglobin bound to CO), the body is simply too depleted of oxygen for cells to continue to function. Breathing air with 100 parts per million of CO can be fatal in half an hour; air with 5,000 parts per million of CO causes death within a few minutes. Carbon monoxide poisoning causes asphyxiation at the cellular level.

Signs of Foul Play

Typically in the United States, when a person dies in a fire, an autopsy is performed to determine the cause of death whether the fire was accidental or arson is suspected. In addition to looking for external burns, the pathologist looks for signs of damage to the tissues lining the airways. The presence of soot in the lungs indicates that the victim was breathing after the fire started. The amount of CO bound to hemoglobin in the blood may also be measured after death.

Sometimes fires are set to cover up or destroy evidence of other crimes, such as murder. As long as remains recovered from a fire scene include airways that can be examined, however, a forensic pathologist can determine whether the victim was alive at the time the fire started. If death occurred before the fire began, the body will show no signs of airway burns, even if the external body is charred. No soot or particulate matter will be found in the airways and lungs, and the level of CO in the blood will be less than 15 percent.

Martiscia Davidson

Further Reading

Faith, Nicholas. *Blaze: The Forensics of Fire*. New York: St. Martin's Press, 2000. Discusses how fire and arson investigators work and how forensic scientists contribute to solving the crime of arson.

MacDonald, Jake. "After the Inferno: Winnipeg's Arson Squad Can Tell How a Fire Started and Often Who Started It, by Sifting Through the Ashes and Reading Scorch Marks on the Wall." *Saturday Night*, May 20, 2000, 24-32. Examines how fires are investigated. Includes discussion of how doctors recognize death by smoke inhalation.

Redsicker, David R., and John J. O'Connor. *Practical Fire and Arson Investigation*. 2d ed. Boca Raton, Fla.: CRC Press, 1997. Provides comprehensive coverage of all aspects of fire investigations, with emphasis on fires that cause deaths.

Shusterman, Dennis. "Predictors of Carbon Monoxide and Hydrogen Cyanide Exposure in Smoke Inhalation Patients." *Journal of Toxicology: Clinical Toxicology* 34 (January, 1996): 61-72. Reports the findings of a research study that looked at the levels of carbon monoxide and cyanide in the blood of smoke inhalation victims.

Tanner, Robert. "New Science Challenges Arson Convictions." *The Washington Post*, December 31, 2006; p. A08. Details the case of a false conviction based partially on smoke inhalation evidence.

See also: American Academy of Forensic Sciences; Arson; Asphyxiation; Autopsies; Carbon monoxide poisoning; Chicago nightclub stampede; Choking; Forensic pathology; Suffocation.

Sobriety testing

Definition: Measures taken by law-enforcement officials to determine whether persons are intoxicated in situations in which being intoxicated is dangerous or unlawful.

Significance: The results of sobriety testing by police officers are often used as evidence in court and may be the primary evidence in cases involving charges such as driving while intoxicated or driving under the influence of alcohol or other drugs.

Many different kinds of testing can reveal the presence or absence of intoxicating substances in the human body. Urine and blood tests can effectively screen for the presence of drugs or alcohol in a person's system, but these tests are not generally convenient for providing information in the field when a law-enforcement officer suspects that someone may be under the influence. Instead, especially during traffic stops, field sobriety tests are used.

A law-enforcement officer may administer a field sobriety test any time the officer has reason to believe that a driver may be intoxicated. Among the many signs that indicate an individual may be under the influence of alcohol are the smell of alcohol on the breath, intoxicated demeanor, and slurred speech. These signs, however, are subjective. To increase the standardization of field sobriety testing across the United States, the National Highway Traffic Safety Administration (NHTSA) created the Standardized Field Sobriety Test (SFST), a set of recommended field test procedures.

The SFST consists of three separate tests,

An officer administers the horizontal gaze nystagmus test, part of the Standardized Field Sobriety Test, to a person suspected of driving under the influence of alcohol. During this test, the officer asks the subject to follow the movement of a small object with his or her eyes, and the officer assesses the individual's ability to follow the object as well as the amount and location of the jerking movements of the eyes. *(© iStockphoto.com/Frances Twitty)*

the results of which the administering officer evaluates on a variety of factors. The first test is designed to measure the subject's horizontal gaze nystagmus (HGN), which is the jerking of the eye that occurs when the eye moves from one side to the other. This occurs naturally and cannot be controlled voluntarily. During the HGN test, the officer asks the subject to follow the movement of a small object, such as a finger or pen, with his or her eyes. The officer moves the object horizontally in front of the subject's face and assesses the individual's ability to follow the object as well as the amount and location of the jerking movements of the eyes. Compared with a person who is not intoxicated, a person who is intoxicated will show more jerking movement when the gaze is more centered.

The other tests in the SFST are the one-leg stand test and the walk-and-turn test. Both are designed to test the subject's ability to do two or more things at the same time. During the walk-and-turn test, the officer asks the subject to take nine steps, heel to toe, in a straight line and then turn and take nine steps back. During the one-leg stand test, the subject attempts to stand on one leg while counting. During both of these tests the officer uses a predetermined set of guidelines to assess the subject's ability to perform the specified tasks. The subject's failure on a set number of attributes results in a determination that the subject is intoxicated. Research has shown that officers who use the three tests of the SFST together make correct determinations of intoxication in more than 90 percent of cases.

Helen Davidson

Further Reading

Haggin, Daniel J. *Advanced DUI Investigation: A Training and Reference Manual*. Springfield, Ill.: Charles C Thomas, 2005.

Wilson, Mike, ed. *Drunk Driving*. Detroit: Greenhaven Press, 2007.

See also: Breathalyzer; Drug abuse and dependence; Drug and alcohol evidence rules; Drug confirmation tests; Mandatory drug testing; National Transportation Safety Board.

Soil

Definition: Earth's outer crust, which consists of rocks and humus, serves as ground for vegetation, and houses a wide array of materials, including glass and metals.

Significance: Soil is the structural matrix or home for bacteria, plants, fungi, and nematodes, all of which are living organisms and all of which exist in the soils of different areas in varying identifiable combinations. Because soil is ubiquitous material and is easily transferred from one place to another, soil evidence often plays a role in criminal investigations. By comparing soil samples, forensic scientists can link persons and objects to crime scenes.

Soil has been used as material evidence in crime scene investigations since the 1890's. For many years, basic microscopy and morphological analyses were the primary means of soil comparison, but increasingly sophisticated techniques have greatly enhanced forensic scientists' ability to compare the contents of soil samples. Depending on the type of case and the other types of evidence available, physical examination of soil alone might provide the complementary information needed. Soils can be classified into different types based on their physical characteristics. Geologists, for example, classify soils according to particle size distribution, pH, color, and moisture content as well as other physical features. The analysis of soils for forensic purposes, however, often requires more detail than simple physical examination can provide. Forensic scientists look at soil not as an isolated material but as a group of materials, including any particles and any organisms that are part of a given sample.

Chemical Analyses

The quantities of soils found at crime scenes are not necessarily abundant, and small samples often limit the techniques forensic scientists can use to perform some physical analyses. Small sample size is not an impediment to analysis of soil's content, however. Scientists can chemically analyze soils for trace elements and metals using techniques such as mass spectrometry (MS), which establishes a relationship between the mass and the ratio of the elements in a sample. MS technology is often coupled with other, more sensitive technologies to elucidate the elemental composition of a wide array of samples, ranging from the simplest to the most complicated matrices, including, but not limited to, drugs,

An investigator collects soil samples. Because soil is easily transferred from one place to another, soil evidence often plays a role in criminal investigations. *(© iStockphoto.com/Bart Coenders)* chemical warfare agents, and environmental samples. Some of the technologies used in combination with MS are inductively coupled plasma (ICP-MS), gas chromatography (GC-MS), liquid chromatography (LC-MS), glow discharge (GD-MS), and capillary electrophoresis (CE-MS).

Other analysis methods that do not involve mass spectrometry can provide similar results, such as inductively coupled plasma-optical emission spectrometry (ICP-OES) and atomic absorption spectroscopy (AAS). These various techniques provide different separation matrices and principles, and analysts must decide which should be used based on the type of sample being analyzed, the limit of detection, and the output resolution requirement.

Environmental samples have to be digested before being introduced into the instrument of choice. Once they are introduced either as a liquid (slurry) or a microspray, the ions are separated on the provided separation matrix based on their mass-to-charge ratio. The number of ions produced for a specific mass is assumed to be proportional to the amount present in the sample; these data are constantly transferred to a computer and analyzed by software that produces a mass spectrum. The masses are then compared to those in reference libraries or in the literature to determine the different elements present in the sample. These methods provide relatively fast, highly specific, and sensitive multielemental analytical information.

Molecular Analyses

When the amount of soil recovered at a crime scene is sufficient for both physical and chemical analyses, a more specific soil profile can be obtained, and this can help establish soil uniqueness. In some instances, however, the recovered amount of soil is too minute to allow either physical or chemical analysis. In such cases, information on soil content may be obtained through DNA (deoxyribonucleic acid) analysis of microbial, fungal, and plant genomes present in the soil. Recent studies have shown that such analysis can provide unique information about the organism or material in question. Novel molecular techniques coupled with separation technologies used for human DNA analysis have been able to provide unique soil "fingerprints" that can be compared with known samples.

Specific markers exist in the DNA of every organism. Plants have sequences repeated in tandem, as is the case with humans. Microbes and fungi contain conserved and variable regions throughout their genomes; the differences encountered in the variable regions are what give each organism its unique identity. Ribosomal ribonucleic acid (rRNA) has been the marker of choice in the analysis of microbial communities because, unlike protein markers, rRNA is ubiquitous.

Terminal restriction fragment length polymorphism (TRFLP) and amplicon length heterogeneity (ALH) have both proven successful in determining the microbial community composition of soils. The first uses labeled primers that will bind to the ends of specific primer sequences to be amplified using polymerase chain reaction (PCR). The PCR product is then cut with restriction enzymes; these molecular scissors recognize specific sequences and cut the DNA wherever a specific site is recognized. Because the sequences of the organisms are different, different patterns are obtained. ALH uses fluorescently labeled universal primers to amplify the variable regions within the genome. Both techniques use high-resolution genetic analyzers to separate the obtained fragments. The results are recorded by a camera and transferred to a computer, which makes the pattern available to the analyst for subsequent comparisons.

Lilliana I. Moreno

Further Reading

Conklin, Alfred R. *Introduction to Soil Chemistry: Analysis and Instrumentation*. Hoboken, N.J.: John Wiley & Sons, 2005. Textbook describes the chemical properties of soil and the different methods that can be used to analyze soil samples.

Heath, Lorraine E., and Venetia A. Saunders. "Assessing the Potential of Bacterial DNA Profiling for Forensic Soil Comparisons." *Journal of Forensic Sciences* 51, no. 5 (2006): 1062-1068. Discusses the use of microbial DNA in establishing differences and similarities in soil material.

Moreno, Lilliana I., et al. "Microbial Metagenome Profiling Using Amplicon Length Heterogeneity-Polymerase Chain Reaction Proves More Effective than Elemental Analysis in Discriminating Soil Specimens." *Journal of Forensic Sciences* 51, no. 6 (2006): 1315-1322. Compares and contrasts the different methods of soil analysis to determine which is better suited for forensic comparisons.

Petraco, Nicholas, and Thomas Kubic. "A Density Gradient Technique for Use in Forensic Soil Analysis." *Journal of Forensic Sciences* 45, no. 4 (2000): 872-873. Describes the preparation of soils for physical characterization based on density.

Pye, Kenneth. *Geological and Soil Evidence: Forensic Applications*. Boca Raton, Fla.: CRC Press, 2007. Provides guidance regarding the potential value and limitations of geological and soil evidence in forensic investigations. Very informative.

Ruffell, Alastair, and Jennifer McKinley. "Forensic Geoscience: Applications of Geology, Geomorphology, and Geophysics to Criminal Investigations." *Earth-Science Reviews* 69 (March, 2005): 235-247. Focuses on the history and improvements of methods for the analysis of soil and the application of soil analysis to crime scene settings.

See also: Atomic absorption spectrophotometry; Bacterial biology; Forensic archaeology; Forensic botany; Forensic geoscience; Forensic palynology; Gas chromatography; Geological materials; High-performance liquid chromatography; Laser ablation-inductively coupled plasma-mass spectrometry; Mass spectrometry; Restriction fragment length polymorphisms.

Soman

Definition: Highly toxic colorless liquid that has potential for use as a chemical weapon.

Significance: Concerns that terrorists could employ chemical agents in attacks have increased law-enforcement agencies' attention to substances such as soman. The manufacture and storage of soman are banned by the United Nations Chemical Weapons Convention of 1993.

The nerve agent soman was first prepared in 1944 in Germany as part of that nation's chemical warfare program. Soman, which has a camphorlike odor, is chemically similar to sarin, but more toxic. Nerve agents such as soman act as inhibitors of the enzyme acetylcholinesterase (AChE). The neurotransmitter acetylcholine is released at nerve endings and causes muscle contraction. In the normal course of affairs, the acetylcholine is soon destroyed by a reaction catalyzed by AChE. If this enzyme is disabled in its function by binding to a nerve agent, the continued presence of acetylcholine produces the symptoms of poisoning: pain and watering in the eyes, contracted pupils (meiosis), respiratory failure, runny nose, incontinence, convulsions, coma, and death.

Although soman is twice as toxic as sarin and more persistent in the environment, the U.S. Army decided in 1948 to develop sarin as a weapon instead of soman. The manufacture of soman would have been more costly, and the lack of a sufficiently effective antidote was felt to be a disadvantage in case of accidental exposures. The Soviet Union, however, did manufacture soman, using captured German technology.

Soman has apparently not been used in warfare or terrorism. Soman poisoning leaves detectable traces on, around, or in the bodies of victims, and blood samples can be tested for AChE levels, which are abnormally low in individuals exposed to the agent. The U.S. military employs test kits and instruments that can detect nerve agents and provide warnings. In the laboratory, soman can be detected through the use of gas chromatography-mass spectrometry (GC-MS) or capillary column gas chromatography using a chiral medium.

Treatment of nerve agent poisoning involves injection of atropine and administration of pralidoxime chloride (2-PAM chloride). This treatment needs improvement, and research in the area is active. A complicating factor that is particularly prominent with soman is an irreversible reaction known as aging, which renders the soman-AChE complex inactive to pralidoxime within about ten minutes of exposure.

During the Persian Gulf War of 1991, U.S. soldiers were given pyridostigmine bromide (PB) as a prophylactic measure in the mistaken belief that Iraq might attack with soman. Carbamates such as PB bind reversibly with AChE and block the soman so that when exposure to the nerve agent ends, AChE can re-form. Nerve agent scavengers such as exogenous AChE can also provide protection.

John R. Phillips

General H. Norman Schwarzkopf with U.S. troops during the Gulf War of 1991. During that conflict, pyridostigmine bromide was distributed to many U.S. troops because of fears that Iraqi forces might use soman as a weapon. *(AP/Wide World Photos)*

Further Reading

Croddy, Eric A., and James J. Wirtz, eds. *Weapons of Mass Destruction: An Encyclopedia of Worldwide Policy, Technology, and History*. Santa Barbara, Calif.: ABC-CLIO, 2005.

Hoenig, Steven L. *Handbook of Chemical Warfare and Terrorism*. Westport, Conn.: Greenwood Press, 2002.

Somani, Satu M., and James A. Romano, Jr., eds. *Chemical Warfare Agents: Toxicity at Low Levels*. Boca Raton, Fla.: CRC Press, 2001.

Suzuki, Osamu, and Kanako Watanabe, eds. *Drugs and Poisons in Humans: A Handbook of Practical Analysis*. New York: Springer, 2005.

Tucker, Jonathan B. *War of Nerves: Chemical Warfare from World War I to al-Qaeda*. New York: Pantheon Books, 2006.

See also: Centers for Disease Control and Prevention; Chemical agents; Chemical terrorism; Chemical warfare; Nerve agents; Nervous system; Sarin; Tabun.

Spectroscopy

Definition: Techniques for producing and analyzing spectra formed by the emission or absorption of electromagnetic radiation accompanying changes between the energy levels of atoms and molecules.

Significance: Using spectroscopy, forensic scientists examine the spectra of evidence samples obtained from crime scenes or related locations to analyze their chemical content and determine the energy levels and molecular structures of the materials. Such analysis may enable investigators to link crime scene materials to suspects.

Forensic scientists use a variety of spectroscopic methods over a large range of frequencies, and their spectroscopic analyses yield a wide variety of information about trace evidence—including soils, glass, drugs, pigments, dyes, inks, fuels, and explosives—found at crime scenes or related locations. The underlying principle of all spectroscopic techniques is that substances selectively absorb certain frequencies of electromagnetic radiation and reflect or transmit others.

One way of classifying spectra is according to whether the radiation is in the infrared (IR), ultraviolet (UV), visible, X-ray, or microwave region of the electromagnetic spectrum. In forensic applications, IR spectroscopy is the most common spectroscopic method used, because most substances absorb IR very selectively. The IR spectra of thousands of substances have been cataloged and stored in computer databases to be used for comparison tests with IR spectra from suspected evidence obtained at crime scenes or related locations. UV and visible spectral analysis are used for some types of evidence, particularly drug samples and arson accelerants found in fire scene debris.

Mass spectrometry (MS) is used to identify unknown substances under investigation. Components of substances are typically separated using chromatography and are then sent into a high-vacuum chamber to be ionized by high-speed electrons. Ion fragments pass through a magnetic field, and the shapes of their parabolic trajectories determine their mass-to-charge ratios. No two substances have the same fragmentation patterns and trajectories. MS acts as a "fingerprint" for analyzed trace evidence.

X-ray fluorescence (XRF) spectroscopy has been used to help identify weapons used in crimes and in analyzing debris that has resulted from explosions. XRF has been successful in identifying paint, leather, plastic, glass, and ceramic samples in forensic studies. The method can reveal the elements contained in pigments of various colors of paint as well as chromium and other elemental content in leather. It has been used to identify the presence of arsenic in glasses and lead in enamels. XRF has also been used successfully to identify hidden fingerprints at crime scenes.

Raman spectroscopy (RS) has proven very useful in identifying fiber, ink, dye, and resin evidence. RS is based on the fact that when light from a high-intensity laser is reflected off a material, a small fraction of the reflected light is shifted to a frequency slightly different from that of the original laser light. From this frequency shift, the sample material can be identified. The RS spectra act as "optical fingerprints" for molecular composition. The method can even differentiate between the compositions of inks of the same color.

Alvin K. Benson

Further Reading

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007.

Tilstone, William J., Kathleen A. Savage, and Leigh A. Clark. *Forensic Science: An Encyclopedia of History, Methods, and Techniques*. Santa Barbara, Calif.: ABC-CLIO, 2006.

See also: Analytical instrumentation; Electromagnetic spectrum analysis; Energy-dispersive spectroscopy; Fourier transform infrared spectrophotometer; Infrared detection devices; Mass spectrometry; Micro-Fourier transform infrared spectrometry; Microspectrophotometry; Nuclear spectroscopy; Scanning electron microscopy; Ultraviolet spectrophotometry.

Sperm. *See* Semen and sperm

Sports memorabilia fraud

Definition: Sale of sports memorabilia falsely claimed to have been autographed or used by a sports celebrity.

Significance: Forgers and other scam artists have taken advantage of the high interest in sports memorabilia among the American public to make a great deal of money selling fraudulent autographs and supposedly game-used sports equipment. Law-enforcement agencies have increased their efforts to address this form of fraud.

Heightened interest in professional sports, a good economic climate in which many people had disposable income, and the explosion of online marketing came together in the 1990's to create an expanded interest in sports collectibles in the United States. With rising interest and prices, forgeries of sports figures' autographs became increasingly common. According to the Federal Bureau of Investigation (FBI), the sports memorabilia market in the early twenty-first century generated more than one billion dollars in sales annually in the United States. Reputable auction houses such as Christy's and Sotheby's, along with many online companies, began holding sales of sports collectibles. Prices soared for memorabilia such as trading cards, autographed pictures, programs, helmets, jerseys, balls, pucks, and other paraphernalia that had been used in competition (referred to by collectors as "game-used" items). As interest and prices increased, forgeries and fraudulent memorabilia flooded the sports collectibles marketplace. The problem expanded from the United States to involve forgers and suppliers in Europe and Asia as well.

Sports Souvenir Forgery and the Law

Forgery has always been illegal, and many law-enforcement agencies maintain divisions to investigate art and document forgery. For several reasons, however, the forging of autographs on sports memorabilia presented new problems for law enforcement. First, most current sports figures do sign autographs, so hundreds of legitimate autographs of a single celebrity may be in existence. This makes it difficult or impossible to prove a direct link between any particular autograph and the sports figure. Second, compared with art, autographs are relatively easy to forge, and, unlike signatures on legal documents, the autographs of sports figures initially did not require authentication, such as witnesses or notarizing. Third, many sports souvenirs are sold through the Internet, which eliminates the opportunity for buyers to examine the goods in person or seek second opinions before they buy and geographically separates buyer and seller, making prosecution for forgery difficult. Finally, many sports forgeries sell for little enough money that duped buyers, should they

Operation Bullpen

The following is excerpted from an overview of Operation Bullpen, a sports memorabilia investigation carried out by the Federal Bureau of Investigation, provided on the FBI's Web site.

In 1997, the FBI in San Diego utilized information from Operation Foul Ball and other sources to institute an undercover operation designed to infiltrate the nationwide memorabilia fraud network. Together with the U.S. Attorney's Office and the Internal Revenue Service, an undercover scenario was devised in which an Undercover Agent would pose as a distributor of American memorabilia in Asia. This scenario enabled the FBI to purchase evidence without causing the sale of forged items to the public. It also made the criminals more likely to openly discuss the counterfeit nature of the memorabilia, because it was "going overseas" beyond the reach of U.S. law enforcement agencies. To support this "cover story," the FBI established the Nihon Trading Company in Oceanside, California. . . .

The key evidence in this investigation were recorded statements which provided evidence of the individuals' involvement in forging, fraudulently authenticating, and/or distributing the materials. In Operation Bullpen, referred to as Phase I, the San Diego Division of the FBI conducted well over 1,000 consensually recorded audio and video tapes. During the consensually recorded conversations, numerous co-conspirators made incriminating statements which illuminated the nature and common practices involved with sports memorabilia fraud. For example, one of the conspirators liked to joke to the Undercover Agent how Mickey Mantle still has one arm out of the grave signing autographs. Other conspirators were noting how Wilt Chamberlain was still available for signing weeks after his death.

A special agent of the Federal Bureau of Investigation displays a "certificate of authenticity" for a baseball purportedly signed by Mother Teresa at a news conference held in San Diego, California, on February 14, 2001, to announce the bureau's arrest of a ring of counterfeiters involved in producing millions of dollars' worth of fake sports trading cards. In the foreground is a printer's proof of a counterfeit card featuring Sammy Sosa. *(AP/Wide World Photos)*

discover they have been swindled, are unlikely to report it to the police.

California was the first U.S. state to pass a law specifically aimed at curbing sports souvenir fraud. The Autographed Sports Memorabilia Statute of 1992 required dealers selling sports figures' autographs to provide certificates of authenticity (COAs) to buyers. Using this law, a group of buyers who had bought forged autographs online sued the Internet auction company eBay, which is based in California, for not providing COAs. They lost their suit when the court decided that eBay is a marketplace, not a dealer, and is therefore exempt from the law. Before long, in any case, COAs lost much of their value, as forgers soon learned that with a little practice and good computers they could easily manufacture false COAs.

In 1997, the FBI began an investigation of sports autograph forgery in San Diego, California, called Operation Foul Ball. This effort broke up five southern California forgery rings and resulted in the conviction of twenty-six individuals. The FBI next initiated a national investigation called Operation Bullpen, which set up a false import-export company in order to infiltrate wholesale providers of fraudulent sports memorabilia. By 2001, raids in twelve U.S. states broke up thirteen memorabilia forgery rings and two sports card forgery rings. Thirty-six individuals were eventually convicted. Despite the involvement of the FBI, however, sports souvenir forgery continues to be a major international problem.

Protecting Against Fraud

In response to Operation Bullpen, Major League Baseball (MLB) became the first sports league to take concerted action to prevent memorabilia fraud. MLB created its own authentication program, which requires the presence of an independent witness to an autograph by any MLB player; at the time an autograph is witnessed, a numbered hologram is placed on the item so that its ownership can be tracked in a database. A number of reputable sports memorabilia companies began using similar procedures; some also videotape sports stars throughout their autograph-signing sessions.

Despite these measures, forgery is rampant. Following Operation Bullpen, the FBI reported finding warehouses full of fraudulent sports memorabilia. The agency estimated that in 2003 at least half the autographed sports and celebrity items sold were fakes, and that the proportion increased to 75 to 80 percent for items sold on eBay. Among the sports figures most popular with forgers are Muhammad Ali and Mark McGwire; it has been estimated that more than 99 percent of the purported Ali and McGwire signatures for sale are forgeries.

To decrease their chances of buying fraudulent items, consumers should buy from reputable dealers or auction houses and should ask for proof of authenticity or evidence that provides a solid link between the sports figure and the autographed item. Consumers should also educate themselves about the history of pens and balls, as these items change over time. For example, if an autograph of an old-time ballplayer is signed with a Sharpie pen, it is a forgery, because Sharpies are relatively new writing instruments. Consumers should also consider the prices being asked for the items they are seeking—if the price of an item is too good to be true, the item is probably a fake. In addition, consumers should avoid collecting the autographs of stars who are having exceptional seasons or who have died unexpectedly, as the incidence of forgeries is highest with the best-known and most newsworthy individuals. Finally, consumers who suspect that any sports memorabilia being offered for sale is fraudulent should report the matter to the police.

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Further Reading

Brayer, Ruth. *Detecting Forgery in Fraud Investigations: The Insider's Guide*. New York: ASIS International, 2000. Provides an introduction to the detection of forged documents. Intended for readers with some background in forensics and the legal aspects of forgery cases.

Nausbaum, David. "Forgeries, Theft Take Some of the Thrill out of Collectibles." *Los Angeles Business Journal*, July 10, 2006, 11. Presents an analysis of the problem of sports forgeries and makes suggestions for combating the problem.

Nickell, Joe. *Detecting Forgery: Forensic Investigation of Documents*. 1996. Reprint. Lexington: University Press of Kentucky, 2005. Excellent introduction to the topic approaches forgery from an investigative perspective. Presents the technical aspects of analyzing documents while discussing several famous forgery cases.

Walton, Kenneth. *Fake: Forgery, Lies, and eBay*. New York: Simon Spotlight Entertainment, 2006. Autobiographical account of memorabilia fraud by a reformed eBay forger.

Williams, Pete. *Sports Memorabilia for Dummies*. Foster City, Calif.: IDG Books Worldwide, 1998. Provides a basic introduction to the pastime of collecting sports souvenirs.

See also: Art forgery; Check alteration and washing; Counterfeiting; Forgery; Handwriting analysis; Hitler diaries hoax; Questioned document analysis; Secret Service, U.S.; Writing instrument analysis.

Spot tests. *See* Crime scene screening tests

Steganography

Definition: Method of hiding information within written documents or electronic files in ways that are not obvious to anyone except the intended recipients.

Significance: In examining electronic evidence in cases of computer-related crimes, forensic scientists may determine that steganography has been used to pass sensitive information in innocent-looking documents or other electronic files.

The term "steganography" comes from two Greek words, *steganos*, meaning "covered," and *graphos*, meaning "writing"; that is, steganography is the science of covered, or hidden, writing. Steganography differs from cryptography. In cryptography, the presence of hidden information is clear even though the information cannot be read easily because it is encoded. In steganography, the presence of hidden information is disguised in an ordinary-looking document that gives no clue to its presence. The hidden information may or may not be encoded, but the strength of steganography is that the presence of the secret information is not apparent.

The information does not call attention to itself, and uninitiated viewers simply see the cover document and are not stimulated to look for additional information in it.

Steganography has a long history. The ancient Greeks are reported to have tattooed secret messages on the shaved heads of slaves, then, after the hair grew back, sent the slaves to deliver the hidden messages. During World War II, spies conveyed secret information in ordinary letters by writing between the visible lines in invisible ink that became visible only when the paper was heated. Photographic microdots were also used during World War II and after, over the course of the Cold War. One of these tiny dots could be substituted for a period at the end of a sentence in a document; the recipient would then remove the dot and enlarge it to retrieve the information it contained.

Modern steganographic techniques involve the insertion of hidden information into computer files. Information can be inserted into text documents, into picture files such as JPEG files, or into audio files such as MP3 files. The secret information is hidden from the ordinary viewer or listener, but the intended recipient can extract the information using a special program and password. Many techniques have been developed for hiding electronic data in computer files using easily available software. The hidden data generally replace irrelevant or relatively unimportant bits in the original file. Data are most successfully hidden when the size of the secret message is small compared with the size of the cover file.

The science of detecting information that has been hidden in this way is called steganalysis. Computer forensics experts can detect data hidden with steganography by using programs designed for this purpose. In their simplest form, these programs compare original (clean-copy) files with altered (data-inserted) files, but many more sophisticated methods of steganalysis have also been developed.

Persons involved in computer-related crime may use steganography to conceal information about their activities from both casual observers and police investigators. Also, steganography may be used in industrial espionage to export sensitive information from company computers to competitors. This method of passing hidden messages has many other potential uses as well.

Martiscia Davidson

Further Reading

Katzenbeisser, Stefan, and Fabien A. P. Petitcolas, eds. *Information Hiding Techniques for Steganography and Digital Watermarking*. Norwood, Mass.: Artech House, 2000.

Radcliff, Deborah. "Quick Study: Steganography—Hidden Data." *Computerworld*, June 10, 2002.

Wayner, Peter. *Disappearing Cryptography: Information Hiding—Steganography and Watermarking*. 2d ed. San Francisco: Morgan Kaufmann, 2002.

See also: Computer crimes; Computer forensics; Cryptology and number theory; Document examination; Internet tracking and tracing; Photograph alteration detection; Tattoo identification.

Stimulants

Definition: Broad group of substances that share the capacity to activate and excite the human central and peripheral nervous systems as well as the cardiovascular system.

Significance: Many people make regular use of nonmedical, legal stimulants such as caffeine, but stimulants are also often misused. Crimes related to the use and distribution of illicit stimulants—including fraud, forgery, robbery, and even murder—occupy many of the resources of law-enforcement agencies and are costly to society.

Drugs that have stimulant properties are many in number and varied in form. All forms of cocaine and amphetamines are classified as stimulants, including concoctions that can be created in small clandestine labs, such as methcathinone, made from amphetamine and cathinone, and the street drug known as crystal or ice, a kin of methamphetamine made from seemingly innocuous and easily available ingredients. Other drugs that stimulate the nervous and cardiovascular systems include widely used substances such as nicotine and caffeine as well as less commonly known substances such as khat leaves (the leaves of the plant *Catha edulis*), which are chewed to deliver mild stimulating effects.

Use and Abuse

Stimulant drugs have a limited number of legitimate uses, such as in the treatment of attention-deficit/hyperactivity disorder (ADHD). Appetite-suppressing drugs (also known as anorectics) used in the treatment of obesity are also stimulants, as are drugs used in the treatment of narcolepsy, a disorder characterized by random immediate onset of sleep. Stimulants are not widely employed in the treatment of other medical problems, as the use of these drugs has not received much support in terms of the balance of benefits over risks. The primary risks of stimulant use include raised blood pressure and the possibility of the development of a substance-use disorder, such as abuse or dependence.

Stimulants have addiction potential because they are reinforcing drugs. Users typically experience feelings of euphoria and power, decreased need for sleep, relief from fatigue, decreased appetite, increased talkativeness, and increased energy. These effects alone qualify stimulants for classification as performance-enhancing drugs, not only for athletes but also for others who may need these benefits, such as workers who need to stay awake during long shifts or long-distance truck drivers. For individuals who are easily distracted, such as those with ADHD, stimulants also tend to decrease distractibility, allowing them to focus their attention. In addition, stimulants may increase sexual interest and excitement and, because of decreased fatigue, improve sexual performance.

The typical routes of administration for recreational stimulants (nasal inhalation, inhalation through smoking, and intravenous injection) tend to promote rapid effects on the body and strengthen the association of taking the drugs with its effects. In general, the quicker a drug takes effect, the easier it is for the body and mind to associate the drug with the experienced pleasure and the greater the addiction potential.

Dangers and Side Effects

The problems associated with stimulant use are numerous. Aside from the desirable effects described above, stimulant intoxication can cause much less attractive effects, including paranoia, anxiety, panic, psychosis, rapid pulse rate, hyperalertness, restlessness, insomnia, confusion, hallucinations, agitation, aggression, violence, and suicidal or homicidal tendencies. It is not uncommon for stimulant use to be associated with crimes related to personal and interpersonal injury, assaults, and accidents.

Stimulant abusers often suffer physical problems such as worn-down teeth (from bruxism, or teeth grinding), injuries from the compulsive repetitive handling or manipulation of objects or the body (for example, facial picking), arrhythmias, heart damage, and even seizures. When withdrawing from stimulants, individuals may experience feelings of confusion and depression, increased fatigue, and other symptoms.

Many of the symptoms of stimulant use, abuse, and dependence mimic the problems of other mental health disorders. Because of this, persons who seek help for such symptoms resulting from stimulant use are often treated as if they have some of these other problems. For example, they may be treated initially for sleep problems, anxiety, depression, or psychosis with drugs such as sleep aids, antianxiety agents, antidepressants, and antipsychotics. As they cease stimulant use and detoxify, their symptoms often resolve or decrease, and they consequently can stop these treatments. In some cases, however, after chronic stimulant use, the damage done can be more lasting, and treatments may need to be maintained.

Legal Issues and Crime

The manufacturers, distributors, and end users of illegal stimulants are all participants in various forms of crime. Manufacturers take part in the illegal procurement of component parts of these drugs and threaten the public health with the dangerous conditions they create in clandestine labs (where poor ventilation can lead to explosions or fires) and with the toxic chemicals they dump into the environment. They also commit crimes such as battery, assault, and murder at times to protect their illegal labs from being discovered or disturbed.

Once the drugs are made, illegal trafficking and sales become part of the picture, as does the potential for money laundering and other financial crimes. For end users, crimes related to intoxication are common, including driving under the influence, as are acts of violence and aggression related to paranoia and other psychological effects. Stimulant users sometimes commit crimes as a result of drug-induced feelings of power and euphoria, which may lead them to believe they are smarter than everyone else and can break laws without fear of being caught. Such users may commit fraud, forgery, crimes of opportunity, and even murder.

Nancy A. Piotrowski

Further Reading

Inaba, Darryl S., and William E. Cohen. *Uppers, Downers, All-Arounders: Physical and Mental Effects of Psychoactive Drugs*. 5th ed. Ashland, Oreg.: CNS, 2003. Provides an easy-to-read overview of a broad spectrum of stimulants, including look-alikes and over-the-counter drugs.

Julien, Robert M. *A Primer of Drug Action: A Comprehensive Guide to the Actions, Uses, and Side Effects of Psychoactive Drugs*. 10th ed. New York: Worth, 2005. Reliable, long-standing text provides information on how particular drugs affect individuals at different life stages, from youth to old age.

Solanto, Mary V., Amy F. T. Arsnten, and F. Xavier Castallanos, eds. *Stimulant Drugs and ADHD: Basic and Clinical Neuroscience*. New York: Oxford University Press, 2001. Presents a technical discussion of how stimulant drugs have been used to treat attention-deficit/hyperactivity disorder. Notes the drugs' effects on behavior and their side effects, as well as relevant brain effects.

Weil, Andrew, and Winifred Rosen. *From Chocolate to Morphine: Everything You Need to Know About Mind-Altering Drugs*. Rev. ed. Boston: Houghton Mifflin, 2004. Presents a down-to-earth discussion of drugs that affect the mind. Easy to read.

Weinberg, Bennette Alan, and Bonnie K. Bealer. *The World of Caffeine: The Science and Culture of the World's Most Popular Drug*. New York: Routledge, 2002. Social history of caffeine addresses the stimulant's presence in a variety of commonly consumed products and its impacts.

See also: Amphetamines; Antianxiety agents; Antipsychotics; Attention-deficit/hyperactivity disorder medications; Club drugs; Crack cocaine; *Diagnostic and Statistical Manual of Mental Disorders*; Drug abuse and dependence; Drug classification; Forensic toxicology; Hallucinogens; Illicit substances; Performance-enhancing drugs.

STR. *See* Short tandem repeat analysis

Strangulation

Definition: Intentional act of applying pressure to a body part to cut off or restrict the flow of blood or air, resulting in loss of consciousness, injury, brain damage, or death.

Significance: Strangulation is a deliberate criminal act that takes place during such crimes as murder, sexual assault, domestic violence, and child abuse. Recognition of the signs of strangulation can aid forensic pathologists in determining cause of death and can help first responders get proper treatment for surviving victims.

Strangulation is used by a perpetrator to silence or kill the victim. Strangulation occurs during sexual assault, rape, domestic violence, child abuse, and other criminal acts. It is estimated that at least 50 percent of rape victims have been strangled.

A deputy coroner testifying in a trial in Ohio in early 2007 uses a drawing and his hands to demonstrate how a murder victim was strangled. *(AP/Wide World Photos)*

The act of strangulation entails applying pressure to a certain part of the body to reduce or stop blood flow to the brain or restrict oxygen in an airway. The brain needs oxygen to survive. Without oxygen, a person may lose consciousness, sustain brain injury or brain damage, or die. The perpetrator's hands or an object, such as a rope or cord, may be used to force restriction of oxygen at the victim's neck.

Only eleven pounds of pressure applied for ten seconds to the neck is necessary to force the restriction of oxygen to cause unconsciousness. Death can occur in four to five minutes with thirty pounds of pressure to the neck. Death can also result within thirty-six hours after strangulation if internal neck swelling is not diagnosed or treated.

After strangulation, injuries to the body may or may not be visible, but internal injuries could have taken place. Internal neck swelling is serious because it can jeopardize the airway passage needed for breathing. Persons who have been strangled and sustained no visible injuries have been known to die several weeks after strangulation as the result of undiagnosed brain damage. For these reasons, it is extremely important for first responders to ask crime victims if they were strangled, with or without loss of consciousness.

Signs of strangulation that should prompt medical attention include red spots on the skin (from capillaries bursting), bloodred eyes, neck swelling (subtle to severe), difficulty swallowing or breathing, vomiting blood, voice loss or raspy voice, coughing, and neck pain. Other signs that a person has been strangled include rope or cord burns, red vertical or horizontal line marks on the skin, scratches and bruises on the neck, and symptoms of brain injury, such as confusion, memory problems, mood changes, or personality changes. It is imperative that investigators carefully document and photograph any signs of strangulation injury.

Mary Car-Blanchard

Further Reading

Spitz, Werner U., ed. *Spitz and Fisher's Medicolegal Investigation of Death: Guidelines for the Application of Pathology to Crime Investigation*. 4th ed. Springfield, Ill.: Charles C Thomas, 2006.

Strack, Gael B., and George McClane. *How to Improve Your Investigation and Prosecution of Strangulation Cases*. San Diego, Calif.: San Diego City Attorney and San Diego City Police, 1999.

See also: Autoerotic and erotic asphyxiation; Autopsies; Choking; Defensive wounds; Forensic photography; Hanging; Homicide; Petechial hemorrhage; Rape; Suffocation.

Structural analysis

Definition: Evaluation of the engineering and construction of buildings and other structures.

Significance: When structures fail or are deliberately damaged, forensic scientists are often involved in conducting analyses to determine exactly what occurred. Structural analyses can reveal whether structural failures were caused by design flaws, by properties of the physical components used, or by other factors. In cases of deliberate destruction by explosive or mechanical means, structural analyses can determine the nature of the criminal acts and provide investigators with information about possible suspects.

The analysis of architectural structures such as buildings, bridges, and highways involves the evaluation of the physical and chemical properties of their material components and the engineering theory behind the ways in which these components are put together, which includes concern with the mechanics of the components' elasticity and their response to natural laws such as the law of gravity. Construction design involves applied theoretical frameworks of physics, chemistry, and mathematics. Generally, when structural deformations and design failures occur, engineers and physicists perform structural analyses; when catastrophic structural failures take place that may have been caused deliberately, forensic engineers become involved in such analyses. Forensic engineers are also sometimes involved in examining structural failures that have led to property damage or personal injury lawsuits; they may be called upon to determine whether such failures resulted from poor design, problems with construction, or lack of maintenance.

Architectural Design and Construction

The designs of structures begin with architects and engineers: Architects provide the artistic designs, and engineers detail the construction elements required to achieve those designs. Construction engineers determine the types and amounts of materials needed for structural projects. Typically, they use computer models to conduct extensive tests and determine how much of each material will be required; they examine the spatial relationships among the components to be used, the amount of weight or pressure each beam or other part can hold, and how the completed structure will function. Usually, engineers construct computer models of each design component and test each virtually under all potential conditions and stresses, such as varying load structures, earthquakes, and strong winds. These tests serve to identify any potential weaknesses that need to be eliminated in structural designs.

Forensic Engineering

Forensic engineering is a highly specialized branch of forensic science that is involved in the analysis of buildings and other constructed artifacts in legal cases of property damage, injury, and death. Most often, forensic engineers are called upon in cases concerned with liability issues resulting from property damage. In such cases, they help to determine the causes of structural failures.

The first task of a forensic engineer in a case of structural failure is to determine whether the structure of interest met all local, state, and federal building regulations, where applicable. For example, if the case concerns a house or business, the engineer must find out whether the structure met all building codes specified by the planning and zoning regulations of the town in which it was located. The engineer then goes on to examine systematically the individual components of the structure and how they related to one another.

One of the most common applications of forensic science in cases of structural failure is the analysis of damaged structures in which fires of suspicious origin are implicated. In such cases, forensic experts—both engineers and fire investigators—examine what remains of the structures to determine the fires' origins. They look at burn patterns and gather evidence for chemical analyses to identify the possible presence of accelerants, which can point to arson.

Forensic engineers are also involved in maintaining safe structures by conducting materials tests and analyses of building codes and reconstruction costs. By analyzing completed existing structures, forensic engineers can provide those responsible for maintaining the structures with recommendations for repairs and improvements that can help the structures remain safe while performing in an efficient manner.

Legal Issues

Legal cases that involve structural or architectural failures are decided under the laws of product liability, which are based in the legal concept that consumers must be protected from harm caused by dangerous or unreasonably unsafe products. Under product liability laws, manufacturers and distributors are responsible for injuries or property damage resulting from poor design of their products (including buildings and components of buildings such as doors and windows). For example, if a bridge was designed to withstand certain load specifications but forensic engineers determine that it failed under lesser pressure, the construction company that built the bridge would be deemed responsible under product liability laws and would be liable to pay compensation for damages and injuries resulting from the structural failure.

Dwight G. Smith

A material research engineer cuts a sample of metal to be analyzed from steel beams recovered from the World Trade Center after the terrorist attacks of September 11, 2001. The National Institute of Standards and Technology began an extensive study of the structural failure of the World Trade Center buildings in 2002. *(AP/Wide World Photos)*

Further Reading

Bosela, Paul A., and Norbert J. Delatte, eds. *Forensic Engineering: Proceedings of the Fourth Congress*. Reston, Va.: American Society of Civil Engineers, 2007. Collection of technical articles presented at a conference of forensic engineers covers a wide range of topics, including natural hazards, residential investigations, performance of transportation facilities, and historical cases.

Brown, Sam, ed. *Forensic Engineering: An Introduction to the Investigation, Analysis, Reconstruction, Causality, Prevention, Risk, Consequence, and Legal Aspects of the Fail-*

ure of Engineered Products. Humble, Tex.: ISI, 1995. Provides a thorough treatment of all aspects of building failure.

Day, Robert W. *Forensic Geotechnical and Foundation Engineering*. New York: McGraw-Hill, 1999. Covers the investigation and evaluation of building damage caused by geological changes, including settlement and expansion of soil and earthquakes. Aimed at professional engineers.

Noon, Randall K. *Forensic Engineering Investigation*. Boca Raton, Fla.: CRC Press, 2001. Comprehensive handbook discusses the procedures investigators follow in criminal cases of structural failure.

See also: Accident investigation and reconstruction; Arson; Blast seat; Bomb damage assessment; Burn pattern analysis; Electrical injuries and deaths; Improvised explosive devices; Oklahoma City bombing; Product liability cases; World Trade Center bombing.

Suffocation

Definition: Severe deprivation of the oxygen supply needed by the body to sustain life.

Significance: Death by suffocation often causes no exterior signs of trauma. During an autopsy, a forensic pathologist may be able to discover signs of chemicals in the lungs or other damage that would lead to a determination of suffocation as the cause of death.

The body can be deprived of oxygen to the point of death in a variety of ways, including through compression of the chest, interference with oxygen absorption, displacement of oxygen in the lungs, and smothering. Suffocation may occur intentionally, as in cases of murder or suicide, or it may occur accidentally.

Compression of the chest to the point of limiting the lungs' ability to expand can cause suffocation. This type of suffocation is a cause of death in situations involving panicked crowds (the most common cause of death in such disasters is suffocation, not trampling, as is often believed), accidents in which the victims are buried in substances such as sand or grain, and accidents in which objects fall on victims' chests. In the combat exercise known as "body scissors," the legs are used to compress an opponent's chest, depriving that person of oxygen. Snakes such as boa constrictors and pythons use this type of suffocation to kill their prey.

The body's absorption of oxygen can be interfered with chemically or physically. Chemical interference can be caused by agents such as carbon monoxide (often from car exhaust) or phosgene (a toxic compound used as a weapon during World War I, but now used as an industrial reagent). These agents interfere with the body's ability to absorb oxygen by bonding with blood cells in place of oxygen.

Another form of interference with oxygen absorption is physical displacement. This occurs when a type of gas takes the place of oxygen in the lungs. Some of the types of gases that can displace oxygen are hydrogen cyanide and potassium cyanide, which were previously used in gas chambers for execution and as chemical weapons and are now used in industrial applications. Displacement may also occur with smoke and other types of fumes or with another substance, such as water. In addition, oxygen may be displaced from the lungs in a vacuum or an extremely low-pressure environment; in such an environment, oxygen is literally sucked out of the lungs.

Smothering is a means of suffocation that involves the obstruction of the flow of air into the lungs. For example, an attacker may cover the mouth and nose of a victim with a physical object, such as a hand, a pillow, or a plastic bag. In some cases, such action may be combined with chest compression.

Marianne M. Madsen

Further Reading

Baden, Michael, and Marion Roach. *Dead Reckoning: The New Science of Catching Killers*. New York: Simon & Schuster, 2001.

Lyle, D. P. *Forensics and Fiction: Clever, Intriguing, and Downright Odd Questions from Crime Writers*. New York: St. Martin's Press, 2007.

Shkrum, Michael J., and David A. Ramsay. *Forensic Pathology of Trauma: Common Problems for the Pathologist*. Totowa, N.J.: Humana Press, 2007.

See also: Asphyxiation; Autoerotic and erotic asphyxiation; Carbon monoxide poisoning; Chicago nightclub stampede; Choking; Drowning; Hanging; Inhalant abuse; Petechial hemorrhage; Smoke inhalation; Strangulation.

Suicide

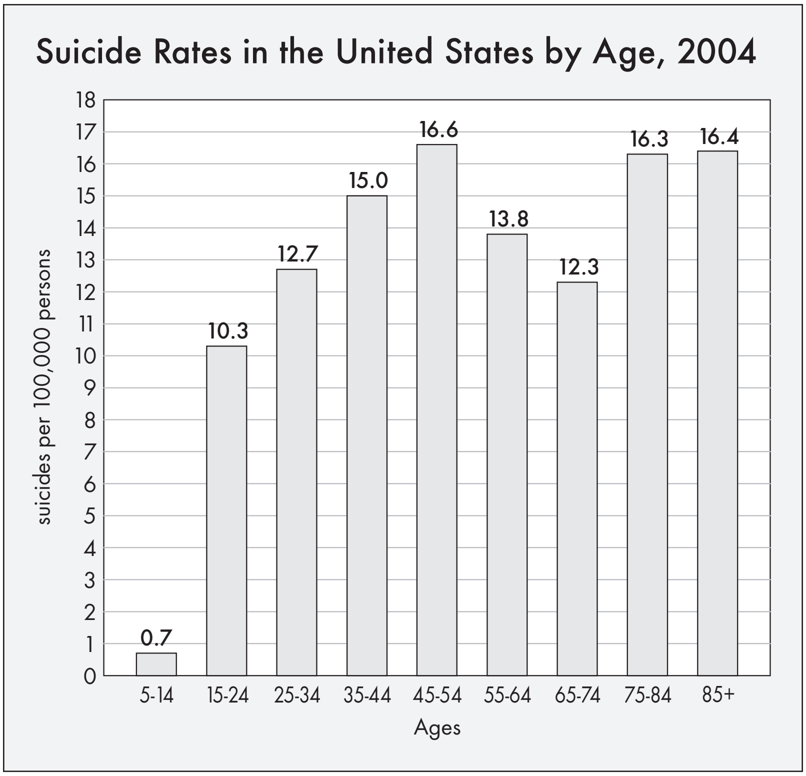
Definition: Act of intentionally killing oneself through one's own effort or with the assistance of another.

Significance: Suicide is one of the leading causes of unnatural death in the world, particularly among teenagers. It is a phenomenon that affects every nation as well as every culture. The strategic use of suicide in warfare and terrorism has become commonplace in the past century, and the topic of assisted suicide has become a source of great controversy.

Suicide has been a part of human society since history has been recorded, and the ethical implications of the act have been debated since ancient times. The scholars of ancient Greece addressed the legitimacy of suicide; Plato rejected the act based on a religious rationale, but Socrates disagreed and ultimately committed suicide. Under the Roman Empire, many soldiers committed suicide after defeat in war or to avoid capture by enemies. Later, Christianity altered views on suicide to mirror the sacrifices made by Jesus Christ. Specifically, Christians typically honored those who committed suicide as a sacrifice for a larger cause, such as in war, but they held in contempt those who used suicide as a way to escape the law or for other reasons deemed cowardly.

Suicide has been used as a strategy in warfare throughout history. During World War II, the Japanese sent what were termed kamikaze pilots to fly bombs into U.S. ships. The North Vietnamese also used suicide tactics against American soldiers during the Vietnam War. Moreover, although suicide is at odds with Islamic law, some Muslims use suicide attacks on their enemies under the notion of martyrdom warfare. The difference between suicide and martyrdom is that martyrdom is undertaken for a higher purpose, whereas suicide is undertaken to escape the hardships of life.

Across cultures, suicide remains a problem in the twenty-first century, with concerns increasing about suicide among teenagers. Moreover,



Source: U.S. National Center for Health Statistics, 2006.

Euthanasia

Passive euthanasia involves aiding the termination of other persons' lives by withdrawing life-support assistance, such as medical treatments, medications, respirator equipment, respirators, nutrition, and water. Active euthanasia involves the administration of treatments or medications designed to end life. Euthanasia is considered to be voluntary when victims request it and involuntary when persons other than the victims request it. Physician-assisted suicide differs from active voluntary euthanasia in that physicians do not perform the actual killings but merely provide the means for suicide, such as prescriptions for lethal doses of drugs. In some jurisdictions, all forms of euthanasia are illegal.

Little systematic research has been done to examine why some people choose assisted suicide over unassisted suicide. However, in contrast to the pattern for suicide in general, about two-thirds of the persons who apply for assistance with suicide in those jurisdictions where the practice is legal are women.

Steven Stack

international debates are ongoing regarding the morality of assisted suicide, or euthanasia, with strong views being expressed on both sides of the topic of the "right to die."

Investigating Suicide

Investigations regarding suicide typically take two forms: research that seeks to explain the phenomenon of suicide and investigations into deaths that appear to have been self-inflicted. Attempts to understand and explain suicide have been undertaken at both micro and macro levels. Macro-level research on the topic has centered on the impact of the social structure on suicide rates across cities and even nationally. Theorists such as Émile Durkheim have attempted to show correlations between factors such as war periods and the Great Depression on suicide rates in the United States. In contrast, micro-level research has attempted to understand individual-level factors that may lead to suicide. For instance, researchers have examined the relationship between suicide and the social pressures placed on teenagers as well as that between suicide and the family problems encountered by adults. Suicide researchers are careful to separate attempted suicides in which the persons survive from completed suicide; many contend that the two are completely separate phenomena with completely separate causes.

Forensic pathologists are typically the members of the criminal justice system who oversee investigations into deaths that are suspicious or unnatural. In the United States, coroners or medical examiners (depending on the state) conduct investigations of unnatural deaths and order lab tests and autopsies on the bodies. However, law-enforcement officers and criminalists often collect data at death scenes that can be just as valuable or even more valuable than autopsy and toxicology test results in determining whether deaths are attributable to suicide, accident, or murder. When an automobile fatality occurs, for instance, police officers may need to conduct exhaustive interviews with other drivers and then with the family and friends of the deceased in order to rule out suicide. At the very least, police investigators have a critical role in collecting the evidence that forensic pathologists use in making their determination.

Because of the myriad circumstances in which unnatural or suspicious deaths may occur, forensic pathologists typically have wide-ranging expertise. They routinely have to make decisions regarding the likely ways in which many kinds of wounds were inflicted on bodies, including bullet wounds, stab wounds, wounds caused by blunt force trauma, and burns. Moreover, when suicide is suspected, pathologists sometimes focus on the life histories, psychiatric data, and other information on the backgrounds of the deceased. Such psychological autopsies can aid in the determination of cause of death, but it should be noted that the use of this technique has been greatly exaggerated in popular media depictions of the work of pathologists.

Brion Sever

Further Reading

Durkheim, Émile. *Suicide: A Study in Sociology*. Translated by John A. Spaulding and

George Simpson. 1951. Reprint. New York: Free Press, 1997. Classic work examines suicide from a sociological viewpoint, focusing on macro-level trends. Warns against using statistics to attempt to understand the causes of suicide.

Gorsuch, Neil. *The Future of Assisted Suicide and Euthanasia*. Princeton, N.J.: Princeton University Press, 2006. Lists the arguments for and against the legalizing of assisted suicide and places the phenomenon within an international context.

Holmes, Ronald, and Stephen Holmes. *Suicide: Theory, Practice, and Investigation*. Thousand Oaks, Calif.: Sage, 2005. Analyzes the theories surrounding the causes of suicide and examines how suicides are investigated. Includes actual suicide notes in discussion of the motives underlying suicide.

Joiner, Thomas. *Why People Die by Suicide*. Cambridge, Mass.: Harvard University Press, 2005. In-depth discussion of the determinants of suicide includes analysis of the differences between those who attempt suicide but survive and those who complete suicide.

Picton, Bernard. *Murder, Suicide, or Accident: The Forensic Pathologist at Work*. London: Hale, 1971. Focuses on the difficulty faced by forensic pathologists in distinguishing deaths by suicide from deaths resulting from murder and accidents.

See also: Autoerotic and erotic asphyxiation; Autopsies; Borderline personality disorder; Celebrity cases; Drowning; Forensic entomology; Forensic pathology; Forensic toxicology; Hesitation wounds and suicide; Psychological autopsy; Ritual killing.

Superglue fuming

Definition: Use of cyanoacrylate vapors to visualize latent fingerprints.

Significance: Fingerprints and palm prints are often critical pieces of evidence encountered at crime scenes. Because most fingerprints are not visible to the naked eye and are easily destroyed, the fuming of prints with the vapors of superglue (cyanoacrylate) has become common. This technique makes permanent what would otherwise be transient pieces of evidence.

Forensic scientists have used superglue fuming since 1982 to visualize latent fingerprints and palm prints on nonporous surfaces such as metals and plastics. The developed prints are white and provide especially good contrast with dark-colored surfaces. Dyes such as rhodamine can be used to enhance the contrast of prints with light backgrounds and can cause prints to fluoresce when viewed under the appropriate conditions.

How Fuming Works

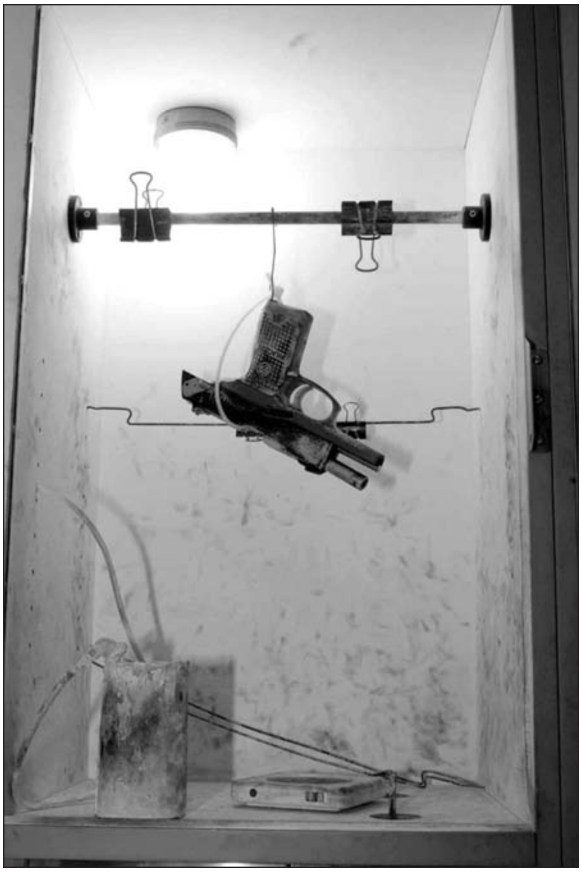
Superglue, like many adhesives, is a polymer. A polymer is a type of molecule that exists in the form of long chains of repeating units, called monomers. Superglue consists almost entirely of cyanoacrylate ester, which consists of carbon, hydrogen, oxygen, and nitrogen and polymerizes (forms long chains) rapidly in the presence of minute amounts of water.

When superglue vapor comes in contact with a fingerprint on a nonporous surface, it quickly begins polymerizing. Layers of polymer build up until the minute details of the fingerprint are visible. Because the vapor interacts only with the fingerprint, the area around the details remains free of superglue. In addition to enabling visualization of the fingerprint, the superglue makes the print permanent, thus preserving it.

Procedure

Superglue fuming is often performed in a fuming tank. The item to be fumed is suspended or propped inside a glass tank, such as an aquarium, so that the area of the item suspected to contain a fingerprint or palm print is not touching any surface of the tank. A source of superglue vapor is also required. The superglue may be vaporized in one of two ways: Either a small amount of sodium hydroxide, a very strong base, is added to the unpolymerized glue or the glue is heated. Crime labs typically employ the heating method, as it tends to be more efficient, but methods of heating the glue vary from lab to lab. The heat source can be anything from a lightbulb to a small warming plate (of the kind designed to hold a coffee mug) to a cup of boiling water.

To begin the fuming, a small amount of superglue (roughly the size of a quarter) is typically placed on an aluminum foil tray, which is then placed above the heat source inside the fuming tank, along with the item to be fumed. The tank is then sealed, and the vapor is allowed to fill the chamber. The vapor interacts with the object in the tank and develops any prints that might be present on the surface. The fuming is allowed to progress for anywhere from less than an hour to six hours, depending on the efficiency of the heat source, the lab's protocols, the size of the tank, and the object being fumed.



A handgun hanging inside a superglue fuming tank, above the small warming plate used to heat the glue. Fingerprints are developed and preserved by the fuming process. *(AP/Wide World Photos)*

When the fuming is complete, the heat source is turned off and the tank is opened. The fumed object can then be removed and examined for developed prints.

Another fuming technique involves the use of a handheld fuming wand, which contains solid superglue along with a butane torch. The torch heats the superglue and causes it to vaporize quickly. These fumes can be directed onto the surface of interest, and high-quality prints can be developed in minutes. An advantage to this method is that most handheld fuming wands are portable, so they can be taken to crime scenes and used to fume large objects that cannot be transported to the lab. Such wands can also be used as vapor sources in traditional fuming tank setups.

Safety Considerations

Although superglue is nontoxic—it is even sometimes used to seal surgical wounds—the vapors given off during the fuming process will bind to skin, eyes, and mucous membranes if these are left unprotected. Persons wearing contact lenses should not come into close proximity to superglue fuming because of the possibility that the lenses will bond to the eyes. The fumes themselves can also be very irritating. To prevent exposure, laboratories generally conduct superglue fuming in chemical fume hoods, and those performing the procedure wear safety goggles and gloves and make sure that none of their skin is exposed.

If a fume hood is not available, such as when a fuming wand is used at a crime scene, extra care must be taken to ensure that no one is exposed to the fumes. In addition to wearing the kinds of personal protective gear noted above, the person using a fuming wand often employs a face mask to avoid inhaling the vapors.

Lisa LaGoo

Further Reading

Champod, Christophe. *Fingerprints and Other Ridge Skin Impressions*. Boca Raton, Fla.: CRC Press, 2004. Comprehensive discussion of fingerprint evidence includes detailed information on superglue fuming.

Gardner, Ross M. *Practical Crime Scene Processing and Investigation*. Boca Raton, Fla.:

CRC Press, 2005. Guide to investigating crime scenes focuses on practical applications of forensic techniques. Discusses the different kinds of tank setups used in superglue fuming.

Genge, N. E. *The Forensic Casebook: The Science of Crime Scene Investigation*. New York: Ballantine, 2002. Easy-to-read overview of crime scene investigation features a section on fingerprints that discusses methods of print visualization, including superglue fuming.

Jackson, Andrew R. W., and Julie M. Jackson. *Forensic Science*. 2d ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2008. Provides a broad overview of forensic science and includes basic information on superglue fuming of fingerprints.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007. Excellent introductory textbook covers most forensic disciplines. Includes in-depth information on fingerprints.

See also: Ear prints; Fingerprints; Imaging; Integrated Automated Fingerprint Identification System; Prints.

T

Tabun

Definition: Highly toxic liquid used as a chemical warfare agent.

Significance: Concerns that terrorists could employ chemical agents in attacks have increased law-enforcement agencies' attention to substances such as tabun. The manufacture and storage of tabun are banned by the United Nations Chemical Weapons Convention of 1993.

Tabun, which was discovered in Germany in the 1930's during a search for new insecticides, is the earliest and most easily manufactured of the so-called nerve gases. Although it has been superseded as a chemical weapon by agents such as VX, its relative ease of manufacture makes it attractive to some nations that might consider using it as a weapon.

Tabun was manufactured and stored in multiton quantities in Nazi Germany during World War II, but it was never used in combat. During the Iran-Iraq War (1980-1988), however, Iraq used the agent against Iranian troops. In 1984, a team sent to Iran by the United Nations found tabun in a dud bomb that Iraq had dropped inside Iran's borders. The team also visited a field hospital where several patients were recovering; they exhibited symptoms consistent with poisoning by tabun, although no detailed tests were done.

Like other organophosphorus nerve agents, tabun is an inhibitor of the vital enzyme acetylcholinesterase (AChE). When tabun is absorbed through the skin or the vapor or aerosol of the agent is inhaled, the chemical binds to AChE. The normal function of AChE is to catalyze a reaction that removes acetylcholine from the nerve endings, where it activates muscle contraction. Inhibition of the enzyme allows accumulation of acetylcholine, which causes sweating, runny nose, incontinence, visual impairment (including pain and contraction of the pupils, or meiosis), respiratory failure, convulsions, coma, and death. The degree of danger depends somewhat on the mode of exposure and the weight of the individual, but very small amounts of nerve agents such as tabun are toxic.

Signs of exposure to tabun in victims include abnormally low AChE levels in the blood. Traces of the agent may also be found in the victims' bodies. Methods have been developed for detecting nerve agents in biological samples at the picogram level using gas chromatography-mass spectrometry (GC-MS) or capillary gas chromatography. Members of the American armed forces use a handheld device, the chemical agent monitor (CAM), that detects nerve agents under field conditions through ion mobility spectrometry.

Treatment of nerve agent poisoning involves injections of atropine and administration of pralidoxime chloride (2-PAM chloride). The oxime tends to displace the nerve agent from the AChE, but it must be given quickly, because a reaction known as aging soon makes the AChE-nerve agent combination irreversible. Drugs given before exposure (prophylaxis) include carbamates (physostigmine, pyridostigmine) and enzymatic organophosphate scavengers.

John R. Phillips

Further Reading

Croddy, Eric A., and James J. Wirtz, eds. *Weapons of Mass Destruction: An Encyclopedia of Worldwide Policy, Technology, and History*. Santa Barbara, Calif.: ABC-CLIO, 2005.

Hoenig, Steven L. *Handbook of Chemical Warfare and Terrorism*. Westport, Conn.: Greenwood Press, 2002.

Somani, Satu M., and James A. Romano, Jr., eds. *Chemical Warfare Agents: Toxicity at Low Levels*. Boca Raton, Fla.: CRC Press, 2001.

Suzuki, Osamu, and Kanako Watanabe, eds. *Drugs and Poisons in Humans: A Handbook of Practical Analysis*. New York: Springer, 2005.

Tucker, Jonathan B. *War of Nerves: Chemical Warfare from World War I to al-Qaeda*. New York: Pantheon Books, 2006.

See also: Centers for Disease Control and Prevention; Chemical agents; Chemical terrorism; Chemical warfare; Chemical Weapons Convention of 1993; Nerve agents; Nervous system; Sarin; Soman.

Tape

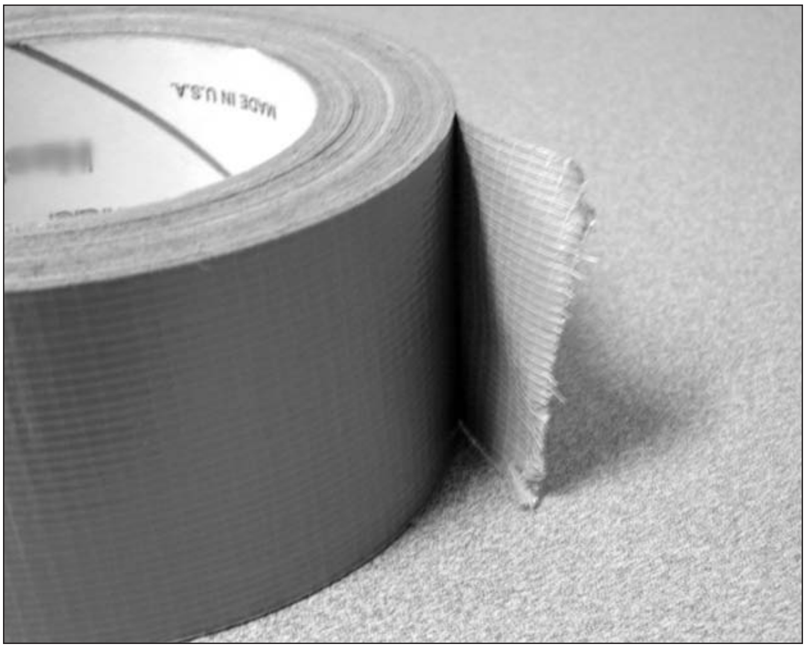
Definition: Manufactured product that consists of a long strip of a backing film with an adhesive applied to one side that allows the film to be stuck to a surface.

Significance: Law-enforcement investigators may encounter various kinds of adhesive tapes as evidence in a range of cases, including homicides, kidnappings, drug trafficking cases, and cases involving explosive devices. By analyzing tape evidence recovered from crime scenes, comparing the physical and chemical properties of the samples with pieces or rolls of tape recovered from suspects or from other items, forensic scientists can provide investigators with valuable information.

Pressure-sensitive adhesive tapes are generally composed of several layers: a release coating, a backing film, and an adhesive coating. The release coating is a very thin layer that prevents the tape from sticking to itself when wound on a roll. The backing film is commonly a type of polymer, such as polyethylene, polypropylene, or polyvinyl chloride, but paper and cloth tapes are also available. The type of adhesive coating used depends on the specific application of the tape, with the most common types of adhesives being natural rubber, styrenated rubber, and acrylic polymers. Packaging tape and electrical tape are the most common types of tapes that forensic scientists encounter in their work.

The first stage of the examination of a tape evidence sample consists of a comparison of the physical characteristics of the recovered and control samples. This includes comparison of the color, surface texture, width, and thickness of the backing film and the adhesive layer. Optical properties such as birefringence and fluorescence are also compared for some tapes. The forensic scientist may use microspectrophotometry to compare the colors of the tapes objectively. Surface striations may also be visible on the film; these are imparted to the tape during its manufacture. Examination of these striations can be carried out in a way that is analogous to a tool-mark comparison.

A range of analytical techniques are then applied to the backing film and to the adhesive



By comparing the physical and chemical properties of tape evidence recovered from crime scenes with pieces or rolls of tape from known sources, forensic scientists can provide investigators with valuable information. *(© iStockphoto.com/Daniel Norman)* layer to determine their chemical compositions. The choice of techniques used depends on the instrumentation available. Techniques commonly applied include Fourier transform infrared (FTIR) spectroscopy, pyrolysis gas chromatography (PyGC), X-ray fluorescence (XRF), and scanning electron microscopy with energy-dispersive spectroscopy (SEM-EDS). If cloth tapes are being examined, the fibers present in the tape are also analyzed.

A conclusive match of the recovered and control tape samples is possible if a physical fit is found between the fractured ends of the two samples. A correspondence of striations on the surface of the film may also prove a conclusive match if it can be shown that the marks alter during the manufacture of the particular tape being examined. Otherwise, a correspondence of physical and chemical features results in a match of class characteristics; the evidential value of such a class match is determined through reference to surveys of similar types of tapes.

Sally A. Coulson

Further Reading

Maynard, Philip, Katrina Gates, Claude Roux, and Chris Lennard. "Adhesive Tape Analysis: Establishing the Evidential Value of Specific Techniques." *Journal of Forensic Sciences* 46, no. 2 (2001): 280-287.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007.

See also: Fibers and filaments; Fourier transform infrared spectrophotometer; Fracture matching; Gas chromatography; Mass spectrometry; Microspectrophotometry; Physical evidence; Tool marks.

Taphonomy

Definition: Study of postmortem changes in organisms from the time of death to the point of discovery.

Significance: Postmortem events alter the condition of human remains and may leave evidence that can potentially be confused with trauma. The study of human decomposition also provides important clues that aid in the estimation of the time since death.

The term "taphonomy" was coined in 1940 by the Russian paleontologist Ivan Yefremov to describe the "laws of burial." Taphonomists attempt to understand events that occur to organisms after death, a period defined as the postmortem interval. Early research in the field of taphonomy focused on the study of fossils, especially the conditions that determine how and why certain organisms are preserved in the fossil record. Since the 1980's, taphonomy has become an important research area in forensic science, focusing on the study of postmortem changes in human remains and estimation of the time since death (TSD), also known as the postmortem interval. This emerging field, known as forensic taphonomy, applies the principles of taphonomy to the study of human decomposition. TSD studies are usually undertaken by anthropologists, entomologists, or pathologists who have forensic expertise, but the examination of postmortem changes in human remains is an interdisciplinary study and may involve a number of different specialists.

Goals of Forensic Taphonomy

Forensic taphonomy addresses several important medicolegal issues, including estimation of the TSD and the study of postmortem changes in human remains caused by decomposition, transport, weathering, or fire. TSD estimation can aid in narrowing down the search for a missing person or can be used to exclude potential suspects from consideration who have alibis for the time when an alleged homicide occurred.

When a corpse is exposed to the environment for a long period of time, estimation of the TSD becomes increasingly difficult. Over time, insects, bacteria, plants, animal scavengers, and other aspects of the physical environment alter remains. Postmortem changes to remains can potentially be misinterpreted as perimortem wounds—that is, trauma inflicted at or around the time of death.

Different taphonomic processes also leave distinct signatures, so the ability to differentiate postmortem changes from perimortem trauma is critical. For example, tooth marks on bone from animal scavenging should not be misinterpreted as perimortem trauma. Taphonomic studies require close examination of the condition of the remains and any alterations caused by the environment. Humans are also considered taphonomic agents, as a perpetrator may be involved in transporting or altering (for example, mutilating or dismembering) remains after death.

An entomology doctoral student at the University of Florida's Institute of Food and Agricultural Sciences examines a colony of blowfly maggots as she conducts research into the growth rates of maggots at various temperatures. Information from such studies can help crime scene investigators determine time of death based on the maggots found on bodies. *(AP/Wide World Photos)*

Stages of Decomposition

When human remains are discovered, one of the first questions asked is, How long has the victim been dead? Decomposition typically occurs in the following predictable sequence of stages: the fresh stage, the bloat stage, the active decay stage, the advanced decay stage, and the dry or skeletal stage. The rate of decay, however, is influenced by a number of factors in the immediate environment, such as temperature, humidity, moisture, availability of insects and animal scavengers, and soil conditions. Bodies that are found indoors or that are buried decompose at slower rates than remains that are deposited on the surface of the ground. In the case of a recent death, medicolegal investigators examine the body for early signs of decomposition.

Changes during the fresh stage of decomposition generally occur within the first few days postmortem. Immediately after death, the body cools until it reaches ambient temperature, a process known as algor mortis. Pooling of blood into the capillaries of the skin, or livor mortis, follows and is fixed by approximately twelve hours after death. Rigor mortis, the hardening of the muscles, begins about two hours after death but may last for up to twenty-four hours.

The bloat stage is marked by the buildup of gases within the body, which causes the abdomen to be distended. The skin also becomes discolored and marbled in appearance. This process may last for several days up to a month after death. Carrion-feeding insects such as blowflies and flesh flies also typically arrive at a corpse within minutes after death. The maggots from these flies use the body as a food source for several weeks to months.

During the active decay stage, maggots, beetles, and other insects reduce the mass of the corpse, and the chest cavity begins to collapse. In the advanced decay stage, remains are nearly skeletonized owing to insect and animal scavenger activity. Finally, in the dry or skeletal decay stage, the skeletonized remains are devoid of soft tissue and odor. Postmortem changes are somewhat predictable within a given region; however, the rate of decomposition is highly variable from region to region.

Taphonomic Studies

Although some taphonomic studies occur within laboratory settings, most research is conducted outdoors with the remains of nonhuman animals, such as pigs. In some locations, however, donated human cadavers are used to study decomposition rates; the Anthropological Research Facility at the University of Tennessee, Knoxville, popularly known as the Body Farm, is perhaps the most widely known example of this kind of research center.

With the establishment of increasing numbers of outdoor taphonomic research facilities in different locations, scientists have been able to gain reliable data on variations in decay rates. These studies, which contribute to an in-depth understanding of the process of human decomposition, provide law-enforcement investigators with information they need to make more accurate estimates of time since death.

Eric J. Bartelink

Further Reading

Galloway, Alison, et al. "Decay Rates of Human Remains in an Arid Environment: Retrospective Study of Decay Rates in the Southwestern United States." *Journal of Forensic Sciences* 34 (May, 1989): 607-616. Reports on the findings of a scientific study of decay rates.

Haglund, William D., and Marcella H. Sorg, eds. *Advances in Forensic Taphonomy: Method, Theory, and Archaeological Perspectives*. Boca Raton, Fla.: CRC Press, 2002. Detailed edited volume focuses on theoretical and practical applications of taphonomy in medicolegal settings.

_______. *Forensic Taphonomy: The Postmortem Fate of Human Remains*. Boca Raton, Fla.: CRC Press, 1997. Collection of essays highlights case studies and research dealing with taphonomy in medicolegal settings.

Komar, Debra A. "Decay Rates in a Cold Climate Region: A Review of Cases Involving Advanced Decomposition from the Medical Examiner's Office in Edmonton, Alberta." *Journal of Forensic Sciences* 43 (January, 1998): 57-61. Reports on the findings of a study of variability in decay rates of remains found in cold climates.

Lyman, R. Lee. *Vertebrate Taphonomy*. New York: Cambridge University Press, 1994. Provides a comprehensive overview of the science of taphonomy for archaeologists, physical anthropologists, and paleontologists.

See also: Adipocere; Algor mortis; Body farms; Decomposition of bodies; Forensic anthropology; Forensic archaeology; Forensic entomology; Livor mortis; Rigor mortis; Skeletal analysis; University of Tennessee Anthropological Research Facility.

Tarasoff rule

Definition: Duty of mental health professionals to warn third parties known to be the subjects of threats of injury or death by patients.

Significance: When California's highest court imposed liability on mental health professionals for serious injuries to third parties known to be the subject of threats by patients, the court held that the public interest in protecting individual safety overrides the maintenance of confidentiality between therapist and patient.

Prior to the 1976 decision of the California Supreme Court in *Tarasoff v. Regents of the University of California*, no law in the United States recognized a therapist's duty toward individuals with whom the therapist had no formal relationship. A therapist had discretion concerning any warning to a third party about a dangerous individual. Maintaining confidentiality within the confines of the therapist-patient relationship was paramount. Following the court's ruling in *Tarasoff*, mental health professionals were charged with the responsibility to take reasonable steps to prevent violence threatened by their patients by warning third parties as well as the appropriate authorities.

Because the court failed to provide guidelines concerning when warnings would be required and left it up to therapists to determine whether patients would in fact act on their threats, the duty imposed on therapists was subject to much conjecture and speculation. When the decision was first handed down, opponents predicted that it would lead to unwarranted hospitalizations and ineffective calls to police and potential victims. They also suggested that therapists might become wary and avoid potentially violent patients, who in turn would be reluctant to talk with therapists about their violent thoughts. Several decades have demonstrated that those fears were unrealistic, however.

Subsequent case law has also clarified a workable solution concerning when a therapist is required to issue a warning to a third party. When a patient expresses a threat of serious harm to an identifiable victim, the legal obligation to protect the intended victim against such danger is imposed on the therapist. That duty may require the therapist to take one or more steps, such as warning the intended victim or others of the danger, notifying law-enforcement authorities, and taking whatever additional actions are necessary, depending on the nature of the case.

Facts of the Case

Prosenjit Poddar was a graduate student from India, studying at the University of California at Berkeley. In the fall of 1968, he met Tatiana (Tanya) Tarasoff at a folk-dancing class. They saw each other weekly throughout that fall, and on New Year's Eve, Tarasoff kissed Poddar. He interpreted this kiss to indicate the existence of a serious relationship between them. When Tarasoff learned of Poddar's feelings, she told him of her involvement with other men and indicated that she was not interested in entering into an intimate relationship with him. In part because of their different cultures, Poddar did not understand Tarasoff's explanation and underwent a severe emotional crisis. He spoke to a friend about his love for Tarasoff and his uncontrollable desire to kill her.

During the summer of 1969, Tarasoff went to Brazil. After she left, Poddar began to improve and, at a friend's suggestion, sought help from the university's health service. He began psychotherapy under the care of a staff psychologist, Dr. Lawrence Moore. During his ninth session with Moore, Poddar confided that he was going to kill Tarasoff when she returned from Brazil. Two days later, Moore personally notified campus police officers that Poddar was capable of harming himself or others; he also wrote a letter to the chief of the campus police in which he stated that Poddar was an acute and severe paranoid schizophrenic and a danger to himself and others. The campus police took Poddar into custody, but they released him when he promised to change his attitude and stay away from Tarasoff. Poddar stopped his therapy.

When Tarasoff returned from Brazil in October, 1969, Poddar continued to stalk her. On October 27, armed with a pellet gun and a kitchen knife, Poddar shot Tarasoff and repeatedly and fatally stabbed her. Afterward, he called the police, confessed, and asked to be handcuffed. Moore's diagnosis of Poddar was confirmed the following day.

The Decision

Poddar was charged with Tarasoff's murder, and he pleaded not guilty by reason of insanity. A jury convicted Poddar of second-degree murder, and he appealed on multiple grounds. The appellate court focused on jury instruction errors made in the trial court and reduced Poddar's conviction to manslaughter. Two years later, the California Supreme Court vacated the judgment, held that the jury instruction error was prejudicial, and remanded the case for retrial. Poddar was not retried. Rather than conduct another lengthy trial, the state released Poddar on the condition that he leave for India and not return to the United States. He did so; he later married in India.

Tarasoff's parents filed a wrongful-death civil action simultaneously against the university's police department, the Regents of the University of California, and the university's health service for failing to warn their daughter about Poddar's desire to kill her. At trial, the case was dismissed because of the absence of a cause of action (legal reason for suing) owing to the physician-patient privilege of confidentiality. Specifically, the court ruled that a physician has a duty only to the patient, not to third parties; therefore, no duty was owed to Tarasoff.

The intermediate appellate court upheld the trial court's decision, but the California Supreme Court reversed, holding that the case stated a cause of action and must be heard. The Supreme Court reasoned that the therapist has a duty to use reasonable care to give threatened persons whatever warnings are necessary to avert foreseeable danger. The duty extends from the patient to the intended victim. Addressing the defendants' assertion that a warning constitutes a breach of the trust inherent in confidential communications, the court recognized the public interest in supporting effective treatment of mental illness and protecting patients' right to privacy and confidentiality but concluded that the public interest in safety from violent assault outweighs these considerations, stating, "The protective privilege ends where the public peril begins."

The initial California Supreme Court decision in 1974 held that the campus police could be found liable for their failure to warn Tarasoff, but at the rehearing in 1976, the police were released from all liability. The holdings with respect to the psychotherapists were essentially the same in both cases and were predicated on the same arguments. The second decision provided therapists greater latitude to "protect" intended victims rather than to "warn" them. It should be noted that the case was never decided on the merits because it was settled for an undisclosed sum of money.

In evaluating the imposition of liability, the California Supreme Court noted the discretion given to psychiatrists to use their best judgment in determining whether patients are dangerous. Courts will generally defer to this discretion. In cases in which patients verbally demonstrate intent to harm others, however, psychiatrists are liable for injuries that arise from patients' carrying out their threats.

Tarasoff's Impact

The court's ruling in *Tarasoff* expanded the legal concepts of duty and foreseeability. Despite initial concerns regarding therapists' inability to predict violent behavior accurately and the effect of breach of confidentiality, these matters have not had the adverse impacts initially feared and predicted. Ultimately, the *Tarasoff* case stimulated greater awareness of violent patients' potential for carrying out such behavior. That, in turn, stimulated closer scrutiny and better documentation concerning this issue.

Since the *Tarasoff* decision, other interesting related questions have arisen, such as whether clergy who engage in pastoral counseling activities have a duty to protect third parties. Because in pastoral counseling there is little or no "control" over the penitent as there is over the patient in psychotherapy, the legal arguments used in *Tarasoff* do not apply to this situation. Scholars feel, however, that most members of the clergy in their discretion will take necessary steps to notify either potential victims or the appropriate authorities.

The *Tarasoff* rule imposes civil liability. The question of criminal liability has not been

Excerpt from the Court's Decision in *Tarasoff*

We conclude that the public policy favoring protection of the confidential character of patient-psychotherapist communications must yield to the extent to which disclosure is essential to avert danger to others. The protective privilege ends where the public peril begins.

Our current crowded and computerized society compels the interdependence of its members. In this risk-infested society we can hardly tolerate the further exposure to danger that would result from a concealed knowledge of the therapist that his patient was lethal. If the exercise of reasonable care to protect the threatened victim requires the therapist to warn the endangered party or those who can reasonably be expected to notify him, we see no sufficient societal interest that would protect and justify concealment. The containment of such risks lies in the public interest.

studied extensively, but one scholar has argued that the breach of the duty to warn should lead to criminal liability for the felony committed by the patient. Furthermore, the duty was reformulated as a duty to treat dangerousness, not as a duty to prevent harm to third parties. It should be noted, however, that no jurisdiction has prosecuted a therapist criminally for a violation of the *Tarasoff* duty to warn.

Although the *Tarasoff* rule applies only in California, it has been considered in every U.S. state, although it is not followed everywhere. Some states have refused to follow *Tarasoff* out of a need to protect the confidential disclosure of information, barring disclosure of any information to third parties. Others follow *Tarasoff* but limit third-party liability to situations in which specific intended victims are named. Still others require that the intended victim be directly threatened by a patient, and some impose a duty on the psychiatrist to take action to prevent the patient from carrying out the threat, including seeking commitment of the patient or obtaining police detention. Most states have extended the therapist's duty to identifiable victims only, and not to the general public. A minority of courts have recognized a broader duty to protect the public from the danger imposed by a patient.

Marcia J. Weiss

Further Reading

Appelbaum, Paul S. *Almost a Revolution: Mental Health Law and the Limits of Change*. New York: Oxford University Press, 1994. Discusses important reforms in mental health law: changes in civil commitment laws, the *Tarasoff* duty to warn, the rights of mental patients to refuse treatment, and changes in the insanity defense

Beis, Edward B. *Mental Health and the Law*. New York: Aspen, 1984. Explains in lay terms the legal aspects of the mental health system and the legal responsibilities of mental health professionals. Useful as a guide to the standards of care and treatment required by the law.

Blum, Deborah. *Bad Karma: A True Story of Obsession and Murder*. New York: Atheneum, 1986. Details the relationship between Poddar and Tarasoff, illustrating their clash of cultures.

Buckner, Fillmore, and Marvin Firestone. "'Where the Public Peril Begins': Twenty-five Years After *Tarasoff*." *Journal of Legal Medicine* 21, no. 2 (2000): 187-222. Offers interesting and complete commentary on the case from the perspective of a quarter century after the ruling.

Frost, Lynda E., and Richard J. Bonnie, eds. *The Evolution of Mental Health Law*. Washington, D.C.: American Psychological Association, 2001. Collection of articles includes discussion of the duty to warn.

Hermann, Donald H. J. *Mental Health and Disability Law in a Nutshell*. St. Paul, Minn.: West, 1997. Succinct summary of the law is intended for use as a reference and study guide by students, lawyers, and mental health professionals.

Slobogin, Christopher. "*Tarasoff* as a Duty to Treat: Insights from Criminal Law." *University of Cincinnati Law Review* 75 (2007): 101-117. Excellent scholarly treatment of the hypothesis that breach of the *Tarasoff* duty could also lead to criminal liability.

See also: Actuarial risk assessment; Courts and forensic evidence; *Diagnostic and Statistical Manual of Mental Disorders*; Forensic psychiatry; Forensic psychology; Guilty but mentally ill plea; Living forensics; Medicine.

Tattoo identification

Definition: Process in which permanent body art and markings are used as information to help determine identity.

Significance: Law-enforcement professionals can use tattoos to identify unknown persons in a number of ways. Tattoos on the bodies of unknown deceased persons can help forensic scientists identify those persons, and information from witnesses about the tattoos seen on criminal perpetrators can help identify suspects. The tattoos worn by particular persons can also help to provide information about group membership, which can be used to trace identity.

Tattooing is a process in which ink or a substance containing dye is introduced into the dermis, a deep layer of the skin that does not regularly renew itself in the way the outer layer of skin, the epidermis, does. The ink or dye is usually deposited in the dermis through the use of an electric machine that produces very rapid movement of a needle (up to three thousand times per minute), although tattooing can also be accomplished by an individual using less professional methods. The dye is not soluble, and as the epidermis is shed, the tattoo remains visible. Tattoos do, however, often fade perceptibly over time.

Distinctive tattoos can be helpful to law-enforcement personnel when they need to identify unknown persons, including suspects and victims of crimes. *(© iStockphoto.com/Barry Crossley)*

Human beings have used tattoos for thousands of years for a variety of religious, cultural, and individual reasons. Governments have also used tattoos at various times throughout history to identify convicts, prisoners of war, and other groups, such as Nazi Germany's tattooing of prisoner numbers on those held in concentration camps during World War II. In the United States, the numbers of persons getting tattoos to make personal statements of identity or group membership are believed to be on the increase. As of 2003, 16 percent of American adults reported having one or more tattoos, with women and men about equally likely to be tattooed. In general, personal tattoos in the United States are becoming larger and more prominently displayed, with increasing use of vibrant colors.

Identification of Suspects

The knowledge that a criminal suspect has a tattoo may be extremely valuable to an investigator in identifying that individual. Many tattoos are placed on areas of the body that are easily visible to others, such as the arms, hands, face, throat, or neck. Additionally, tattoos are often brightly colored, and many feature easily recognizable and memorable items, objects, or words.

After a crime has been committed, it can often be difficult for witnesses to provide investigators with a clear description of the perpetrator, given that people who commit crimes often attempt to disguise some or all of their features, using gloves, hats, masks, and other devices. A tattoo that is not completely covered, or is momentarily exposed, can provide an important clue to a criminal perpetrator's identity. Witnesses often have blurry or differing memories of events, but they may be able to recall seeing a tattoo of an easily recognizable object, such as a well-known cartoon character, even when they cannot provide police with information on the perpetrator's eye color, height, or distinguishing facial features.

In addition to being useful for positive identification if a suspect is found, tattoos can give investigators possible leads. Many groups—such as street gangs, biker groups, and military divisions—have their own individualized tattoos that members get to identify themselves as part of their groups. If the perpetrator of a crime has a recognized group tattoo, this can give investigators a good lead on where to seek additional information.

Because tattoos are generally permanent, they can also be used to identify persons who may have changed or aged significantly since the most recent description or photograph available to investigators. Tattoos are also much more difficult to conceal than hair color, eye color, or other features commonly used to describe individuals. Some tattoos are even used to cover up marks—such as scars, birthmarks, or even other tattoos—that might be used as identification.

Although it is not common, tattoos can be removed by a complex and expensive laser procedure that often requires repeated visits to a doctor or specialist. Because this procedure is available, law-enforcement authorities cannot always rule out an identification because the individual does not have a specific tattoo.

Identification of Human Remains

Tattoos are often extremely valuable evidence in the identification of human remains. When an individual is reported missing, any information about tattoos or other body modifications (such as piercings) that person has can be useful in helping investigators determine the identity of any human remains that are discovered. Even when a specific identification of unknown remains is not possible, tattoos on the body can help by providing starting points for investigation. For example, tattoos may indicate group membership or may indicate that the deceased was a regular customer at a local tattoo shop. Tattoos are usually visible until the body is significantly decomposed.

During investigations of major catastrophes involving large numbers of victims, such as the tsunami that hit Thailand in 2004 or the terrorist attacks on the World Trade Center in 2001, identification of victims is often strongly aided by the examination of tattoos. Also, forensic anthropologists often find tattoos helpful in the identification of bodies recovered from mass graves. When the mass graves are of recent origin, examination of tattoos may enable the identification of individual victims. When the mass graves are ancient, examination of tattooing may help to identify the groups or tribes to which the individuals in the graves belonged.

Helen Davidson

Further Reading

Cox, Margaret, et al. *The Scientific Investigation of Mass Graves*. New York: Cambridge University Press, 2008. Presents a penetrating discussion of the techniques of identifying remains recovered from mass graves and also addresses the ethical issues involved.

Fenske, Mindy. *Tattoos in American Visual Culture*. New York: Palgrave Macmillan, 2007. Provides a history of tattooing in the United States, with a special focus on the cultural aspects of the tattoo through history.

McCartney, Carole. *Forensic Identification and Criminal Justice: Forensic Science, Justice, and Risk*. Portland, Oreg.: Willan, 2006. Discusses the forensic and legal issues involved in identification.

Rush, John A. *Spiritual Tattoo: A Cultural History of Tattooing, Piercing, Scarification, Branding, and Implants*. Berkeley, Calif.: Frog, 2005. Presents the history of tattooing and other body modifications, along with discussion of the functions tattooing has fulfilled in ancient and modern societies.

Thompson, Tim, and Sue Black, eds. *Forensic Human Identification: An Introduction*. Boca Raton, Fla.: CRC Press, 2007. Provides information about various techniques used by forensic experts to identify individuals both alive and deceased. Includes a section on identification using tattoos and other body modifications.

See also: Asian tsunami victim identification; Composite drawing; Croatian and Bosnian war victim identification; Decomposition of bodies; Gang violence evidence; Mass graves; September 11, 2001, victim identification; Skeletal analysis; Steganography.

Taylor exhumation

Date: June 17, 1991

The Event: The body of Zachary Taylor was exhumed after more than 140 years so that an autopsy could be performed to determine whether the twelfth president of the United States died of poisoning, as many had long speculated.

Significance: The sudden death of Zachary Taylor in the sixteenth month of his presidency caused considerable speculation. If Taylor was poisoned, as many presumed he was, those who were responsible were never brought to account. Although the autopsy performed in 1991 was intended to settle the question of Taylor's cause of death, the results failed to convince some historians that Taylor was not murdered.

The deaths of presidents, especially when sudden and unexpected, often give rise to conspiracy theories. On July 4, 1850, President Zachary Taylor attended a ceremony for the laying of the cornerstone for the unfinished Washington Monument. The day was hot and humid, but Taylor, presumably wishing to look presidential, dressed in a heavy coat and wore both a necktie and a hat. Ravaged by thirst, he consumed large quantities of warm water from a pitcher left in the sun. He also drank a large glass of cold milk and overindulged in some cherries and pickles.

Back at the White House, he shed his warm clothing and showed signs of an illness diagnosed as cholera morbus, a general classification of the digestive ills that plagued many Washingtonians during the sweltering summers. He spent a miserable night fighting nausea and diarrhea but was well enough the following day to work in his office. The following day, however, he fell ill again. The doctor who was summoned treated Taylor with opium and with a medication that contained mercury; both treatments were aimed at calming his digestive system and settling his upset stomach.

On July 9, Taylor's condition worsened to the point that it was publicly announced that the president was probably near death. At ten o'clock on that Tuesday night, Taylor, aware he was dying, called his family to his bedside; within an hour, he died. Vice President Millard Fillmore succeeded him, taking the oath of office the following day.

Taylor was buried on July 13 in Washington's Congressional Cemetery, where his remains rested until they were transferred to Louisville, Kentucky, on October 25, 1850. He remained buried there, with his wife's remains interred beside him after her death in 1852, until the two were disinterred on May 6, 1926, and moved to a newly constructed mausoleum in the Zachary Taylor National Military Cemetery in Louisville.

During the late 1980's, historians began to speculate that Zachary Taylor had been poisoned—with either arsenic or strychnine—by supporters of slavery who had been outraged by Taylor's support of the Compromise of 1850, which enabled California and New Mexico to enter the union as nonslave states. Two notable people who opposed the president's stance on this issue were Senator Henry Clay and Taylor's vice president, Millard Fillmore. Finally, in 1991, Taylor's great-great-great-grandson, Dabney Taylor, encouraged the exhumation of Taylor's remains for postmortem examination.

The Application of Forensic Science

On June 17, 1991, the body of Zachary Taylor was exhumed and transported to the Oak Ridge National Laboratory in Tennessee. Even though it had been interred for 141 years, it was reasonably well preserved. Two pathologists, Larry Robinson and Frank Dyer, conducted an autopsy on the remains, examining the bones and hair of the dead president for any toxic materials that might have contributed to his death. After Robinson and Dyer completed their work, the medical examiner of Kentucky reviewed their autopsy report and, being in agreement with the findings, issued a statement declaring that Taylor had died from natural causes and that trace elements of arsenic found in his body were one-thousandth the quantity needed to kill anyone.

This was not the end of the matter, however. Michael Parenti and other historians questioned the validity of Robinson and Dyer's autopsy findings. Parenti asserted that the pathol-

Contemporary lithograph depicting President Zachary Taylor on his deathbed in 1850. *(Library of Congress)*

ogists did not test hair very close to Taylor's scalp, hair that would have grown in the period during which the president was dying and that, had Taylor been poisoned, would have contained concentrations of toxic elements far in excess of what was found in the autopsy. Based on this argument, a request was made to the National Park Service in 1997 to exhume Taylor's body a second time for a more thorough autopsy. The request was rejected.

R. Baird Shuman

Further Reading

Bauer, K. Jack. *Zachary Taylor: Soldier, Planter, Statesman of the Old Southwest*. Newtown, Conn.: American Political Biography Press, 1994. Offers an extensive assessment of Taylor's career and his election as president on the Whig ticket.

Bumgarner, John R. *The Health of the Presidents: The Forty-one United States Presidents through 1993 from a Physician's Point of View*. Jefferson, N.C.: McFarland, 1994. Considers each U.S. president from George Washington to Bill Clinton from a medical standpoint.

Deem, James M. *Zachary Taylor*. Berkeley Heights, N.J.: Enslow, 2002. Presents a brief overview of Taylor's life, aimed primarily at adolescent readers. Factually solid, eminently readable.

Joseph, Paul. *Zachary Taylor*. Edina, Minn.: Abdo, 2002. Provides an accessible introduction to Taylor's life and politics.

Kops, Deborah. *Zachary Taylor: America's Twelfth President*. New York: Children's Press, 2004. An overview of the life, presidency, and death of Zachary Taylor directed toward young readers.

Parenti, Michael. *History as Mystery*. San Francisco: City Lights Books, 1999. Chapter 6 of this discussion of historical mysteries focuses on the death of Zachary Taylor and raises serious questions about the 1991 autopsy.

See also: Arsenic; Beethoven's death; Drug confirmation tests; Exhumation; Food poisoning; Lincoln exhumation; Louis XVII remains identification; Nicholas II remains identification; Poisons and antidotes.

Telephone tap detector

Definition: Device that indicates the presence of an eavesdropping device on a telephone line.

Significance: In criminal and terrorist investigations, high-stakes legal proceedings, industrial espionage, and other activities, knowing the content of telephone conversations can provide evidence against criminals or business and personal advantages to competitors or adversaries. For those who believe they may be targeted for telephone surveillance, the ability to detect the presence of a tap on a telephone line provides an important defense.

Wiretapping is the accessing of telephone conversations by direct interception of the telephone signal. Historically, wiretap laws in the United States were designed to protect the content of telephone conversations. Initiating a telephone wiretap required a court order and a high level of proof that the wiretap was essential to a law-enforcement investigation. The Patriot Act, which was passed following the 2001 terrorist attacks on the Pentagon and on the World Trade Center in New York City, made it easier for law-enforcement agencies in the United States to tap telephones. All the Patriot Act requires is that the requesting agency certify that information likely to be obtained from the tap is relevant to an investigation.

Traditional telephone tap detectors are devices that, when spliced into telephone lines, indicate when the voltage on the lines changes. When a tap detector is installed, it is set to monitor the voltage on the line when it is assumed to be untapped. If a physical tap is placed on the line, the voltage will decrease. Other events, such as listening in on a phone extension, will also cause the voltage to decrease. Changes in telephone transmission and telephone tapping technologies have, however, rendered traditional telephone tap detectors almost useless against all but the crudest types of taps. Despite this, some electronics retailers continue to sell voltage-change telephone tap detectors.

Changes in telephone technology have made it easier to intercept telephone calls as well as more difficult to detect taps or interceptions. For example, older analog cellular telephone conversations can sometimes be picked up on police scanners. Others can be picked up by nearby baby monitors. There is no way for the telephone users to detect whether someone is listening in on these conversations. Most telephone transmissions are now digital, however, which has reduced this problem. Digital transmissions, although often encoded, must by law be made available to law-enforcement agencies with legal authority to wiretap.

Voice over Internet Protocol (VoIP) technology allows telephone conversations to be carried

The Patriot Act and Electronic Surveillance

Title III of the Patriot Act of 2001 permits law-enforcement officers to enter buildings covertly for the purpose of installing the listening devices needed for electronic surveillance. Covert entry is authorized, however, only when Title III warrants are issued. To obtain warrants, law-enforcement officers must show the following:

- Probable cause that specific offenses are about to occur, have occurred, or are occurring
- That evidence is like to be obtained by the intercept or wiretap
- That all other investigative techniques either have failed or will fail to provide the necessary evidence or that they are too dangerous to employ
- That the locations of the proposed wiretaps are sites of criminal activity
- That telephones are being used to conduct criminal activity at those sites

on over the Internet. VoIP communications are not generally covered under traditional wiretap laws. These transmissions can be intercepted in sophisticated and difficult-to-detect ways similar to those used to intercept other kinds of electronic data transmitted between computers.

As of 2008, telephone taps of either landlines or cellular telephones initiated by telephone companies at the request of law-enforcement agencies were virtually undetectable. Many illegal telephone taps are also difficult to impossible to detect, despite the claims made by companies selling traditional wiretap detectors.

Martiscia Davidson

Further Reading

Diffie, Whitfield, and Susan Landau. *Privacy on the Line: The Politics of Wiretapping and Encryption*. Cambridge, Mass.: MIT Press, 2007.

Olejniczak, Stephen P. *Telecom for Dummies*. Indianapolis, Ind.: Wiley, 2006.

See also: Dial tone decoder; Electronic bugs; Electronic voice alteration; Internet tracking and tracing; Voiceprints.

Thalidomide

Definition: Sedative drug prescribed for pregnant women in the late 1950's and early 1960's to combat morning sickness until it was found to cause serious physical deformities during fetal development.

Significance: When taken by pregnant women between the twentieth and fortieth days of gestation, thalidomide causes severe birth defects. The thalidomide tragedy showed that governments need to be scrupulous in determining the possible risks posed by new drugs before granting permission to manufacturers to market those drugs. Forensic scientists must investigate unusual medical conditions that appear in the population as rapidly as possible so that regulations can be put in place to avert disaster.

Prior testing of thalidomide had been seriously flawed when the drug was introduced into West Germany during the late 1950's, marketed vigorously as an antidote against a variety of human ailments, including morning sickness. By 1959, an estimated one million Germans were using the drug on a daily basis, and some German pharmacies allowed the purchase of thalidomide without a prescription. An advertisement by the German company selling the drug misleadingly declared that thalidomide was an antidote for morning sickness, that it relieved tensions associated with pregnancy, that it could be taken as often as necessary, and that it would harm neither pregnant women nor their unborn children.

Discovering Deformities

In December, 1961, William McBride, an Australian physician, reported in a major medical journal that he had attended the births of a number of babies who showed severe physical abnormalities and whose mothers had used thalidomide. Shortly thereafter, German physicians reported similar outcomes and presented pictures of newborns with various deformities, including some with finlike appendages attached to their shoulders instead of arms and hands.

At that time, thalidomide was being sold in forty-six countries under fifty-one different brand names. It has been estimated that between five thousand and ten thousand newborns suffered serious defects throughout the world as the result of their mothers' use of thalidomide. The injuries occurred primarily in Western Europe, Canada, Australia, and Japan. In West Germany, after prolonged court hearings, more than twenty-eight hundred persons received compensation for the harm they suffered as a result of the use of thalidomide

In the United States, the drug company Richardson-Merrell applied to the Food and Drug Administration (FDA) in 1960 for approval to market thalidomide. The application went to Dr. Frances Kelsey, who possessed a doctorate in pharmacology and a medical degree but had been working at the FDA for only a month. Kelsey was pressured by her superiors and by the drug company to approve thalidomide, but

A three-year-old girl, born in the early 1960's without arms to a German mother who took the drug thalidomide. The girl uses power-driven artificial arms. *(AP/Wide World Photos)*

she insisted that better test results had to be obtained before she would recommend approval. As a result of Kelsey's stance, only seventeen cases of thalidomide-related deformity among newborns occurred in the United States. In 1962, Kelsey was awarded the President's Award for Distinguished Federal Civilian Service for her firm stand against federal approval of thalidomide.

Remedial Actions

The powerful lesson that emerged from the dire consequences of the failure to block the marketing of thalidomide outside the United States was that governments must be vigilant in monitoring new products produced by drug companies and should strongly resist companies' efforts to enhance their profits by bringing drugs into the marketplace prematurely. In addition, forensic specialists need to analyze the reported results of tests on new drugs carefully to ensure that the testing has been conducted on adequate samples of animals and humans and that the results are accurately presented.

Following the thalidomide disaster, an important step was taken toward protecting the public in the United States with the passage in 1962 of the Kefauver-Harris Amendment, a measure that had been languishing in congressional committees through many sessions. The bill eliminated a previous provision of U.S. law that allowed drug companies to sell new drugs to the general public if the FDA did not say otherwise for six months after the drugs were submitted to the FDA for approval. Since passage of the amendment, drug companies can sell new drugs only after the FDA has affirmed that the products are safe and effective on the basis of "substantial evidence." Such evidence must include the results of carefully conducted scientific trials using matched groups where possible; that is, during the testing of a new drug, persons in one group undergo treatment with the drug while those in another are given a placebo, a harmless pill that resembles the drug being tested.

In 1998, the FDA approved thalidomide for limited uses. It has been shown to provide dramatically effective treatment for complications of Hansen's disease (leprosy); trials found relief of symptoms in more than 70 percent of those given the drug, compared with only 2.5 percent of those who were administered a placebo. Thalidomide has also been approved for use in the treatment of the symptoms of acquired immunodeficiency syndrome (AIDS), some forms of cancer, and various skin conditions.

Gilbert Geis

Further Reading

Mason, David. *Thalidomide: My Fight*. London: Allen & Unwin, 1976. Tells the story of Mason's daughter, Louise, who suffered the absence of limbs as a result of her mother's use of thalidomide. Mason led the campaign in Britain for compensation to thalidomide victims.

Roskies, Ethel. *Abnormality and Normality: The Mothering of Thalidomide Children*. Ithaca, N.Y.: Cornell University Press, 1972.

Presents an analysis of the experience of Canadian victims of thalidomide injuries. Considers the reactions of family members, neighbors, and hospitals and addresses the psychological consequences of the injuries.

Sjöström, Henning, and Robert Nilsson. *Thalidomide and the Power of Drug Companies*. New York: Penguin Books, 1972. Offers details of the self-interested behavior of the drug companies in the marketing of thalidomide and their opposition to compensation claims.

Stephens, Trent D., and Rock Brynner. *Dark Remedy: The Impact of Thalidomide and Its Revival as a Vital Medicine*. Cambridge, Mass.: Perseus, 2001. Traces the history of thalidomide from its creation to its therapeutic uses in the twenty-first century.

Teff, Harvey, and Colin R. Munro. *Thalidomide: The Legal Aftermath*. Farnborough, England: Saxon House, 1976. Provides details of the litigation that resulted from the claims for compensation by thalidomide victims.

See also: Actuarial risk assessment; Antianxiety agents; Autopsies; Barbiturates; Chemical agents; Control samples; Product liability cases.

Thanatology

Definition: Study of death among human beings, including investigation of the circumstances surrounding deaths of individuals, the grief experienced by loved ones, and larger social attitudes toward death.

Significance: The field of thanatology is interdisciplinary, including such areas of study as religion, medicine, psychology, sociology, psychiatry, social work, anthropology, and pharmacology. Much of the work of thanatologists focuses on palliative care for dying individuals and their families, which involves treating pain and addressing the physical, psychosocial, and spiritual issues related to death.

The term "thanatology" derives from the Greek word for death, *thanatos*. Thanatology explores how questions about the meaning of life and death affect the dying and their loved ones, recognizing that these questions are relevant to the psychological health of individuals, families, communities, and cultures. Because death is such a broad and complex subject, thanatology relies on holistic knowledge and practice.

Evolution of Thanatology

During the mid-twentieth century, many Americans considered death a taboo topic, to the extent that death was an unacceptable topic for scholarly research, public education, or public discussion. Eventually, however, this attitude was challenged by the initiatives of a number of pioneers, including Cicely Saunders, William Lamers, and Elisabeth Kübler-Ross. In 1967, Saunders founded St. Christopher's Hospice in London, England; St. Christopher's is often credited as being the first hospice. Saunders emphasized that dying is not simply a biomedical or physical event; it also has psychosocial, familial, and spiritual implications. At St. Christopher's, she tried to create a homelike, family-centered atmosphere that would allow dying persons to live life fully, free from debilitating pain and incapacitating symptoms. In 1974, Lamers founded a hospice in Marin County, California, that viewed home care as the model of hospice treatment and stressed psychosocial care and the use of volunteers.

The hospice movement is based on the recognition that the dying process is part of the normal process of living, and hospice care focuses on enhancing the quality of remaining life. From their beginnings in the mid-1960's, hospice programs expanded quickly; within forty years, more than eight thousand hospices were in operation all around the world. Both the hospice philosophy and the growth of hospices improved the treatment of dying persons and encouraged the study of the dying process.

The growth of the hospice movement was in part a reaction to medicine-driven care that abandoned those who were no longer responsive to treatment. In addition, the movement resonated with persons who were beginning to question consumerism and those who were seeking a return to nature. Hospice care affirms life and neither hastens nor postpones death. It seeks to preserve and promote the inherent potential for growth within dying individuals and their families during the last phase of life.

In *On Death and Dying*, first published in 1969, Kübler-Ross wrote of natural death at a time when many people were becoming increasingly averse to the medical profession's technological and impersonal approach to care of the dying. She posited that dying persons go through five stages: denial, anger, bargaining, depression, and acceptance. Through case vignettes, she made a powerful plea for humanistic care for dying persons. Although research has found that the five stages she delineated are not characteristic of all dying individuals, Kübler-Ross's call for humanistic care in the last stage of life is an enduring legacy.

Dr. Elisabeth Kübler-Ross was a pioneer in the field of thanatology. Her book *On Death and Dying* (1969) made a strong plea for humanistic care for dying persons. *(AP/Wide World Photos)*

Issues and Resources

Technological advances have raised many issues surrounding death, such as how long people live, when they know that they are dying, and where they typically die. Among the end-of-life decisions that dying persons and their family members often face are decisions regarding advance care plans, life-support options, giving and receiving communications about the dying person's medical condition, and who will make health care decisions when the dying person is no longer able to do so. In addition, dying persons and their families may discuss the topics of autopsy, organ donation, and euthanasia. Within a diverse society, culturally meaningful thanatology practice requires a commitment to personal and professional assessment in response to the challenges presented by cultural differences in death, dying, and bereavement.

One resource in the field of thanatology is the Association for Death Education and Counseling (ADEC), one of the oldest interdisciplinary professional organizations for persons who work with the dying. Dedicated to promoting excellence in death education, care of the dying, grief counseling, and research in thanatology, ADEC provides information, support, and resources to its multicultural, multidisciplinary membership and, through its members, to the public. ADEC has a two-level program in which individuals can become certified in thanatology or fellows in thanatology. Certification status indicates that a person has special educational training in the field. Fellow status recognizes that a person has met specific knowledge requirements (as measured through a standardized test) and has demonstrated competence in teaching, research, or clinical practice through a professional portfolio.

Lillian M. Range

Further Reading

Balk, David, ed. *Handbook of Thanatology: The Essential Body of Knowledge for the Study of Death, Dying, and Bereavement*. New York: Routledge, 2007. Comprehensive text presents wide-ranging discussion of death-related issues. Includes sections on dying, end-of-life decision making, loss, traumatic death, and death education.

Becvar, Dorothy S. *In the Presence of Grief: Helping Family Members Resolve Death, Dying, and Bereavement Issues*. New York: Guilford Press, 2001. Provides a detailed portrait of death through case studies and personal stories of grief and struggle.

Corr, Charles A., Clyde M. Nabe, and Donna M. Corr. *Death and Dying, Life and Living*. 5th ed. Belmont, Calif.: Wadsworth, 2006. Thorough text covers all aspects of death and dying, including chapters on developmental issues, legal concerns, and challenges of the twenty-first century.

DeSpelder, Lynne Ann, and Albert Lee Strickland. *The Last Dance: Encountering Death and Dying*. 7th ed. New York: McGraw-Hill, 2004. Highlights the main issues in thanatology in a comprehensive and readable way.

Kübler-Ross, Elisabeth. *On Death and Dying*. 1969. Reprint. New York: Charles Scribner's Sons, 2003. Classic work focuses on the lessons that the dying can teach their doctors, nurses, and clergy, as well as their own family members.

See also: Antemortem injuries; Autopsies; Coroners; Forensic nursing; Forensic pathology; Homicide; Opioids; Physiology; Psychological autopsy; Suicide.

Thin-layer chromatography

Definition: Technique used to separate chemical compounds into their individual components.

Significance: By using thin-layer chromatography to determine the chemical components that make up particular substances, forensic scientists can help to identify the origins of those substances or link samples found at crime scenes to potential suspects.

Using thin-layer chromatography (TLC), forensic scientists can analyze the dye composition of fibers, poisons in food, pigments contained in plant specimens, or the ingredients in chemical weapons, explosives, or drugs. This method can also be used to detect the presence of a controlled substance in urine or blood.

TLC involves a stationary phase (a solid) and a mobile phase (a liquid or gas). As the name suggests, the technique uses a thin layer of silica gel, alumina, or cellulose coated on a piece of flat and inert glass, acetate, metal, or plastic. The silica gel or alumina is the stationary phase. The mobile phase is the solvent used.

First, a solution containing the sample of interest is "spotted" or applied to the TLC plate alongside reference or control spots (of solutions containing known substances) near the bottom of the plate. The plate is dipped into a solvent, often ethanol or water, such that the plate is minimally submerged. The chamber containing the solvent and plate is covered. By capillary action, the solvent travels up the TLC plate. The spots are dissolved and moved up by the solvent. This is called chromatographic development. The rate and distance of movement depend on the molecular forces and solubility of the chemical compounds in the solvent. Solutes (the compounds contained within a spot) with a greater affinity for the solvent will tend to spend more time with the solvent than solutes with less affinity for the solvent.

Colorless substances can also be separated by TLC. One common method involves the addition of a fluorescent compound such as manganese-activated zinc silicate to the adsorbent and visualization under a black light. Another method is the use of iodine vapors as a general unspecific color reagent.

The movement of the solvents can be determined through the calculation of a retention factor value. Retention factor values of known and unknown compounds can be compared to provide an index of similarity. Compounds with similar retention factor values tend to share solubility characteristics.

Rena Christina Tabata

Further Reading

Hahn-Deinstrop, Elke. *Applied Thin-Layer Chromatography: Best Practice and Avoidance of Mistakes*. Translated by R. G. Leach. 2d ed. Weinheim, Germany: Wiley-VCH, 2007.

Sherma, Joseph, and Bernard Fried, eds. *Handbook of Thin-Layer Chromatography*. New York: Marcel Dekker, 2003.

See also: Chromatography; Column chromatography; Fax machine, copier, and printer analysis; Forensic toxicology; Quantitative and qualitative analysis of chemicals; Questioned document analysis; Separation tests.

Tire tracks

Definition: Impressions left by vehicle tires on semisoft surfaces.

Significance: Tire tracks are often found at crime scenes, and analysis of such tracks can provide important information for investigators. Tracks can reveal the size and weight of a vehicle as well as the brand, model, and size of the tire; these details may link a suspect's vehicle to a crime scene.

By examining tire tracks, forensic investigators can determine the distance between two or more wheels of a vehicle, which can allow them to estimate the size, weight, and wheelbase of the vehicle. In addition to this information, the tread impressions that tires leave in soft soil, mud, dust, or snow reveal identifiable patterns: solid design elements interspersed with grooves. Databases containing pictures of the thousands of different tread designs in existence are widely available, and forensic investigators can use these to find matches for the tire tread impressions found at crime scenes. By finding a tire tread match, investigators can deduce the brand, style, and size of the tire, which also gives them a general idea of the type of vehicle on which the tire is likely mounted.

Because tires on motor vehicles do not wear evenly, they develop unique use patterns. If a suspect's vehicle is located, wear patterns seen in tire impressions from the crime scene can be compared to wear patterns on the vehicle's tires, often with enough accuracy to identify the vehicle positively as having been at the crime scene.

Forensic scientists record tire tread impressions either by photographing them or by casting them. Photography is usually the method of choice when the impressions are less than one-fourth inch deep and tracks at the scene are not confusingly overlapped. Photographs are first taken of the general scene, to place the location of the tracks in context. A ruler is then placed next to each tread impression to indicate scale, and close-up photographs are taken. When impressions are photographed in snow, they are first gently sprayed with a product called Snow Print Wax or colored spray paint to increase contrast.

Casting is a method of making a three-dimensional copy of an impression. This is the method of choice for deep or confusing impressions. Powdered casting material is mixed with water and gently poured into the impression.

Investigators gather tire-track evidence outside a church destroyed by an arson fire in Panola, Alabama, in early 2006. *(AP/Wide World Photos)*

After the material dries, it is removed from the scene and cleaned by technicians. The resulting cast can then be compared to tires in the tire design database or to tires on a suspect's vehicle. Courts generally accept tire impression photographs and casts that match a suspect's vehicle as physical evidence that the vehicle was present at the crime scene.

Martiscia Davidson

Further Reading

Bodziak, William J. *Tire and Tire Track Evidence: Recovery and Forensic Examination*. Boca Raton, Fla.: CRC Press, 2008.

Rainis, Kenneth G. *Hair, Clothing, and Tire Track Evidence: Crime-Solving Science Experiments*. Berkeley Heights, N.J.: Enslow, 2006.

Staggs, Steven. *Crime Scene and Evidence Photographer's Guide*. 2d ed. Wildomar, Calif.: Staggs, 2005.

See also: Casting; Footprints and shoe prints; Forensic photography; Physical evidence; Reagents; Trace and transfer evidence.

Tool marks

Definition: Impressions or abrasions made by tools when they contact surfaces.

Significance: Tools are often used in the commission of crimes, and the marks made by these tools can be valuable pieces of evidence. Trained examiners can gain information about the physical specifications of individual tools from the marks they create, and these specifications can be compared with tools known to be in the possession of suspects.

Broadly defined, a tool is any object used to gain a physical advantage. Because criminal offenders often use tools to gain access to areas to which they would not otherwise have access, tool marks are commonly found at crime scenes, particularly on items such as window and door frames and safes.

Class and Individual Characteristics

When conducting tool-mark analysis, forensic scientists compare tools and their marks by examining class characteristics, which narrow down the type and perhaps even brand of a tool, and individual characteristics, which can directly match a tool to a mark. For example, if a crowbar was used to pry a window open, the tool mark found on the window frame might show that the profile of the tool consisted of two 1.5-centimeter edges with a 4-millimeter gap between the edges. These class characteristics can be used to eliminate all crowbars that have profiles that do not fit those specifications. Continuing the example, if a suspect is identified and a crowbar is found in that person's possession that has a profile consisting of two 1.5-centimeter edges separated by a 6-millimeter gap, that crowbar could be eliminated as the one used to pry the window open. If the suspect is found to have a crowbar consistent with the tool mark, however, further analysis would have to be performed, with the examiner comparing individual characteristics.

Individual characteristics on tools are typically the results of tiny imperfections or damage. When a tool has imperfections that were introduced in the manufacturing process, this can result in microscopic striations, or lines, in any marks the tool makes. The marks made by a damaged tool will also exhibit striations, and these are often more pronounced than striations due to manufacturing. No two tools will have exactly the same pattern of striations in their tool marks. Because of this, a microscopic comparison of striations made by a known tool to striations found in a tool mark from a crime scene can be used to determine whether the two tool marks are consistent—that is, whether they had to have come from the same tool.

Methods of Analysis

If a tool mark found at a crime scene is on an object that can be transported back to the crime lab, the object is collected. If a tool mark appears on a surface that cannot be taken back to the lab, such as a floor or wall, a cast of the mark is made so that the details of the mark can be analyzed at the lab.

Each tool mark collected is first examined for different types of class characteristics as the scientist attempts to gain information about the type of tool that was used to create the mark. If a suspect has been identified, a search warrant may then be obtained for tools in that person's possession so that the tools can be compared with the specifications of the tool that made the evidence tool mark. Any tools identified are brought back to the crime lab and used to make tool marks in the same material as the object containing the questioned tool mark. The forensic scientist then compares the marks on a microscopic level to see if the striations are consistent with each other.

The FBI's Firearms-Toolmarks Unit

The Federal Bureau of Investigation operates many highly specialized forensic investigation units, including the Firearms-Toolmarks Unit (FTU). This division applies advanced scientific techniques to examinations of firearms, components of ammunition, bullet trajectories, gunshot residue, tool marks, and other related forms of physical evidence. In addition to collecting, analyzing, and processing evidence used in FBI investigations, the FTU serves as a liaison in the fields of tool-mark and firearm analysis with other national and international forensic laboratories and law-enforcement agencies, for which it also provides training.

Evidentiary Value

The utility of tool-mark analysis has long been accepted among forensic scientists, but the evidentiary value of such analysis has come into question because it is difficult for scientists to assign measures of statistical significance to their findings. The difficulty in assessing statistical significance stems from a lack of defined criteria for pronouncing that a match has been made between a known tool mark and a questioned tool mark. That is, no standard has been set regarding a minimum number of striations that must be consistent for an identification to be considered definitive. Rather, all striations have to match, regardless of how many are present.

Problems have also arisen in the field as a result of a perceived subjectivity in the interpretation of tool-mark evidence. Accusations have been made for some time that the comparison of tool marks constitutes more of an art than a science. Despite these allegations, however, tool-mark analysis continues to play an important role in crime scene investigations.

Lisa LaGoo

Further Reading

Gardner, Ross M. *Practical Crime Scene Processing and Investigation*. Boca Raton, Fla.: CRC Press, 2005. Guide to investigating crime scenes focuses on practical applications of forensic techniques. Includes discussion of the surfaces on which tool marks are typically found.

Genge, N. E. *The Forensic Casebook: The Science of Crime Scene Investigation*. New York: Ballantine, 2002. Easy-to-read overview of crime scene investigation includes a short section on tool marks as well as an interview with an examiner.

Mozayani, Ashraf, and Carla Noziglia, eds. *The Forensic Laboratory Handbook: Procedures and Practice*. Totowa, N.J.: Humana Press, 2006. Practical guide to the procedures carried out in forensics labs provides basic information on tool-mark analysis and the evidentiary value of the findings.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007. Excellent introductory textbook addresses most forensic disciplines. Contains several sections on tool marks and other kinds of impression evidence.

Thurman, James T. *Practical Bomb Scene Investigation*. Boca Raton, Fla.: CRC Press, 2006. Presents information regarding the examination of tool marks found in close proximity to explosion scenes.

See also: Bite-mark analysis; Casting; Class versus individual evidence; Control samples; Document examination; Federal Bureau of Investigation Laboratory; Fracture matching;

Lindbergh baby kidnapping; Lock picking; Microscopes; Physical evidence; Scanning electron microscopy.

Toxic torts

Definition: Civil wrongs that involve personal injuries caused by toxic substances.

Significance: Forensic scientists play a major role in conducting scientific studies to show causal relationships between toxic substances and personal injuries and to assist the government in regulating toxic substances to prevent toxic tort litigation.

Toxic torts, environmental lawsuits, and product liability cases are often linked together as modern causes of action that have experienced tremendous growth in the United States since World War II owing to rapid rates of industrial and technological change. Toxic tort cases involve complex issues of proof—that particular toxic substances cause specific harms. The scientific evidence necessary to demonstrate causation is not easily admissible in a court of law, and admissibility requires satisfaction of the standards set forth in *Daubert v. Merrell Dow Pharmaceuticals* (1993). Plaintiffs who suffer personal injury from toxic substances thus may not always receive justice because of the difficulties in showing causation. In addition, some injuries caused by toxic substances may not manifest themselves until long after exposure to the substances, and future litigation may be barred by statutes of limitation and issue preclusion because courts have already rendered final decisions in the cases.

History

Toxic tort litigation grew out of common-law tort actions, especially nuisance, negligence, and strict liability claims. Historical examples of common-law claims for injuries caused by environmental pollution include claims filed in England in the early years of the Industrial Revolution. These causes of action were based on allegations that smoke, odors, noise, and toxic substances were affecting the health and welfare of individuals. Modern-day toxic tort cases are usually based on a theory of negligence. If the toxic substance is ultrahazardous, however, strict liability may apply.

Although toxic tort litigation concerns private personal injuries, toxic substances are regulated by society through public law. The U.S. Congress has charged the Environmental Protection Agency with carrying out and enforcing the provisions of many of the federal laws that regulate the manufacture, sale, and use of toxic substances and the disposal of such substances in the air, water, and soil. Those involved in public regulation and enforcement, however, have not been able to keep up with the ever-growing list of toxic substances capable of causing personal injuries. Complex toxic tort litigation is thus on the rise despite the government's attempt to prevent toxic torts.

Toxic Substances

Toxic substances include any substances that could cause injury to a person's bodily integrity. Generally, harmful biological and chemical substances such as hazardous wastes and asbestos have been considered to be toxic substances, but radiological and other injurious substances as well as natural products such as tobacco may also be considered toxic.

New products and substances are constantly entering the global marketplace, many times with little regulation, and some substances may not be deemed toxic and personally injurious for years after they are introduced. Such findings are usually made after lengthy scientific investigation, study, and analysis. When a finding of toxicity is made about a particular product, the U.S. government usually steps in and removes the product from the marketplace or requires that manufacturers provide specific warnings concerning its toxicity and its proper use. By that time, however, it may already be too late for many people who have been exposed to the product, as many incurable diseases linked to toxic substances can take long periods to appear.

Proof

The most difficult element of proof in toxic tort litigation is causation. Forensic experts conduct research and provide expert testimony to show that exposure to certain toxic substances causes specific personal injuries. Initially, much of the reasoning in toxic tort lawsuits is based on deductive guesswork about what appears to be the most obvious cause of a particular harm—the existence of a toxic substance. However, the legal system does not allow scientific guesses as evidence, so forensic scientists must satisfy the *Daubert* standard by showing that their opinions concerning causation are reliable.

When a substance is implicated in a toxic tort lawsuit for the first time, a pioneering scientist must attempt to show that the substance caused the personal injury or will cause additional harm in the future. Forensic scientists are usually able to identify suspect toxic substances such as asbestos and tobacco that might be linked to human harm such as cancer. Making a scientifically reliable connection between a toxic substance and a personal injury, however, is very difficult, particularly when other factors may be at play. Moreover, because of ethical considerations, human subjects are rarely involved in scientific studies concerning the effects of toxic substances. Instead, animal studies are often used, and the results of such studies are not as reliable.

Carol A. Rolf

Further Reading

Chiodo, Ernest P. *Toxic Tort: Medical and Legal Elements*. Philadelphia: Xlibris, 2007. Compares and contrasts the medical and legal issues in toxic tort litigation and suggests techniques to ensure the admissibility of scientific evidence.

Cranor, Carl F. *Toxic Torts: Science, Law, and the Possibility of Justice*. New York: Cambridge University Press, 2006. Explores the use of scientific evidence in toxic tort litigation and the complexities associated with the admissibility of such evidence.

Eggen, Jean MacChiaroli. *Toxic Torts in a Nutshell*. 3d ed. St. Paul, Minn.: West, 2005. Introductory text highlights theories of liability, defenses, and damages in toxic tort and environmental litigation.

Madden, M. Stuart, ed. *Exploring Tort Law*. New York: Cambridge University Press, 2005. Collection of essays presents an exploration of tort law that is both historical and global, including discussion of modern litigation that encompasses toxic tort lawsuits and class actions.

Madden, M. Stuart, and Gerald W. Boston. *Law of Environmental and Toxic Torts: Cases, Materials, and Problems*. 3d ed. St. Paul, Minn.: Thomson/West, 2005. Textbook explains theories, elements of proof, and difficulties in proving causation in toxic tort litigation, especially for injuries not yet in evidence.

Rudlin, D. Alan, ed. *Toxic Tort Litigation*. Chicago: American Bar Association, 2007. Outlines theories, evidence admissibility, settlement, and procedural issues in toxic tort litigation. Also includes detailed information related to several toxic substances.

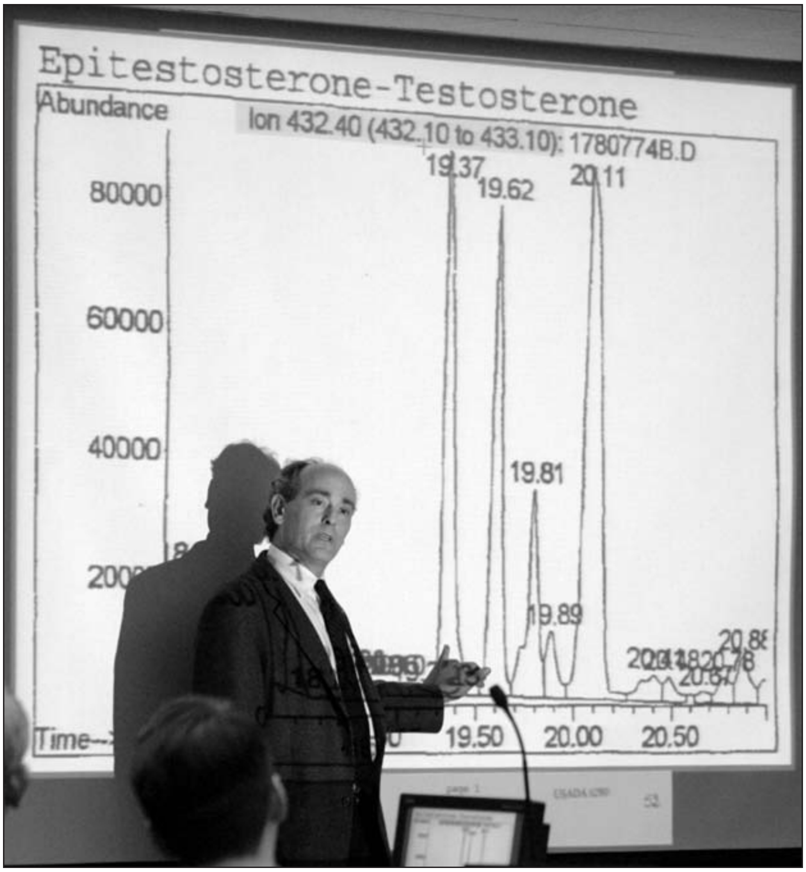
See also: Biotoxins; Chemical agents; Courts and forensic evidence; *Daubert v. Merrell Dow Pharmaceuticals*; Forensic toxicology; International Association of Forensic Toxicologists; Mycotoxins; Product liability cases; Toxicological analysis.

Toxicological analysis

Definition: Methodologies used to identify and quantify the presence of drugs (including alcohol) and toxins in samples and to interpret the significance of the results.

Significance: In forensic science, toxicological analysis encompasses aspects of sample preparation, chemical analysis, and interpretation of results. Toxicology plays a vital role in a wide range of different case types encountered in forensic work, including death investigations (criminal or otherwise), impaired driving, sexual assault, and drug use in sports or in other matters involving questions about human performance.

Toxicology departments are among the busiest in most forensic laboratories, owing to the pervasiveness of drug and alcohol use and the potential for the involvement of these substances in a wide range of case types. Toxicological analysis may be performed on a variety of sample types, including materials of biological and nonbiological origin. Typical biological samples include blood, urine, visceral tissues (such as tissues from the liver), stomach contents, hair, and saliva. Nonbiological samples may include portions of food and/or beverages, syringes, and other items. The analysis may be qualitative (for example, simple identification of the presence of a substance within a sample) or quantitative, where the amount or concentration of a toxin contained within the sample is important for toxicological interpretation.



At an arbitration hearing in May, 2007, concerning doping allegations against 2006 Tour de France champion Floyd Landis, a toxicologist testifies about abnormalities on a chart of urine test results from the French government's National Laboratory for Doping Detection. *(AP/Wide World Photos)*

Procedures

After properly collected, handled, and documented samples are obtained and submitted to the laboratory, toxicological analysis often occurs in four distinct phases. The first stage involves consideration of the circumstances of the case and any requests for particular analyses from the submitting agencies (coroner or medical examiner, police agencies). In this step, details about particular symptomatology or events that occurred in the case provide some guidance for the toxicologist in deciding which drugs or toxins to analyze for, which sample types are suitable (pending availability) for analysis, and which methods to use.

Next, samples generally undergo some form of preparation to remove residual impurities prior to chemical analysis, given the chemical complexity of samples typically encountered in forensic work (such as decomposed tissues). This sample preparation process typically involves some combination of homogenization, dilution, and selective extraction of the compounds of interest from the background material into a pure solvent. Extraction generally involves manipulation of the chemical conditions (such as pH, solvent, or temperature) to favor diffusion of drugs or toxins from the sample matrix into another phase. For example, acidic drugs may be ionized as a result of proton loss at elevated pH values.

Extraction may then first require a reduction of pH in a blood sample, ensuring that the acidic drug remains uncharged and therefore more soluble in an organic solvent that is immiscible (incapable of mixing) with the blood. Adding such a solvent to a blood sample creates two phases: an aqueous blood phase and an organic phase. Shaking this mixture results in diffusion of the drug into the organic phase, leaving many of the blood constituents in the aqueous phase. Similar approaches may be used to isolate basic compounds or neutral (that is, neither acidic nor basic) compounds.

Multiple extraction cycles may be performed on the same sample, or multiple, different extraction steps may be performed in series in an effort to create the "cleanest" extract possible. In many cases, extracts are then concentrated through evaporation of the extraction solvent to improve the sensitivity of detection in the subsequent analysis step.

Analysis of prepared samples then generally occurs by instrumental methods, including spectrophotometry, gas chromatography, liquid chromatography and mass spectrometry. It should be noted that, despite even the best sample preparation efforts, prepared extracts still usually contain multiple chemical compounds. Consequently, most instrumental analyses used in toxicological analysis include some sort of separation of the constituents of the extract mixture (for example, through gas or liquid chromatography). Forensic scientists may use these methodologies qualitatively, quantitatively, or in combination to provide as much information about the chemical makeup of extracts as possible.

Interpretation of Results

After all of the analyses of a given extract have been conducted and have been thoroughly reviewed for scientific completeness, the analytical results are collected and interpreted collectively for their toxicological significance. Here, important considerations include drug concentrations, the sample type in which they were measured (that is, a given drug concentration in a blood sample may have toxicological implications that are different from the implications for the same concentration in a urine sample), any potential drug interactions (such as the combination of alcohol and other depressant drugs), and the circumstances of the case, including any special considerations (such as the stability of a given drug under a particular set of storage conditions). Generally, the toxicologist must conduct a thorough review of the scientific literature to assess the effects of different drugs at different concentrations and under different circumstances.

After the four phases of analysis are complete, the toxicologist prepares a report detailing which samples were analyzed, the analytical findings, and the methods by which the results were obtained. This report also contains the toxicologist's conclusions and statements regarding sample handling, continuity of evidence, and chain of custody. The scientist may then be called upon to provide testimony as an expert witness and further questioned about the contents of the report.

James Watterson

Further Reading

Baselt, Randall C. *Disposition of Drugs and Chemicals in Man*. 7th ed. Foster City, Calif.: Biomedical Publications, 2004. Describes the properties and associated tissue concentrations of a wide range of toxic compounds and discusses the techniques used to analyze these chemicals.

_______. *Drug Effects on Psychomotor Performance*. Foster City, Calif.: Biomedical Publications, 2001. Comprehensive reference work presents information on the impairing effects of a wide range of therapeutic and illicit drugs.

Brunton, Laurence L., John S. Lazo, and Keith L. Parker, eds. *Goodman and Gilman's the Pharmacological Basis of Therapeutics*. 11th ed. New York: McGraw-Hill, 2006. Authoritative advanced textbook explains basic pharmacological principles and the specific pharmacological features of therapeutic agents. Includes some discussion of illicit agents.

Karch, Steven B., ed. *Drug Abuse Handbook*. 2d ed. Boca Raton, Fla.: CRC Press, 2007. Describes the pharmacological, physiological, and pathological aspects of drug abuse in general, and individual chapters address specific compounds, such as alcohol, as well as specific issues related to drug abuse, such as workplace drug testing.

Levine, Barry, ed. *Principles of Forensic Toxicology*. 2d ed., rev. Washington, D.C.: American Association for Clinical Chemistry, 2006.

Introductory textbook describes the analytical, chemical, and pharmacological aspects of a variety of drugs of forensic relevance.

See also: Alcohol-related offenses; Analytical instrumentation; Drug abuse and dependence; Forensic toxicology; Gas chromatography; High-performance liquid chromatography; Homogeneous enzyme immunoassay; Illicit substances; International Association of Forensic Toxicologists; Mass spectrometry; Poisons and antidotes; Sherlock Holmes stories; Toxic torts; Ultraviolet spectrophotometry.

Toxicology. *See* Forensic toxicology

Trace and transfer evidence

Definitions: Trace evidence is evidence present in very small amounts, requiring careful attention, and often special techniques, to detect. Transfer evidence is evidence that has moved from one person or object to another (for example, from a crime victim to the perpetrator or vice versa).

Significance: Trace evidence and transfer evidence often take the form of fibers, hairs, soils, paint chips, and other tiny pieces of material that must be carefully collected from crime scenes and transported to the laboratory for analysis. The information gained from forensic analysis of such evidence can help law-enforcement investigators to link suspects to crime scenes.

Although trace evidence and transfer evidence are conceptually distinct, the terms "trace" and "transfer" are frequently applied to the same materials, the debris (hairs, fibers, dust, glass and paint fragments, and other materials, natural and manufactured) that French forensic pioneer Edmond Locard characterized as containing the "mute witnesses" of criminal truth. Locard's exchange principle, widely regarded as the fundamental idea behind forensic science, insists that "every contact leaves a trace." This transfer—blood on a door handle, for example—need not be unperceived, but it is the difficult-to-perceive transfer (the "trace") that is likely to survive attempts to scrub away evidence of mischief.

"Trace" Versus "Transfer"

When surfaces touch, transfer evidence is produced, although transfer can occur without direct contact. Surfaces pick up matter and leave matter behind, or disturb the material already there, or both. Stepping in the mud may leave behind a shoe print (possibly one with great individuality); it also may take away material from the mud and leave behind material from the shoe.

Transfer evidence thus can be viewed as including both "pattern transfer" evidence, such as imprints and impressions (of fingerprints, shoe prints, tire tracks, and so on), and "trace transfer" evidence, such as hairs, fibers, glass fragments, soil, and blood. The former is often referred to simply as "pattern evidence," the latter as "trace evidence." The phrase "trace, or transfer, evidence" (occasionally further abbreviated to just "trace evidence") is sometimes used as a loose label for both.

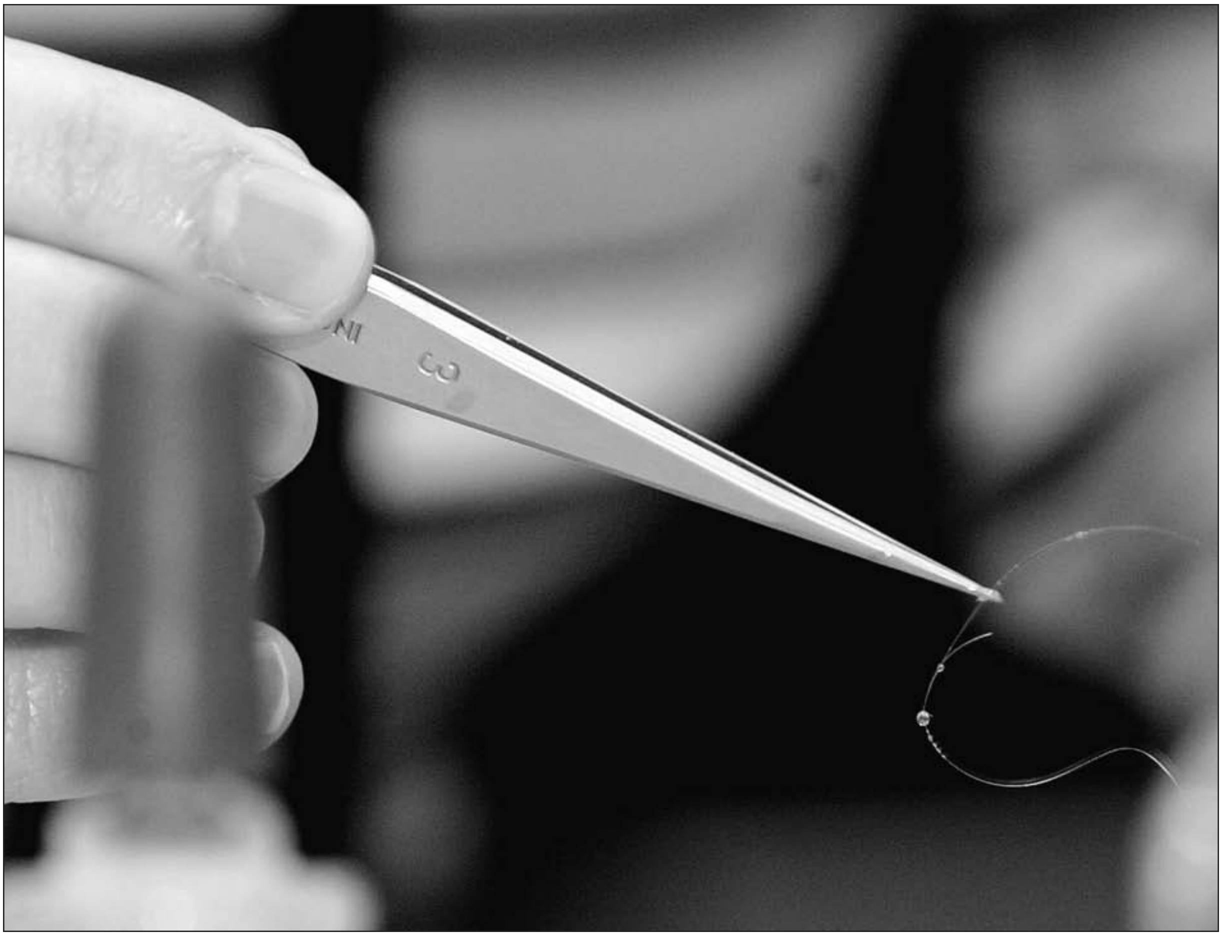
As a practical matter, what falls into the category of trace evidence is influenced by bureaucratic factors such as crime lab organization, including spatial layout, equipment distribution, staffing contingencies, and funding requirements. "Trace" functions to some extent as a catchall category, and so the kinds of evidence that fall into that category can vary enormously. As one trace analyst has put it, "Trace analysis is the section of the crime lab where, if they don't know where to send it, they send it to us."

Problems with Trace Evidence

Some problems related to the use of hair, fiber, and other trace and transfer evidence in criminal cases have involved familiar concerns about proper quality control in the collection, preservation, testing, and documentation of evidence. Other problems have arisen owing to the professional or moral failings of individual "experts" who have overstated the significance of "matches." Despite much loose talk about two or more items "matching" or "being similar," and about results "corroborating" or being "consistent with" a certain hypothesis, much trace evidence at best rules out certain possibilities.

More decisive, positive implications depend heavily on judgments about probabilities. How likely is it that a fiber found on a murder victim came from the carpet in a vehicle belonging to the defendant? Given a glass fragment found on a suspect that is similar to the glass in a crime victim's home, when is it reasonable to conclude that it comes from that source? Forensic scientists devote much effort to trying to establish relevant numbers, and many statistical mistakes can be made in reasoning about these matters. Calculating the likelihood of variation among items of a given kind (such as hairs or glass fragments) is part of the problem and part of why it is important that forensic scientists conduct comparisons using control samples.

The emergence of DNA (deoxyribonucleic acid) analysis has played a role in decreasing the emphasis on trace and transfer evidence. It has also prompted recognition of serious flaws in both the scientific and the judicial utilization of results. In establishing the innocence of numerous individuals who have been convicted of crimes, DNA evidence has provided an indictment of the evidence (often hairs, fibers, or other trace evidence) on the basis of which those individuals were originally convicted. This development has contributed to a decline in the prestige attached to the analysis of trace evidence.



A technician in the Georgia Bureau of Investigation's Trace Lab examines a strand of hair collected as evidence. *(AP/Wide World Photos)*

The Future of Trace Evidence

In announcing a symposium on trace evidence sponsored by the Federal Bureau of Investigation (FBI) and the National Institute of Justice (NIJ) in 2007, Sandra Koch of the FBI Laboratory's Trace Evidence Unit noted that "collection, preservation, analysis, and eventual use in court [of trace/transfer evidence] have declined in recent years." Half a decade earlier, retired forensic scientist Larry Ragle had lamented that "it has become more difficult for the lab personnel to justify spending the time it takes to characterize trace evidence, hairs, and fibers, or even to train new scientists in the techniques," and that in some jurisdictions "crime scene investigators no longer spend the time to search for and collect the standards necessary for comparison should trace evidence be important as the investigation progresses."

Trace evidence stands in the shadow of the rapid advance of DNA analysis, but it might nonetheless have a brighter future. The progress of nanotechnology (the science of ultrasmall—molecular-scale—particles and processes) may be expected to lead to the identification of yet subtler class characteristics of materials as well as to increased ability to detect individualizing features of wear and idiosyncrasies of manufacture in what were formerly indistinguishable mass-produced objects. (Whether such developments will have practical application within the context of underfunded and overtasked crime labs is another question.)

Moreover, trace evidence and transfer evidence are important for their role in the maintenance of an open-minded, holistic approach to forensics. As one crime lab director has observed:

> It used to be that when our firearms unit received a bullet, the first thing they'd do would be they'd wash it off so they could see all their little grooves and markings so they could do their comparison. . . . [They now realize that] there might be blood on there that's important. . . . Directors of crime labs have to . . . not lose the ability of people to recognize evidence beyond their one little specialty.

Edward Johnson

Further Reading

Aitken, Colin G. G., and Franco Taroni. *Statistics and the Evaluation of Evidence for Forensic Scientists*. 2d ed. Hoboken, N.J.: John Wiley & Sons, 2004. Provides extensive discussion of the statistical issues involved in the interpretation of trace and transfer evidence.

Fisher, Jim. *Forensics Under Fire: Are Bad Science and Dueling Experts Corrupting Criminal Justice?* New Brunswick, N.J.: Rutgers University Press, 2008. Surveys the weaknesses that exist in some areas of forensic science, including the analysis of hair and fiber evidence.

Fletcher, Connie. *Every Contact Leaves a Trace: Crime Scene Experts Talk About Their Work from Discovery Through Verdict*. New York: St. Martin's Press, 2006. Presents commentary from more than eighty professionals in the field of forensic science, with a focus on the difference between their real-life work and depictions of forensic work in the popular media. Includes an extensive discussion of trace evidence.

Houck, Max M., ed. *Mute Witnesses: Trace Evidence Analysis*. San Diego, Calif.: Academic Press, 2001. Collection of essays presents a variety of viewpoints on central concerns in the handling and interpretation of trace evidence.

_______. *Trace Evidence Analysis: More Cases in Mute Witnesses*. Burlington, Mass.: Elsevier Academic Press, 2004. Second anthology edited by Houck discusses a variety of cases involving trace evidence.

Kelly, John F., and Phillip K. Wearne. *Tainting Evidence: Inside the Scandals at the FBI Crime Lab*. New York: Free Press, 1998. Recounts the effects of incompetence, dishonesty, and cover-up in a number of trace evidence cases handled by the nation's most prestigious forensic lab.

Lee, Henry C., Timothy Palmbach, and Marilyn T. Miller. *Henry Lee's Crime Scene Handbook*. San Diego, Calif.: Academic Press, 2001. Discusses proper evidence collection, preservation, and assessment. Lee is one of the best-known practitioners of forensic science in the United States.

Ragle, Larry. *Crime Scene*. Rev. ed. New York: Avon Books, 2002. Provides detailed information on the procedures used in the collection, testing, and interpretation of trace and other evidence.

See also: Animal evidence; Blood residue and bloodstains; Class versus individual evidence; Crime scene protective gear; Cross-contamination of evidence; Defensive wounds; Fibers and filaments; Forensic geoscience; Glass; Gunshot residue; Hair analysis; Hit-and-run vehicle offenses; Locard's exchange principle; Paint; Semen and sperm; Soil.

Training and licensing of forensic professionals

Definition: Education in forensic techniques and certification of competence in the practice of such techniques.

Significance: Professionalization implies that self-regulation, in some cases supplemented by laws, should determine appropriate standards for the education and certification of those who practice the profession. The standards of competence for forensic professionals, however, are in many cases unspecified or vary by jurisdiction, or from field to field, or are only loosely connected with evidential standards. This situation has prompted both demands for greater professionalization of the field of forensic science and worries about the restrictive effects of excessive regulation.

In the late nineteenth century, when Sir Arthur Conan Doyle created his master detective character Sherlock Holmes, who used his multifarious knowledge and his powers of ratiocination to clarify mysteries that had flummoxed Scotland Yard's energetic but imperceptive Inspector Lestrade, the idea of applying science to the solution of crime was largely speculative. Since that time, forensic science has developed sophisticated techniques and given birth to a variety of professional organizations, but still only limited agreement exists on exactly what forensic professionals should know, or even what constitutes competence in the field. Debate continues concerning how should modern criminalists—the heirs of both Holmes and Lestrade—should be trained and certified.

Varying Standards

In the early twenty-first century, the profession of private investigator is licensed throughout the United States, but forensics as a field is wide open. Some specialists, such as medical examiners, are subject to certification, and many specialists are regulated by their own professional organizations, but some observers have argued that greater unification and professionalization of those who have business with forensic issues is in order.

The problem is that "forensic science" is not a natural science; rather, forensic science includes any science that is useful, more or less often, in settling facts of interest in the courtroom. Over time, new sciences emerge and old "sciences" sometimes fade. In the era of Alphonse Bertillon (1853-1914), knowing how to measure various human physical features, such as ears, was important, but fingerprinting largely displaced that older system of identification. More recently, fingerprinting has seen its own preeminence challenged by DNA (deoxyribonucleic acid) "fingerprinting" as well as by worries about accuracy and puzzles created by computerization.

In addition to disagreements about the criteria for training and the necessity and scope of licensing, disagreements exist even about standards for evidence. With regard to fingerprints, for example, no standard has been established regarding the minimum number of points of commonality that must be present for examiners to consider a match reliable. Various nations have differing requirements, and requirements in the United States vary across states and even across police jurisdictions within states.

In the courtroom, these issues are reflected in debates about who can or should be accorded expert witness status. Leading British forensic entomologist Zakaria Erzinçlioglu (1951-2002) at the time of his death was conducting a vigorous campaign for the British courts to rethink who ought to be able to function as expert witnesses in those courts.

In 1995, the American Academy of Forensic Sciences (AAFS), concerned by the wide variation in certification standards used by different boards, undertook to make the credentialing process for forensic scientists more rational. As a result, the AAFS in 2000 established the Forensic Specialties Accreditation Board (FSAB) as a way of "accrediting the certifiers." The FSAB considered and rejected the idea of allowing accreditation through independent organizations, such as the National Commission of Certifying Agencies or the American Board of Medical Specialties, because "the forensic community would be unwisely delegating its professional oversight responsibility to non-forensic organizations."

Georgia Private Investigator Bill

The complex issues in the area of licensing are illustrated by the controversy in 2006 over a bill passed by the Georgia state legislature (2006 H.B. 1259) making it (with limited exceptions) a felony to engage in the private detective business without a license. This included "obtaining or furnishing . . . information" about crimes or the "securing of evidence . . . to be used before any court." The bill was supported by the Georgia Association of Professional Private Investigators as a way to improve the image of private investigators and "protect the public" from untrained, fly-by-night amateurs. "We have all seen them," the president of that organization wrote. "They spring up. . . . They screw up the investigation and their actions result in their clients losing their cases. . . . Meanwhile the 'investigator' has decided that this is not as much fun as they had thought and . . . moved on."

Computer consultants argued that the bill would unreasonably require them to be licensed

Recommendations for Education and Training

In June, 2004, the National Institute of Justice published a special report titled Education and Training in Forensic Science: A Guide for Forensic Science Laboratories, Educational Institutions, and Students. *The report, created by the Technical Working Group for Education and Training in Forensic Science, makes the following recommendations concerning training in the forensic sciences.*

Undergraduate degree. Undergraduate forensic science degree programs are expected to deliver a strong and credible science foundation that emphasizes the scientific method and problem-solving skills. Exemplary programs would be interdisciplinary and include substantial laboratory work, as most employment opportunities occur in laboratory settings. Natural sciences should dominate undergraduate curriculums and be supported by coursework in specialized, forensic, and laboratory sciences and other classes that complement the student's area of concentration.

Graduate degree. Graduate programs can move students from theoretical concepts to discipline-specific knowledge. Exemplary curriculums can include such topics as crime scenes, physical evidence, law/science interface, ethics, and quality assurance to complement the student's advanced coursework. Graduate programs should be designed with strong laboratory and research components. Access to instructional laboratories with research-specific facilities, equipment, and instrumentation and interaction with forensic laboratories are required to enhance the graduate-level experience. By emphasizing written and oral communication and report writing, graduate programs can prepare students for future courtroom testimony.

Forensic scientists have an ongoing obligation to advance their field through training and continuing professional development. Training programs should include written components (e.g., instructor qualifications, student requirements, performance goals, and competency testing), and their content should contain several core and discipline-specific elements guided by peer-defined standards. Continuing professional development . . . should be structured, measurable, and documented.

as private investigators and that in general the bill's provisions were inconsistent with the (sometimes) legally recognized right of scientific experts to examine evidence and testify to their findings. Moreover, as computer commentator Mark Rasch sensibly and cynically observed, "Internet based crimes occur across jurisdictions, but licensing boards' authority does not. So a company performing computer forensics in Georgia, run by a licensed PI in Georgia who had to examine a hard drive in California, theoretically would either have to obtain a license in California or retain the services of a California PI to do the work. Is this a full employment program for former cops?"

In May, 2006, Governor Sonny Perdue vetoed the bill, noting that it "fails to exclude from the private investigator licensing requirement many professions that collect information or may be called as expert witnesses in court proceedings." Although computer forensics consultants celebrated the veto as a victory, the political issue about increasing the penalty was not dead, and in any event unlicensed investigation remained illegal (albeit a misdemeanor) under existing law. Other states, of course, have other laws, some similar and some not. The larger issues—about what constitutes competence in matters of forensic science, who should have the authorization to train and to certify that competence, and how to ensure national (and, increasingly, international) commensurability—remain unresolved.

Edward Johnson

Further Reading

Barnett, Peter D. *Ethics in Forensic Science: Professional Standards for the Practice of Criminalistics*. Boca Raton, Fla.: CRC Press, 2001. Presents a concise treatment of the ethical issues affecting the training and licensing of forensic professionals.

Hallcox, Jarrett, and Amy Welch. *Bodies We've Buried: Inside the National Forensic Academy, the World's Top CSI Training School*. New York: Berkley Books, 2006. Describes the National Forensic Academy's ten-week training course for law-enforcement agents. Topics of the training include the identification, collection, and preservation of evidence.

Inman, Keith, and Norah Rudin. *Principles and Practice of Criminalistics: The Profession of Forensic Science*. Boca Raton, Fla.: CRC Press, 2001. Provides an introduction to "good practices" (including ethics) in the forensic science profession.

Rasch, Mark. "Forensic Felonies." *Security Focus*, April 24, 2006. Commentary helped to sound the alarm (from computer consultants' point of view) about the proposed Georgia felony penalty for unlicensed investigation.

Robberson, John. "President's Pen." *The Connection: Official Newsletter of the Georgia Association of Professional Private Investigators*, April, 2006, 3. Presents professional private investigators' explanation of their support for the Georgia bill changing unlicensed investigation from a misdemeanor to a felony.

See also: American Academy of Forensic Sciences; American Society of Crime Laboratory Directors; Computer forensics; *Daubert v. Merrell Dow Pharmaceuticals*; DNA fingerprinting; Ethics; Expert witnesses; Federal Bureau of Investigation Forensic Science Research and Training Center; Federal Law Enforcement Training Center; Fingerprints; International Association for Identification; International Association of Forensic Toxicologists; Pseudoscience in forensic practice; Sherlock Holmes stories.

Trial consultants

Definition: Persons with expertise that can be applied to courtroom settings who aid attorneys in preparing and executing trial strategies.

Significance: Among the various services provided by trial consultants, the one perhaps most relevant to forensic science is that of preparing expert witnesses to give courtroom testimony. Forensic scientists are often called to testify in court regarding the findings from their examination of evidence, and they may work with trial consultants beforehand so that they can present their testimony in the most effective manner.

Most law schools focus on teaching legal theory, legal writing, argumentation, bar exam preparation, and other practical matters of being a lawyer. Law schools do not generally include much instruction in disciplines such as psychology, sociology, statistics, anthropology, judgment and decision-making sciences, presentation technology, marketing, or market research. Many of these disciplines however, have proven helpful to attorneys as they seek to develop and carry out strategic arguments at trial. Since the 1980s, the gap between expertise in the law and expertise in these other areas has been filled by a growing number of specialists known as trial consultants.

Jury Selection

One area in which trial consultants have specialized is jury selection. Using psychological principles, consultants aid attorneys by identifying the characteristics of potential jurors that they believe will cause the jurors to be more or less likely to be sympathetic to the attorneys' clients or arguments. By examining the attitudes and experiences of the people in the pools from which jurors are selected, jury consultants draw conclusions about how each would be likely to decide given cases. With this information, attorneys can attempt to have excused from juries any persons they believe will be inclined to be unsympathetic toward their clients.

Preparation of Expert Witnesses

Attorneys frequently call on forensic scientists and other experts in scientific and technical fields such as physics, chemistry, biology, and psychology to testify in court. These experts are not always skilled at public speaking, and they can seem uneasy on the witness stand. Trial consultants often help to prepare experts so that they appear relaxed and confident as they present their testimony, which can aid their credibility with jurors. Sometimes this involves rehearsing with experts in simulated courtroom settings. Trial consultants also explain to expert witnesses the best ways for them to get particular messages across and how to avoid becoming flustered or confused under cross-examination.

Presentation Materials

Some trial consultants specialize in producing visual aids that attorneys use in presenting the facts of cases to juries. Photographs, time lines, charts, graphs, documents, and animations are among the types of visual materials that trial attorneys may need to convey facts clearly to juries. If such materials are confusing or even just difficult to see, jurors may fail to grasp the points the attorneys are trying to make. Many trial consulting firms can produce much higher-quality visual aids than trial attorneys could make on their own because these firms employ graphic artists and creative designers.

Pretrial Research

One way in which trial consultants gather information to help plan the strategies to be used in jury trials is by conducting research. Such research can take a wide variety of forms, from simple surveys to complete mock trials. The aim in each case is to discover how members of the public, ideally persons similar to the potential jurors, will view the case, the attorney, and the arguments that will be presented.

One of the methods that trial consultants often use in conducting research is the focus group. The consultant for a case recruits members of the public and pays them to listen to the case, both the arguments presented by the side that hired the consultant and the arguments that may be made by the opposing side. After the focus group members have heard all the arguments, they may be asked to discuss the case with a moderator, to respond to questionnaires about the case, or even to conduct a mock deliberation. The consultant records and then analyzes all of the feedback from the group.

Often, consultants find out through focus groups and other kinds of pretrial research that members of the public do not see cases in the same ways the attorneys do. Such research may reveal particular weaknesses in attorneys' arguments or even problems with the ways in which people react to the attorneys themselves.

Dr. Jo-Ellan Dimitrius (right), seated next to an attorney while serving as a consultant during the jury selection phase of former professional basketball player Jayson Williams's manslaughter trial in 2004. A specialist in predicting the behavior of jury members, Dimitrius has consulted in more than one thousand trials and has coauthored books on jury selection and "reading" people. She also appeared in a brief documentary about the making of the motion picture *Runaway Jury* (2004). *(AP/Wide World Photos)*

Pretrial research can also uncover weaknesses in the ways in which attorneys and witnesses present information, especially if the information is complicated.

Controversy

Trial consulting is a relatively new field, and it has been the source of controversy. For example, some members of the legal community have raised questions about whether attorneys who employ consultants have an unfair advantage, given that many clients cannot afford to pay for their attorneys to hire consultants. Also, some observers have expressed concern about the fact that, unlike the legal profession, the field of trial consulting is largely unregulated, and consultants need no special licensing or certification. Of the many services offered by trial consultants, those involving jury selection are perhaps the most controversial; it has been argued that consultants' input into the jury selection process may be seen as a violation of the right to an impartial jury trial, as provided for in the Sixth Amendment to the U.S. Constitution.

Robert Bockstiegel

Further Reading

Ball, David. *Theater Tips and Strategies for Jury Trials*. 3rd ed. Notre Dame, Ind.: National Institute for Trial Advocacy, 2003. Volume for attorneys, written by a trial consultant, discusses approaches to jury persuasion based in theater concepts.

Cotterill, Janet. *Language and Power in Court: A Linguistic Analysis of the O. J. Simpson Trial*. New York: Palgrave Macmillan, 2003. Draws on transcripts from Simpson's murder trial as well as interviews conducted after the trial with Simpson and jurors in the case to examine the importance of the role of the language used in the courtroom. Includes discussion of the jury selection process.

Kassin, Saul M., and Lawrence S. Wrightsman. *The American Jury on Trial: Psychological Perspectives*. New York: Hemisphere, 1988. Discusses all aspects of the American jury system, from jury selection to jurors' decision-making processes.

Mauet, Thomas A. *Trials: Strategy, Skills, and the New Powers of Persuasion*. New York: Aspen, 2005. Volume aimed at attorneys focuses on courtroom strategy and the art of juror persuasion.

Posey, Amy J., and Lawrence S. Wrightsman. *Trial Consulting*. New York: Oxford University Press, 2005. Describes the growth of the profession of trial consulting and explains the primary activities performed by trial consultants, including witness preparation, the conduct of focus groups and mock trials, and jury selection.

See also: Competency evaluation and assessment instruments; Courts and forensic evidence; Criminology; Expert witnesses; Eyewitness testimony; Legal competency; *People v. Lee*; Police psychology; Simpson murder trial.

Truth serum

Definition: Any of a number of drugs that depress the cerebral nervous system and reduce inhibitions.

Significance: The search for methods to secure intelligence, confessions, and details of criminal acts led law-enforcement agencies to employ pharmaceutical products such as scopolamine and barbiturates (notably sodium amytal and sodium thiopental) to try to induce persons to reveal information that they would not disclose voluntarily. The designation "truth serum" is misleading, however, as subjects under the influence of such drugs may lie. Success sometimes results when the persons interrogated come to believe that they can only tell the truth.

The term "truth serum" was introduced into forensic language during the 1920's by Dr. Robert House of Ferris, Texas. When House administered scopolamine to induce what was called "twilight sleep" to ease the difficulties of childbirth, he noticed that the drug made patients talkative and that they often revealed information that they otherwise would not have disclosed.

In 1963, the U.S. Supreme Court ruled in *Townsend v. Sain* that information acquired in interrogation after the use of a "truth serum" is not admissible in court in criminal cases. Charles Townsend, a heroin addict suspected of murder, suffered severe withdrawal pains while being interrogated by law-enforcement investigators. After a police doctor injected Townsend with scopolamine and phenobarbital, allegedly to treat the effects of the opiate withdrawal, Townsend confessed to the murder. The Court declared that, because of the use of "truth serum," Townsend's confession failed to meet the constitutional requirement that it be voluntary.

Two developments that followed the terrorist attacks on New York City and the Pentagon on September 11, 2001, focused renewed attention on the use of truth serum in the United States. The first was a U.S. Supreme Court opinion that stated that the fight against terrorism might require "heightened deference to the judgment of the political branches with respect to matters of national security" (*Zadvydas v. Davis*, 2001). Second, William Webster, a former chief of the Central Intelligence Agency (CIA) and the Federal Bureau of Investigation (FBI), urged the Pentagon to administer truth serum drugs to defiant Taliban and al-Qaeda prisoners to obtain information that could prevent fresh terrorist attacks. Webster's critics maintained that the use of truth serum constitutes a violation of international treaties in that such use invades the privacy of, inflicts indignity on, and compromises the bodily integrity of the subject.

Gilbert Geis

Further Reading

Geis, Gilbert. "In Scopolamine Veritas: The Early History of Drug-Inducted Statements." *Journal of Criminal Law, Criminology, and Police Science* 50 (November/December, 1959): 347-357.

Horsley, J. Stephen. *Narco-analysis: A New Technique in Short-Cut Psychotherapy*. London: Oxford University Press, 1948.

Moenssens, Andre A. "Narcoanalysis in Law Enforcement." *Journal of Criminal Law, Criminology, and Police Science* 52 (November/December, 1961): 453-458.

Winter, Alison. "The Chemistry of Truth and the Literature of Dystopia." In *Literature, Science, Psychoanalysis, 1830-1970: Essays in Honour of Gillian Beer*, edited by Helen Small and Trudi Tate. New York: Oxford University Press, 2003.

_______. "The Making of 'Truth Serum.'" *Bulletin of the History of Medicine* 79, no. 4 (2005): 500-533.

See also: Barbiturates; Brain-wave scanners; Drug abuse and dependence; Ethics; Interrogation; Polygraph analysis; Pseudoscience in forensic practice.

A scientist at the Rocky Mountain Laboratory of the U.S. Public Health Service performs necropsies on tularemia-infected guinea pigs during the early 1940's. The animals were injected with water from mountain streams suspected as sources of the disease. *(Library of Congress)*

Tularemia

Definition: Infection caused by the bacterium *Francisella tularensis*.

Significance: Commonly known as rabbit fever, tularemia is a disease endemic in North America as well as parts of Europe and Asia. Its relevance to forensic science lies chiefly in its potential for use as a bioweapon.

Tularemia is a naturally occurring disease. Its primary hosts are rabbits, prairie dogs, muskrats, and other small mammals, but it can also be transmitted by ticks and deerflies. After infection, onset is rapid. Symptoms include headache, fatigue, dizziness, and nausea. If untreated, tularemia may result in death.

The U.S. Centers for Disease Control and Prevention (CDC) regards *Francisella tularensis* as a viable bioweapon agent because tularemia is highly infective and incapacitating yet has relatively low lethality, a consideration in its possible deployment near a civilian population. The bacterium is easy to distribute both as an aerosol and in municipal drinking water supplies. Aerosol release would have the most widespread effect on public health, especially if done in urban settings. *F. tularensis* is classified as a Category A agent, which means it has serious potential for inducing terror in a population (other Category A agents include *Yersinia pestis*, the bacterium that causes plague; *Variola major*, the virus that causes smallpox; *Bacillus anthracis*, the bacterium that causes anthrax; and *Clostridium botulinum*, the bacterium that causes botulism). Japan, the Soviet Union, and the United States have all stockpiled *F. tularen-*

sis in the form of offensive weapons at different times in their histories. It is now known that the Soviet army used the pathogen against the Germans during World War II in the Battle of Stalingrad.

Because the early symptoms of tularemia are similar to those of many ordinary or seasonal infections, an attack using *F. tularensis* on the general population in any given area in the United States could easily take health authorities by surprise. With an incubation range of one to fourteen days and average onset of symptoms taking from three to five days, an attack might not be immediately detected. Security measures that have been taken against this possibility include the installation in thirty U.S. cities of sensors that constantly monitor the air for deadly pathogens. If epidemiologists suspect the deliberate or unexplained release of the tularemia organism, standard practice is for them to contact the appropriate law-enforcement agencies immediately.

One of the things that makes the possibility of the use of the tularemia pathogen as a weapon particularly worrisome is that no vaccine against the disease is available to the general public, in contrast to other possible bioterror agents such as anthrax and smallpox. Some comfort is provided by the availability of potent and effective antibiotics against tularemia.

Robert Klose

Further Reading

Dembek, Zygmunt F., Ronald L. Buckman, Stephanie K. Fowler, and James L. Hadler. "Missed Sentinel Case of Naturally Occurring Pneumonic Tularemia Outbreak: Lessons for Detection of Bioterrorism." *Journal of the American Board of Family Practice* 16 (July/August, 2003): 339-342.

Dennis, David T., et al. "Tularemia as a Biological Weapon: Medical and Public Health Management." *Journal of the American Medical Association* 285 (June 6, 2001): 2763-2773.

Siderovski, Susan Hutton. *Tularemia*. New York: Chelsea House, 2006.

See also: Bacteria; Bacterial biology; Bacterial resistance and response to antibacterial agents; Biological terrorism; Biological warfare diagnosis; Biological weapon identification; Biological

Symptoms and Spread of Tularemia

The Centers for Disease Control and Prevention provides the following information about tularemia.

What Are the Symptoms of Tularemia?

Symptoms of tularemia could include:

- sudden fever
- chills
- headaches
- diarrhea
- muscle aches
- joint pain
- dry cough
- progressive weakness

People can also catch pneumonia and develop chest pain, bloody sputum and can have trouble breathing and even sometimes stop breathing.

Other symptoms of tularemia depend on how a person was exposed to the tularemia bacteria. These symptoms can include ulcers on the skin or mouth, swollen and painful lymph glands, swollen and painful eyes, and a sore throat.

How Does Tularemia Spread?

People can get tularemia many different ways:

- being bitten by an infected tick, deerfly or other insect
- handling infected animal carcasses
- eating or drinking contaminated food or water
- breathing in the bacteria, *F. tularensis*

Tularemia is not known to be spread from person to person. People who have tularemia do not need to be isolated. People who have been exposed to the tularemia bacteria should be treated as soon as possible. The disease can be fatal if it is not treated with the right antibiotics.

Weapons Convention of 1972; Biosensors; Biotoxins; Chemical Biological Incident Response Force, U.S.; Pathogen genomic sequencing.

Typewriter analysis

Definition: Process by which experts examine typewritten documents to determine information about the typewriters on which the items were produced.

Significance: Typewriter analysis can play a vital role in any investigation involving a document believed to have been produced on a typewriter, such as a ransom note, threat letter, or forged document. Although typewriter analysis has faded in importance since the use of computers and printers has become widespread, forensic scientists are still called upon at times to analyze documents produced on typewriters.

Handwriting is widely understood to differ from person to person, making the source of a handwritten note or document easily identifiable. In contrast, many people believe that typewritten documents all look the same and that finding the sources of documents created on typewriters should be difficult, if not impossible. Although typed documents are less easy to distinguish from one another than handwritten documents, an expert in typewriter analysis can determine a lot of useful information from a single typewritten document.

The processes used in typewriter analysis differ slightly depending on the document in question and the goal of the investigation. If the goal is to determine the originator of a document, a single specific typewriter may need to be identified. If the goal is to determine whether an important historical document is a forgery, determining pertinent information about the type of machine used, and when it first became available, may be enough.

To determine whether a typewritten document was created on a certain machine, an expert compares a sample document typed on the machine in question to the relevant document. The comparison can be made to a document known to have been created on that machine, such as a letter or bill, or it can be made to a document typed solely for the purpose of comparison.

The expert compares the two documents side by side, sometimes using a hand magnifier or a high-powered microscope. The first determination to be made is usually whether the two documents came from machines of the same make and model. To determine this, the expert compares the two documents in terms of the spacing between letters, the shapes of the letters,

The unique traits that distinguish individual typewriters are much more pronounced in documents made using early models, which could not sustain the uniformity over time of later models. Individual keys tended to become increasingly dirty, chipped, and misaligned, and some keys made lighter impressions than others. Although modern computers have displaced typewriters—which are no longer manufactured in the United States—typewriter analysis remains important in investigations involving historical documents. *(© iStockphoto.com/José Luis Gutiérrez)* the spacing between lines of type, and other attributes.

Although typewriters of the same make and model will produce very similar documents, individual typewriters can have attributes that make them specifically identifiable. Some of these traits may have come from the factory, such as a slightly misshapen letter. More commonly, they occur over time and with wear of the typewriter. Different letters, and even different parts of letters, wear differently. This means that any document typed on a particular machine will show the same slight imperfections in particular letters. An expert can use such imperfections to determine whether the typewriter used to create the comparison document also created the document in question.

Helen Davidson

An Early Case Solved by Typewriter Analysis

On its Web site, the Federal Bureau of Investigation describes a case solved through typewriter analysis in an article titled "The Birth of the FBI's Technical Laboratory: 1924 to 1935":

Harrington Fitzgerald, Jr., a mental patient in a Pennsylvania veterans' hospital more than one hundred miles away from his nearest relatives, opened and quickly sampled the box of chocolates from "Bertha." Perhaps he thought the November 1933 delivery was an early Christmas present; if so, it was the last one he received. Fitzgerald died soon after eating the first poisoned treat. As the crime occurred on federal property, Agents of the U.S. Bureau of Investigation [the FBI's predecessor] investigated. Mr. Fitzgerald's sister, Sarah Hobart, quickly became the primary suspect and so Agents solicited samples of her handwriting. These samples along with the package's wrapper and card were sent to Headquarters for analysis in the Bureau's new Technical Laboratory.

There, Special Agent Charles Appel, a balding, meticulous investigator, received the evidence and began to compare the handwriting samples to the note card. He reported that the note from "Bertha" and the Hobart samples revealed no match. More analysis could be done, he suggested, if the investigating Agents would obtain samples from Hobart's husband and track down the family's typewriter. Diligent detective work led Philadelphia Agents to a typewriter Mrs. Hobart had conveniently sent in for repair at a local shop. Using samples of type from the Hobart machine, Appel quickly determined that it was the machine on which the mailing label on the package of poisoned candy was typed. Confronted with the evidence, Sarah Hobart confessed.

Further Reading

Koppenhaver, Katherine M.. *Forensic Document Examination: Principles and Practice*. Totowa, N.J.: Humana Press, 2007.

Vastrick, Thomas W. *Forensic Document Examination Techniques*. Altamonte Springs, Fla.: Institute of Internal Auditors Research Foundation, 2004.

See also: Document examination; Fax machine, copier, and printer analysis; Federal Bureau of Investigation Laboratory; Forensic linguistics and stylistics; Forgery; Paper; Questioned document analysis; Unabomber case; Writing instrument analysis.

Ultraviolet spectrophotometry

Definition: Analytical chemistry technique used as a screening tool in classifying chemical compounds.

Significance: Forensic scientists often use ultraviolet spectrophotometry when conducting preliminary screening to identify classes of compounds, such as in drug screening, detection of explosives, toxicology, paint analysis, and soil discrimination.

Ultraviolet (UV) spectrophotometry is a nondestructive, sensitive technique that measures light absorbed by a sample in the ultraviolet spectral region. UV spectrophotometry has two general uses in forensics: screening and quantitation. Although not useful as a confirmatory test, UV spectrophotometry is a good preliminary screening method to identify classes of organic compounds with aromatic rings or conjugated systems. These structural features are common in many types of drugs and other controlled substances and in many materials used in explosives.

UV spectrophotometry can be used as a screening tool to identify a class or group of compounds in a sample. Although scientists can determine the presence or absence of suspected compounds using this technique, UV spectrophotometry has limited specificity because structurally related compounds can generate similar spectra. Many compounds, including various drug groups, produce characteristic spectra, but these spectra typically do not provide enough detail for specific compound identification; they are most useful for determining a class of compounds present in a sample. UV spectrophotometry is thus most useful for single-component analysis of samples with known or suspected composition, such as pharmaceuticals.

Different compounds have varying capacities to absorb UV light, so mixtures of compounds can complicate analysis. For example, a compound that absorbs UV light strongly combined with a controlled substance that is a weak UV absorber may generate a spectrum that masks the presence of the controlled substance. Specific compound identification requires more precise chemical analytical tools that can provide structural detail, such as infrared (IR) spectroscopy or mass spectrometry (MS).

UV spectrophotometry can also be used to quantify a substance in a sample. The amount of UV light absorbed by a sample corresponds to the concentration of a particular substance in the sample. A forensic scientist can use such a quantitative procedure, for instance, to compare the concentration of a substance in a sample that is suspected of being tampered with to the concentration of the same substance in a known, unaltered sample. These measurements can be followed with more thorough analyses using other techniques to determine the actual concentration and identity of the substance in question.

UV spectrophotometry can be used to identify controlled substances and drugs of abuse, such as amphetamines and methamphetamine. This technique can also be used to detect compounds that might be found in explosives, such as compounds that contain nitro groups attached to aromatic rings. Forensic scientists also use UV spectrophotometry in analyzing soils and paints as well as in quantifying DNA (deoxyribonucleic acid). For analysis of small samples, UV spectrophotometry can be combined with a microscope in the technique known as microspectrophotometry.

C. J. Walsh

Further Reading

Bell, Suzanne. *Forensic Chemistry*. Upper Saddle River, N.J.: Pearson Prentice Hall, 2006.

Houck, Max M., and Jay A. Siegel. *Fundamentals of Forensic Science*. Burlington, Mass.: Elsevier Academic Press, 2006.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005.

See also: Analytical instrumentation; Electromagnetic spectrum analysis; Energy-dispersive spectroscopy; High-performance liquid chromatography; Microspectrophotometry; Quantitative and qualitative analysis of chemicals; Spectroscopy.

Unabomber case

Date: Bombings took place between May, 1978 and April, 1995

The Event: Unabomber was the name given to the unknown perpetrator of a series of bombings in the United States that targeted primarily victims associated with universities and airlines. Many of the explosive devices were sent through the U.S. mail.

Significance: The Unabomber case brought ecoterrorism to the attention of American law-enforcement agencies and led to one of the largest manhunts in the history of the Federal Bureau of Investigation.

Ted Kaczynski, the Unabomber, carried out one of the longest single-handed strings of bombings in the history of terrorism. From 1978 to 1995, he delivered at least sixteen bombs to targets, some through the U.S. mail and others through hand delivery. In a little less than seventeen years, Kaczynski killed three people and wounded twenty-three, succeeding in inserting terror into the psyches of many Americans. At the end of his reign of terror, *The New York Times* and *The Washington Post* published a long essay written by Kaczynski in exchange for a halt to the bombings. Kaczynski was captured the next year and eventually pleaded guilty in 1998 to federal charges related to the bombings. He received a sentence of four life terms, escaping the death penalty that federal prosecutors originally sought.

Kaczynski's Early Life

Ted Kaczynski was born on May 22, 1942, in Chicago, and in his childhood, educators at Evergreen Park Central School deemed him a gifted student. It has been reported that he scored 157 on an IQ test when he was ten years old. He was allowed to skip the sixth grade and to take classes with older students. In his journal, Kaczynski stated that being placed into classes with older children caused considerable difficulty in his life; he was verbally taunted and found that he was unable to fit in socially.

Kaczynski attended high school at Evergreen Park Community High School. Although he excelled academically, he continued to struggle socially, feeling isolated from other students. He briefly experienced some social fame in high school when he constructed a pipe bomb in one of his science classes, but he generally remained a loner throughout his high school career. His isolation was exacerbated when he was allowed to skip the eleventh grade and graduated from high school at the age of fifteen. Kaczynski was then accepted into Harvard University and began classes there in 1958 at the age of sixteen.

Kaczynski struggled in social relationships throughout college and felt particularly uncomfortable interacting with women. He again excelled in academics, however, and graduated in 1962. He then moved to the University of Michigan in Ann Arbor, where he received both a master's degree and a Ph.D. in mathematics. Some of his professors there later described him as ambitious, talented, and gifted. While in graduate school, he also taught undergraduate classes and published a number of articles. It has been reported that Kaczynski had confusion about his gender during graduate school, experiencing fantasies of being a female, and that he contemplated a sex change at this time. Instead of addressing that issue, however, he sought psychiatric help for anxiety.

Kaczynski took a job as assistant professor of mathematics at the University of California at Berkeley in 1967, but he did not relate well to his students. Despite attempts by administrators to persuade him otherwise, he resigned from his position in 1969, and his professional life began to spiral downward in conjunction

This widely circulated sketch of the suspected Unabomber was created by forensic artist Jeanne Boylan for the Federal Bureau of Investigation before Ted Kaczynski was apprehended in 1996. *(AP/Wide World Photos)*

with his social life. After his resignation, Kaczynski returned to Illinois and lived in a small house owned by his parents. He was largely unemployed during this period, working random jobs and borrowing money from his parents to get by.

In the 1970's, Kaczynski lived as a hermit, interacting with only a few people and slipping deeper into social isolation and anger, which he directed against the technological advancement of society. His relationships with family members became increasingly odd, as he accused them of emotional abuse and persistently sought apologies. Some psychologists who have reviewed Kaczynski's life believe that he was showing signs of schizophrenia.

Kaczynski began writing about the evils of technology, including its control over individuals. He also began planning to kill people in an apparent attempt to make a statement about the evils of technology. In 1978, at the same time he was starting to put his desire to commit terrorism into motion, Kaczynski was working with his brother and father at a foam-rubber factory.

Bombings and Investigation

The first bomb that Kaczynski aimed at another person was placed in a package left at the University of Illinois at Chicago in 1978; the package carried the return address of Professor Buckley Crist at Northwestern University. The package was found and sent back to the professor, who was suspicious of receiving a returned package that he had never mailed. A campus police officer at the university, Terry Marker, then opened the package and it detonated, causing Marker minor injuries.

Kaczynski followed this initial attack with attempted bombings of airlines in 1979. He sent several bombs in the mail to airline officials and placed a bomb in the cargo hold of an American Airlines flight from Chicago to Washington, D.C. That bomb did not explode because of a defective timer, but it did begin to smoke while the flight was in the air, causing the pilot to undertake an emergency landing. Officials of the Federal Bureau of Investigation (FBI) stated afterward that the bomb was easily strong enough to bring down the airplane. Although the FBI initially thought that the attempted airline bombings might be the work of a disgruntled airline employee, the psychological profile of the Unabomber (the term comes from the FBI's designation of the case as UNABOM, for "university and airline bomber") pointed to an intelligent man who was possibly an academic.

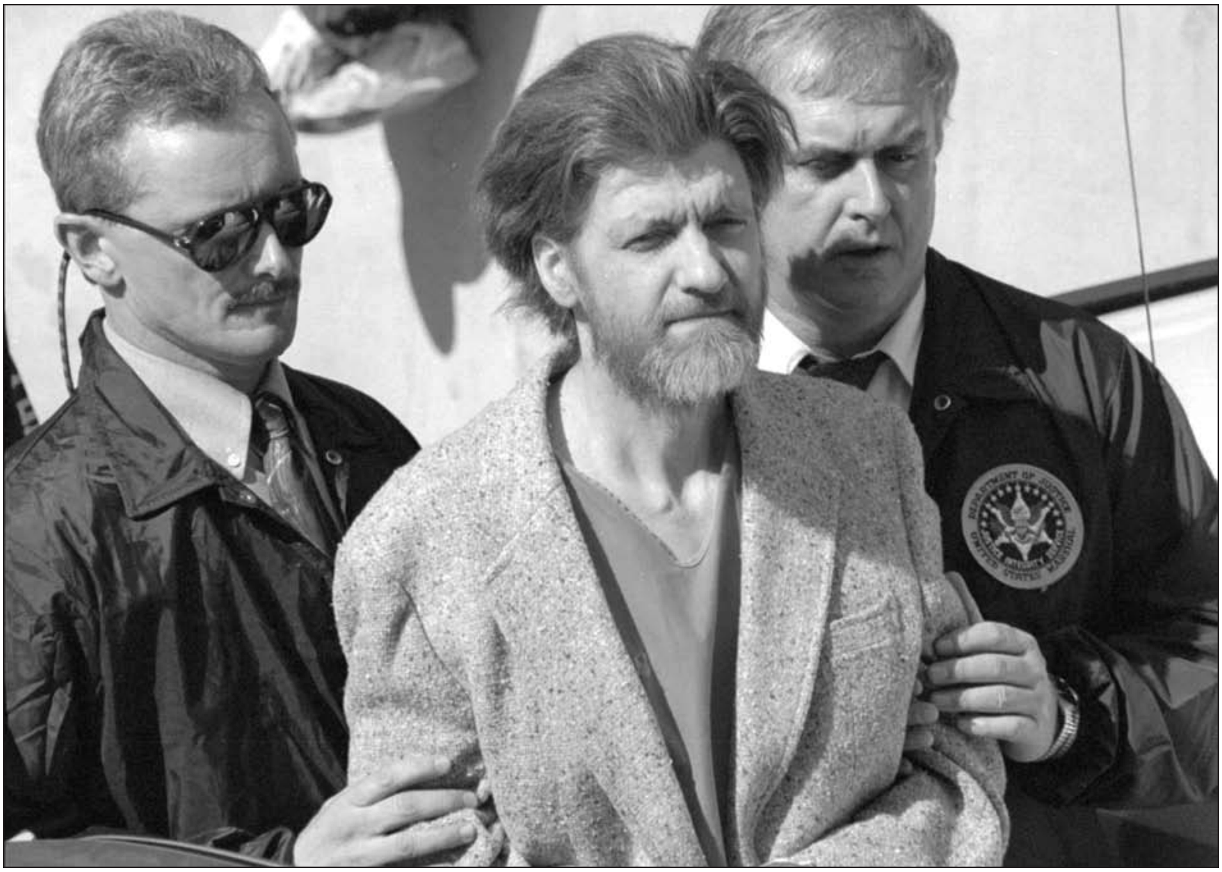
Kaczynski continued his bombings in the early to mid-1980's, and his desire to cause serious harm to others became a reality. In 1985, one of his bombs caused John Hauser, a graduate student at the University of California, Berkeley, and member of the U.S. Air Force, to lose several fingers and the vision in one eye. Kaczynski then targeted two computer stores, one in 1985 and one in 1987. Computer store owner Hugh Scrutton became the first person to die in one of the Unabomber's attacks on December 11, 1985.

For unknown reasons, Kaczynski took a six-year hiatus from his bombings before launching new attacks in 1993. That year, one of his devices seriously injured David Gelernter, a computer science professor at Yale University, and another caused Charles Epstein, a geneticist, to lose fingers. He continued his attacks in 1994 and 1995; his bombs killed advertising executive Thomas J. Mosser, whose company had helped Exxon repair its image after the *Exxon Valdez* oil spill, and Gilbert P. Murray, the president of the California Forestry Association, an organization that lobbies for the timber industry.

Manifesto and Capture

In 1995, Kaczynski began to mail letters to former victims in which he threatened dire consequences if his paper titled "Industrial Society and Its Future" was not published in a significant newspaper or newspapers. This work, which later became known as the Unabomber manifesto, was published by *The New York Times* and *The Washington Post* on September 19, 1995. The overriding themes of the work were antigovernment, anti-big business, and antitechnology.

Law-enforcement authorities' investigation of the Unabomber was at a standstill at the time the manifesto was published, with nothing to go on but a sketch artist's rendering of a man in sunglasses and a hooded jacket or sweatshirt, some fingerprints, and few other clues. The fingerprints that investigators lifted from some of the bombs were later found not to match Kaczynski's, leading some to speculate that the prints may have been part of Kaczynski's purposeful attempts to mislead investigators. The FBI had also changed its profile of the Unabomber, describing the likely suspect as a



Federal agents escort Ted Kaczynski (center) from the federal courthouse in Helena, Montana, on April 4, 1996. Kaczynski was charged with one count of possession of bomb components during the court appearance. *(AP/Wide World Photos)*

The Unabomber's Forensic Psychiatric Evaluation

The following excerpt from a forensic psychiatrist's report, dated January 16, 1998, details the procedures undertaken to determine Ted Kaczynski's competency to stand trial.

During this evaluation, Mr. Kaczynski was interviewed by Sally C. Johnson, Chief Psychiatrist and Associate Warden of Health Services for the Federal Correctional Institution in Butner, North Carolina. During this evaluation, Mr. Kaczynski was interviewed by the examiner on eight occasions at the Sacramento County Jail, with a total interview time of approximately 22 hours. The interviews took place either in the lineup room conference area or in confidential attorney visiting booths on the second or eighth floor. At the start of the initial interview and briefly during subsequent interviews on 01/12/98 and 01/13/98, the defense attorneys were present to answer Mr. Kaczynski's questions regarding the evaluation process. In addition to the clinical interviews, formal review was conducted of previous medical evaluations, as well as previous neuropsychological and psychological testing results. Additional psychological testing administered during this evaluation included the Minnesota Multiphasic Personality Inventory-2 (01/12/98), the Millon Clinical Multiaxial Inventory-II (01/12/98), the Beck Depression Inventory (01/15/98), and the Draw a Person Picking an Apple from a Tree projective drawing (01/15/98). Psychological testing administered during this evaluation was administered by Dr. Johnson. Scoring and interpretation of tests were accomplished with the assistance of psychology staff at FCI Butner.

At the outset of this evaluation and repeatedly throughout the week, the purpose of the evaluation and limits of confidentiality of information provided were discussed with Mr. Kaczynski. He was informed that the information and the observations made would provide the basis for completion of a report which would be available to the Judge, as well as the Defense and Prosecuting Attorneys. He was advised that a provision was in place to protect the privacy of any en camera materials. He demonstrated an adequate understanding of this information.

blue-collar mechanic who might work in the airlines industry.

After the manifesto was published, Ted Kaczynski's brother, David Kaczynski, contacted authorizes to tell them about his suspicion that his brother was the Unabomber. He had previously seen letters written by his brother that he believed were similar to the manifesto, and forensic linguists in the FBI were able to match these writings with the manifesto. Ted Kaczynski was arrested on April 3, 1996, in the mountains of Montana, where he had been living in a small cabin.

Although Kaczynski was diagnosed with paranoid schizophrenia, it was determined that he was competent to stand trial. He pleaded guilty before the case went to trial, however, and was sentenced to life in prison without the possibility of parole. He later made an attempt to withdraw his plea, but his request was denied and the court's decision was upheld on appeal.

Brion Sever

Further Reading

Arnold, Ron. *Ecoterror: The Violent Agenda to Save Nature—The World of the Unabomber*. Bellevue, Wash.: Free Enterprise Press, 1997. Argues that conservation and ecology movements have become increasingly dangerous and attempts to link the Unabomber's crimes to a radical environmental agenda.

Chase, Alston. *Harvard and the Unabomber: The Education of an American Terrorist*. New York: W. W. Norton, 2003. Discusses the societal and personal environment in which Kaczynski came of age to explore his motivations. Includes photographs.

Graysmith, Robert. *Unabomber: A Desire to Kill*. Washington, D.C.: Regnery, 1997. Presents a full account of Kaczynski's life and crimes.

Waits, Chris, and Dave Shors. *Unabomber: The Secret Life of Ted Kaczynski*. Helena, Mont.: Farcountry Press, 1999. Interesting work is coauthored by a man who was Kaczynski's

neighbor in Montana for twenty-five years. Includes photographs.

See also: Bomb damage assessment; Bombings; Crime scene sketching and diagramming; Criminal personality profiling; Federal Bureau of Investigation; Forensic linguistics and stylistics; Handwriting analysis; Improvised explosive devices; Oklahoma City bombing; Typewriter analysis.

University of Tennessee Anthropological Research Facility

Date: Established in 1972

Identification: Facility at which forensic anthropologists conduct research on the decomposition of human remains and the identification of skeletal or badly decomposed bodies.

Significance: The Anthropological Research Facility at the University of Tennessee provides human identification services and death investigation training to arson investigators, county medical examiners, and various federal, state, and local law-enforcement agencies.

Dr. William M. Bass is credited with establishing the University of Tennessee's Anthropological Research Facility in 1972. Soon after Bass began working at the University of Tennessee in 1971, the state medical examiner asked him to do some consulting work on several death investigations. Although Bass had been trained as a forensic anthropologist, he had limited experience with cases involving human decomposition. In addition, little research had been conducted to document the stages of human decomposition. As a result, Bass and the faculty of the Anthropology Department at the University of Tennessee created the Anthropological Research Facility, now commonly known as the Body Farm, so that forensic anthropologists could study postmortem decomposition of human remains.

The Body Farm is located on a three-acre tract of land close to the university's Knoxville campus; it hosts about 120 bodies at any given time. The Body Farm serves as a primary research facility for doctoral students in forensic sciences and as a training site for crime scene investigators, law-enforcement officers, morticians, dental experts, emergency medical personnel, decontamination experts, and anthropologists. Research at the Body Farm has helped forensic anthropologists to document the decomposition of the human body in relation to weather, water, indoor versus outdoor settings, clothing, insects, small mammals, and other variables.

The University of Tennessee also houses the nation's largest modern bone collection, the William M. Bass Donated Skeletal Collection. Data on the skeletal remains in the collection are entered into the University of Tennessee's Forensic Anthropology Data Bank. This database is the primary tool that forensic anthropologists across the United States use to determine age, sex, stature, ancestry, and other unique characteristics from skeletal remains.

The University of Tennessee's Forensic Anthropology Center inspired the formation of the National Forensic Academy (NFA), one of the leading law-enforcement investigation training centers in the United States. The NFA offers an intensive ten-week training program designed to educate law-enforcement agents in evidence identification, collection, and preservation. The primary goal of the NFA is to prepare law-enforcement officers to recognize crucial components of crime scenes and improve the process of evidence recovery and submission.

Kimberly D. Dodson

Further Reading

Bass, Bill, and Jon Jefferson. *Beyond the Body Farm: A Legendary Bone Detective Explores Murders, Mysteries, and the Revolution in Forensic Science*. New York: William Morrow, 2007.

_______. *Death's Acre: Inside the Legendary Forensic Lab the Body Farm Where the Dead Do Tell Tales*. New York: G. P. Putnam's Sons, 2003.

Hallcox, Jarrett, and Amy Welch. *Bodies We've Buried: Inside the National Forensic Academy, the World's Top CSI Training School*. New York: Berkley Books, 2006.

See also: Autopsies; Body farms; Crime laboratories; Crime scene documentation; Crime scene investigation; Decomposition of bodies; Evidence processing; Forensic anthropology; Forensic sculpture; Sex determination of remains; Skeletal analysis; Taphonomy.

U.S. Army Medical Research Institute of Infectious Diseases

Date: Founded on January 27, 1969

Identification: Federal medical research laboratory equipped to handle high-level hazardous biological materials.

Significance: With the increasing threat of both domestic and international bioterrorism, the U.S. Army Medical Research Institute of Infectious Diseases has been instrumental in training and providing diagnostic support to federal, state, and local law-enforcement agencies while maintaining its primary mission of finding medical ways to protect military personnel from biological weapons.

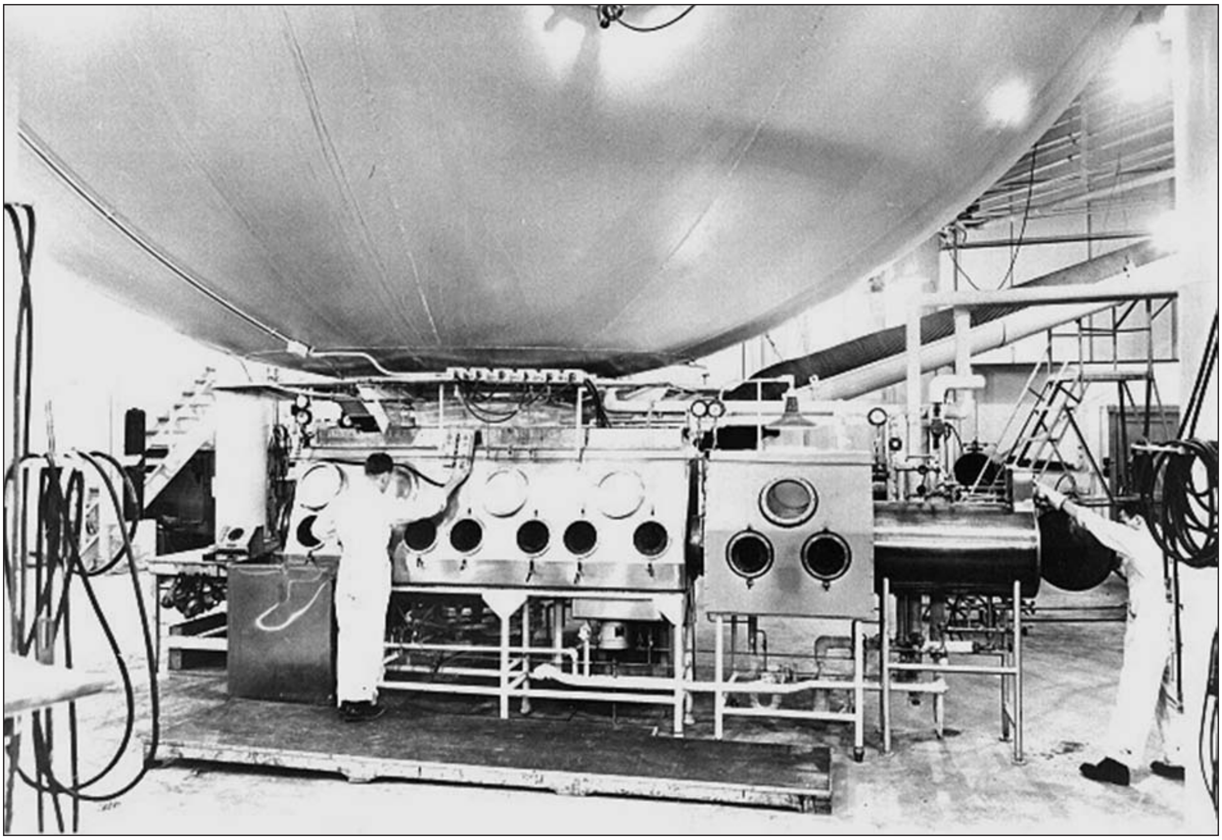
The U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID), located at Fort Detrick in Frederick, Maryland, was established to perform basic and applied research on ways to prevent and treat biological threats to American military personnel. USAMRIID replaced the U.S. Army Medical Unit at Fort Detrick, which conducted research on offensive biological weapons. Offensive research was discontinued in 1969, and American stockpiles of biological weapons were destroyed in the early 1970's.

To contain dangerous and highly transmissible organisms safely, USAMRIID has a biosafety level 4 (BSL-4) laboratory and BSL-4 patient ward for treating infected individuals. BSL-4 is the most secure level of biohazard laboratory. Access to BSL-4 facilities is strictly limited, and complex engineering features of these facilities prevent the escape of hazardous material. USAMRIID also contains lower-security BSL-2 and BSL-3 laboratories. The facility employed about 750 scientists and support personnel in 2006, with the number expected to grow to 1,300 by the end of the decade.

USAMRIID is the lead laboratory for the U.S. Biological Defense Research Program, the primary mission of which is to protect and treat members of the armed forces who are exposed to infectious agents such as *Bacillus anthracis* (the bacterium that causes anthrax), *Clostridium botulinum* (the bacterium that causes botulism), and Ebola and other dangerous viruses. Some biological threats are exotic organisms that service members might encounter only when they are deployed to foreign lands, whereas others, such as anthrax, are potential agents of bioterrorism that could be released on either military or civilian populations.

Research at USAMRIID involves the development of vaccines against biohazards, establishment of treatment regimens for infected individuals, and development of decontamination procedures. The organization works with other institutions, including the U.S. Centers for Disease Control and Prevention and the World Health Organization, in conducting research and surveillance and in responding to biological threats. In developing vaccines, USAMRIID collaborates with private industry. Vaccine research often results in health benefits to civilians as well as to military personnel.

In the twenty-first century, USAMRIID has become increasingly involved in working with law-enforcement organizations on domestic bioterrorism. For example, in September, 2001, when letters containing anthrax spores were sent through the mail to several American media outlets and politicians, USAMRIID analyzed more than 31,000 samples of suspect material submitted by law-enforcement agencies as part of Operation Noble Eagle. Since 2001,



Nicknamed the “Eight Ball,” this one-million-liter steel sphere was built at Fort Detrick in 1952 to measure the virulence of anthrax spores and other airborne bacteria. The device was not used after 1969, when the U.S. military began to dismantle its offensive biological weapons program. *(AP/Wide World Photos)*

USAMRIID has provided training for many thousands of law-enforcement agents in the handling of potential biohazards and decontamination of biocontaminated sites. The institute also provides diagnostic support for law-enforcement agencies across the United States.

Martiscia Davidson

Further Reading

Linden, Caree V. “Bio-warfare Detectives.” *Soldiers Magazine*, May, 2005, 42-45.

Preston, Richard. *The Demon in the Freezer: A True Story*. New York: Random House, 2002.

Wheelis, Mark, Lajos Rózsa, and Malcolm Dando, eds. *Deadly Cultures: Biological Weapons Since 1945*. Cambridge, Mass.: Harvard University Press, 2006.

See also: Anthrax; Anthrax letter attacks; Biological weapon identification; Biological Weapons Convention of 1972; Centers for Disease Control and Prevention; Chemical Biological Incident Response Force, U.S.; Epidemiology.

V

ValuJet Flight 592 crash investigation

Date: Airliner crashed on May 11, 1996

The Event: On May 11, 1996, ValuJet Flight 592, en route from Miami International Airport to Hartsfield International Airport in Atlanta, Georgia, crashed minutes after takeoff. The plane dived into the Florida Everglades, complicating the investigation into the causes of the crash as well as recovery of the remains of the passengers and crew.

Significance: The forensic investigation into the crash of ValuJet Flight 592 focused on causes and effects. The ultimate impact of the disaster was a shift in the Federal Aviation Administration's mandate from "promotion" to "safety" in the civil aviation industry.

ValuJet was one of several discount airlines created during the reconfiguration of the passenger airline industry following the bankruptcy of such major carriers as Pan American World Airways, Eastern Airlines, and several others. On May 11, 1996, one of ValuJet's DC-9-32 aircraft was carrying 105 passengers and 5 crew members. Within minutes of takeoff, the copilot requested clearance from the control tower for the plane to return to Miami because of fire and smoke in the passenger cabin and cockpit. Soon after, however, the plane plunged into the Everglades, reportedly at an angle of some 75 degrees. The Miami-Dade County Police Department began search-and-rescue operations in the dangerous alligator- and snake-infested terrain, which was also covered with flammable aviation fuel, only to determine that there were no survivors.

Candalyn Kubeck, the first American female chief pilot to die in an accident, was in command of Flight 592. The plane, which was built in 1969, had been found to have several violations during ValuJet's two and one-half years of operations, but it had never been grounded.

The Investigation

The plane's flight data recorder, which measured eleven types of aircraft movement and control settings, was recovered on May 13. The voice recorder, or "black box," was retrieved on May 15. The cockpit tape had recorded a brief, unidentified sound some six minutes after takeoff and indicated that the crew had been informed of fire and smoke conditions in the passenger cabin about twenty-two seconds later. Eleven seconds after that, the copilot requested clearance to return to Miami, but the plane crashed four minutes later, barely 20 miles west of the airport.

The search for human remains and wreckage ended on June 10. Some 75 percent of the aircraft was recovered, and the Metro-Dade County medical officer reported that by then the remains of 36 of the 110 crash victims had been identified.

The radio message of fire and smoke on board was confirmed by the state of the wreckage. Suspicions focused on the nature of the cargo stored in the plane's forward hold, which included more than one hundred oxygen generators, the safety devices used in aircraft to provide oxygen to passengers when cabin pressure is lost. The investigators concluded that a chemical reaction inside one or more of the generators had ignited and in turn set fire to three aircraft tires also stored in the hold; from that point, the fire spread quickly. It was not clear, however, whether these conditions compromised the plane's controls first or whether the conflagration had disabled the crew.

The investigators also discovered that ValuJet, in the interest of keeping expenses down, had farmed out maintenance and loading operations to a subcontractor: SabreTech, based in Phoenix, Arizona. It was also found that ValuJet had exercised very little supervision over this subcontractor. The oxygen generators had not been properly packed, lacked safety caps, and were incorrectly labeled as empty rather than as hazardous cargo as they should have been, given that the chemical reaction that creates oxygen in such generators can also create heat of up to 500 degrees Fahrenheit. The fire that occurred on the plane was further evidenced by the fact that the recovered debris included a scorched seat frame, two heat-damaged oxygen generators, and a partially burned aircraft tire.

The Federal Aviation Administration (FAA) shut down ValuJet on June 17, 1996, for an indefinite period after an intensive thirty-day investigation had uncovered "serious deficiencies" in the airline's operations. These deficiencies included failure to perform repairs properly, failure to document repairs, flying aircraft known to have serious maintenance problems, and ignoring FAA safety directives. ValuJet was required to pay two million dollars as part of the cost of having its fleet reinspected. When ValuJet resumed operations several months later, it had merged with another company and was known as AirTran Airways. In December, 2001, SabreTech faced 220 charges of murder and manslaughter involving the 110 victims of ValuJet Flight 592. The case was settled out of court, however, with SabreTech pleading no contest and agreeing to donate one-half million dollars to charity.

Final NTSB Report

All of these and other matters contributing to the tragedy were brought out in the report of the National Transportation Safety Board (NTSB) of August 19, 1997. In the report, the NTSB criticized the FAA for failing to enforce its ten-year-old recommendation that smoke detectors and fire suppression systems be installed in all aircraft cargo holds. The NTSB also expressed doubt whether ValuJet's maintenance chief at the time of the crash, David Gentry, was properly qualified for his position and criticized ValuJet's lack of supervision over SabreTech.

Underlying the problems noted by the NTSB was the cozy relationship between the airline industry and the FAA as well as the U.S Department of Transportation (DOT) as a whole, which is responsible for the public's transportation safety. This is a general problem because often those responsible for overseeing airline industry matters themselves come from the ranks of the industry; this built-in conflict of interest makes the authorities sympathetic to the problems of the airlines in a highly competitive environment and thus unwilling to treat the airlines too harshly.

Politics also played a role. The airline industry is a significant financial contributor to the campaigns of many U.S. senators and members of Congress who sit on important committees dealing with civil aviation, a situation that leads to considerable reciprocal back-scratching. Thus, even crusaders among the regulators (such as Mary Schiavo, former inspector general of the U.S. Department of Transportation) were largely ignored when they charged that crucial negative reports on ValuJet's earlier violations preceding the crash of Flight 592 had

ValuJet's Older Fleet

The ValuJet budget airline was started in late 1993, and by the time of the crash of Flight 592 in May, 1996, it had increased its fleet to fifty-one airplanes, mostly used DC-9s, following spectacular growth and profitability. The average age of planes in ValuJet's fleet was more than twenty-six years, about fifteen years older than the aircraft of major U.S. carriers. The plane on Flight 592 had been built in 1969 and had returned to airports seven times in the previous two years because of safety problems.

According to experts, older aircraft are not necessarily less safe than newer aircraft, but older planes do require more rigorous maintenance. To a large extent, however, ValuJet's profitability rested on its ability to cut costs—and at times corners as well. To save money, instead of using its own maintenance workers, ValuJet had contracted with an outside firm, SabreTech, and did not provide appropriate supervision of SabreTech's work. One of the consequences of the crash of Flight 592 was that the Federal Aviation Administration began to investigate the performance of such relatively inexpensive subcontractors.

Robert Francis, vice chairman of the National Transportation Safety Board, stands amid some of the wreckage of ValuJet Flight 592 gathered in a hangar by investigators. *(AP/Wide World Photos)*

been suppressed so that the flying public would not be alarmed.

Consequences

On May 23, 1996, all passenger planes were forbidden to carry the kind of generator suspected of causing the ValuJet crash (although empty generators were exempted from the ban). Schiavo resigned from the Department of Transportation in July, 1996, and went public with her complaints. In part as a result of the crash of Flight 592, the U.S. Congress reworded the dual mandate with which the Federal Aviation Administration had originally been entrusted, namely, to promote civil aviation and ensure its safety. The FAA mandate became to promote safety as a priority but also to encourage the development of civil aviation.

Peter B. Heller

Further Reading

Calder, Simon. *No Frills: The Truth Behind the Low-Cost Revolution in the Skies*. London: Virgin Books, 2002. Describes the lack of adequate government controls that led to the crash of ValuJet 592.

Cobb, Roger W., and David M. Primo. *The Plane Truth: Airline Crashes, the Media, and Transportation Policy*. Washington, D.C.: Brookings Institution, 2003. Presents one of the most thorough accounts of the ValuJet disaster available.

Fallows, James. *Free Flight: From Airline Hell to a New Age of Travel*. New York: PublicAffairs, 2001. Explains the crash of ValuJet 592 as a sequence of misfortunes, each of which was individually so trivial that no one was able to foresee the deadly synergistic effect.

Krause, Shari Stamford. *Aircraft Safety: Accident Investigations, Analyses, and Applications*. 2d ed. New York: McGraw-Hill, 2003. Uses various case studies to discuss the numerous causes that underlie airplane accidents.

Schiavo, Mary, with Sabra Chartrand. *Flying Blind, Flying Safe*. New York: Avon Books, 1997. The former inspector general of the U.S. Department of Transportation lambastes the Federal Aviation Administration and former DOT employees for playing politics at the expense of the flying public's safety.

See also: Accident investigation and reconstruction; Airport security; Autopsies; Flight data recorders; National Transportation Safety Board.

Victimology

Definition: Study of victims of crimes and the nature of victimization.

Significance: Information about the victims of crimes forms an important element of criminal investigations. Any attempt to understand individual crimes is incomplete without an understanding of the victims.

The term "victimology" was coined by the German American psychiatrist Fredric Wertham (1895-1981) in 1949. In its broadest sense, the term applies to the study of all persons who suffer losses of any kind through their own acts or the acts of others or of nature. However, in the narrower sense in which victimology pertains to the forensic sciences, the term applies mainly to the study of victims of crimes perpetrated by others. Any given crime involves both a perpetrator and a victim. The study of perpetrators has long been a primary focus of criminology, and a large body of knowledge has been built in this area. By contrast, the scientific study of crime victims has received less attention. However, since the last decades of the twentieth century, interest in the roles played by victims of crime has greatly increased.

Possible reasons for the lag in the scientific study of victims compared with the study of crime and its perpetrators might include the perception that victims play a relatively insignificant role in crimes as well as the tendency among many people to fault the victims themselves for their misfortunes. Studies begun during the 1940's sought to establish typologies of victims. Two of the earliest researchers in this field, Hans von Hentig and Benjamin Mendelsohn, are considered the founders of victimology as a subdiscipline.

Mendelsohn, an attorney who began his research during the 1950's, discovered in the interrogations of crime victims and other witnesses he conducted while preparing his cases that interpersonal relationships often existed between victims and offenders. From that discovery, he developed a six-stage classification of victims. His categories ranged from completely innocent victims to those who were more guilty than the alleged offenders; he also described what he called "pretend victims."

Studies of victimology during the 1970's began considering the levels of responsibility of victims in the process of their victimization. Stephan Schafer and L. A. Curtis considered what they called functional responsibilities of the victim. These ranged from no responsibility to total responsibility. During the 1980's, Benjamin Mendelsohn expanded on his earlier work with his general victimology theory, which developed the concepts of self-victimization, social victimization, and technological victimization.

Andrew Karmen authored the definition used in modern victimology, which encompasses the crimes, potential victim-offender relationships, victim experiences with the justice system, and other social groups within victims' communities. The major omission of Karmen's definition is the study of the victim. Advocation of a focus on the victim is one of the areas of controversy within victimology.

Evolution of Victim Responsibilities

In primitive human societies, members who were victimized by others were generally expected to take responsibility for exacting revenge and recovering whatever they may have lost. As the victims themselves were responsible for achieving justice, their societies generally provided neither rules for protection of their members nor officials to enforce rules. When victims needed help in exacting revenge and recovering their losses they turned to their relatives, fellow clan members, or fellow tribesmen, depending on the contexts of the situations.

In cases of severe crimes, blood feuds or family feuds often developed. Such feuds could last for long periods and were difficult to terminate. As societies developed more complex institutions of government, they generally worked to prevent feuds by formalizing rules for restitution. An example can be seen in the Code of Hammurabi; this set of laws, issued by Hammurabi during his reign as king of Babylon, from approximately 1792 to 1750 B.C.E., changed the role of victims by making the state responsible for administering punishments to perpetrators and restoring losses to victims. During medieval Europe's age of feudal barons and monarchs, crimes came to be defined as acts against the state. Consequently, the state itself received whatever compensation or restitution was taken from perpetrators of crimes. The victims of the crimes then became witnesses for the state.

During the early colonial era in North America, victims of crimes were made responsible for investigations and had to pay for the warrants that sheriffs needed to make arrests. Moreover, the victims were also responsible for procuring attorneys to prosecute the accused. After the United States achieved its independence and adopted the U.S. Constitution (1789) and the Bill of Rights (1791), justice systems changed considerably. Crimes were redefined as acts against the state (in the broad sense), which represented its citizens, and the state itself became the victim. State and local governments established offices of public prosecutors, who acted on the behalf of government and society. This transformation gave government the incentive to create investigative bodies within law-enforcement agencies and helped to launch the modern forensic sciences needed by those bodies.

Meanwhile, public prosecutors assumed responsibility for determining what charges should be levied against persons accused of committing crimes. Prosecutors also determined the sanctions and punishments that should be sought in criminal cases. These changes left the actual victims of the crimes with the responsibility only to file formal complaints with police. The police, in turn, were responsible for investigating complaints, finding and analyzing evidence, and forwarding their findings to the prosecutors. Victims were then left to become witnesses in whatever criminal prosecutions developed.

Victim Movements

During the 1960's, concepts of victim rights again changed, along with the rise of new social movements. These changes began with the Civil Rights movement, an amorphous nonviolent mass movement calling attention to the historical victimization of members of ethnic and racial minorities in the United States. This movement was soon followed by the anti-Vietnam War movement, which revealed that political and governmental systems and controls could be changed by common citizens. The third major movement was the women's liberation movement, which addressed the victimization of people based on their gender. It was followed by the law-and-order movement, the first to draw attention to victims of crime.

Other developments during the 1960's also affected victims of crime. For example, the state of California established one of the earliest victims' compensation programs. During the 1970's, volunteer programs began arising to aid victims of domestic violence, rape, and

The Victims of Crime Act

Passed into law on October 12, 1984, this federal legislation established the Crime Victims Fund to help finance state compensation programs as well as assist victims of federal crimes. Demonstrating the federal commitment to assist crime victims, the Victims of Crime Act (VOCA) quickly became a key component in the funding of programs throughout the United States.

During the early 1980's, President Ronald Reagan supported the growing movement for the right of crime victims to receive fair treatment. In 1981, he proclaimed an annual National Victims of Crime Week. In April, 1982, he established the President's Task Force on Victims of Crime, which made sixty-eight recommendations to help victims. During the following October, he signed the Victim and Witness Protection Act, which increased penalties on those who tried to intimidate victims or witnesses, mandated restitution to victims from offenders, and required the consideration of victim impact statements at sentencing in federal criminal trials.

The Victims of Crime Act of 1984 established the Crime Victims Fund, which at first had a cap of $100 million per year. Each state was to receive at least $100,000, and 5 percent of the fund would go to victims of federal crimes. Rather than coming from taxpayers, revenues for the fund are obtained from fines, penalty fees, forfeitures of bail bonds, and literary profits from convicted offenders. By 1988, the fund was supporting fifteen hundred programs a year, and its maximum was increased to $150 million. VOCA was well received by the American public, and the law's success encouraged states to do more to assist victims.

Thomas T. Lewis

other crimes through the creation of safe houses. As these efforts became better organized, national associations arose in what might be called a movement for victims' rights. During the early 1980's, President Ronald Reagan responded to this movement by ordering the creation of the President's Task Force on Victims of Crime. This significant development was followed by passage of the federal Victims of Crime Act of 1984, which created a system for funding compensation paid to victims of crime.

Assessing Victimization

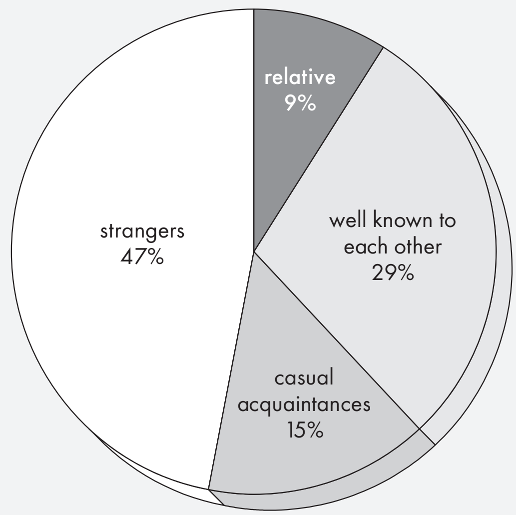
Scientific studies of victims must be conducted without bias or prejudgments. It is important that researchers examine tangible evidence when attempting to determine the extent to which victims are responsible for their own victimization. The roles of victims may range from no responsibility to shared responsibility to provocation. Without sufficient information about the victims' roles, analyses of crimes are incomplete and may possibly be in error.

The primary sources for measuring crime and victimization are the Federal Bureau of Investigation's (FBI) Uniform Crime Report (UCR), the National Incident-Based Reporting System (NIBRS), and the U.S. Bureau of Justice Statistics' National Crime Victimization Survey (NCVS). The UCR is an annual crime report that has been prepared by the FBI since 1930. Its value to studies of victimization is limited by its emphasis on street crimes reported by law enforcement. By contrast, the NIBRS records victim information for many offenses. Although the NCVS is administered nationally and seeks to cover both reported and unreported crimes and victimizations, its data include only persons at least twelve years of age and exclude many persons who are in military service or residents of some institutions.

The scientific study of victims has shown that crime is not a random event. If it were, then it would affect all persons, regardless of their gender, race, ethnicity, socioeconomic class, or location. Studies of victims have shown that the most frequently victimized category of persons comprises male adolescents who are members of racial and ethnic minorities and live in economically depressed urban areas. Studies have shown that many victims and perpetrators of crimes share the same characteristics and are known to one another. These findings challenge the often-presented image of crime as an interracial phenomenon; rather, it is more often intraracial.

Richard L. McWhorter

Victim-Offender Relationships in Violent Crimes



Source: U.S. Bureau of Justice Statistics, *Criminal Victimization*. Percentages reflect data for all violent crimes reported in the United States in 2002.

Further Reading

Carney, Thomas P. *Practical Investigation of Sex Crimes: A Strategic and Operational Approach*. Boca Raton, Fla.: CRC Press, 2003. A former commanding officer of the Manhattan Special Victims Squad presents case histories to illustrate the skills needed to investigate sex crimes effectively.

Cohen, Lawrence E., and Marcus Felson. "Social Change and Crime Rate Trends: A Routine Activity Approach." *American Sociological Review* 44 (1979): 588-608. Explains how people's everyday behaviors can increase their likelihood of becoming crime victims.

Curtis, L. A. *Criminal Violence: National Patterns and Behavior*. Lexington, Mass.: D. C. Heath, 1974. Provides an early discussion into the function of victim responsibilities.

Doerner, W. G., and S. P. Lab. *Victimology*. 4th ed. Dayton, Ohio: Anderson, 2005. Popular survey text provides an introduction to the field of victimology, with a focus on the possible mental health disorders resulting from different types of criminal victimization.

Hentig, Hans von. *The Criminal and His Victim: Studies in the Sociobiology of Crime*. New Haven, Conn.: Yale University Press, 1948. Early discussion by a father of victimology presents a typology of victims.

Karmen, Andrew. *Crime Victims: An Introduction to Victimology*. Belmont, Calif.: Wadsworth/Thomson Learning, 2001. Introductory text focuses on victims' rights and functions in the American criminal justice system.

Mendelsohn, Benjamin. "Victimology and Contemporary Society's Trends." *Victimology* 1 (1976): 8-28. Essay by an early pioneer in victimology discusses a wide range of issues in the field.

Miethe, T. D., R. C. McCorkle, and S. J. Listwan. *Crime Profiles: The Anatomy of Dangerous Persons, Places, and Situations*. 3d ed. Los Angeles: Roxbury, 2006. Discusses the most frequent offender, victim, and situational characteristics of seven major types of crimes and presents some possible theoretical explanations.

Schafer, Stephan. *The Victim and His Criminal: A Study in Functional Responsibility*. New York: Random House, 1968. Considers the interaction between victim and criminal in a typology of victim precipitation.

See also: Criminology; Cyberstalking; Defensive wounds; *Diagnostic and Statistical Manual of Mental Disorders*; Forensic psychology; Living forensics; Rape; Rape kit; Ritual killing; Sexual predation characteristics.

Violent sexual predator statutes

Definition: Laws that prevent the release of dangerous sex offenders into the community after they complete their prison sentences, instead requiring them to be committed to secure psychiatric facilities.

Significance: Violent sexual predator statutes have been a source of legal controversy because they extend the confinement of offenders who have already served their maximum sentences. These laws have also been a source of controversy among mental health professionals who question the indefinite hospitalization of offenders for whom no effective treatments are available.

In 1990, in response to the rape and sexual mutilation of a six-year-old boy by a formerly incarcerated sex offender, Washington State enacted the Community Protection Act (CPA). Regarded as the first modern violent sexual predator statute, the CPA permits prosecutors to initiate civil commitment proceedings against certain types of sex offenders. Incarcerated sex offenders who are found to have mental disorders that place them at risk to commit additional sex offenses in the future can be involuntarily committed to secure psychiatric facilities after they complete their prison sentences. Those who are committed to psychiatric facilities can be released from those facilities only when psychiatric professionals find that they no longer pose any danger to the community.

Several U.S. states already had passed laws that were similar to Washington State's CPA, but the earlier laws had been repealed or fallen into disuse. After enactment of the CPA, however, more than one dozen states and the District of Columbia passed violent sexual predator statutes modeled on the CPA. These laws differ in specific provisions from state to state, but they have two basic characteristics in common: the application of the civil commitment process to sex offenders and the designation of certain sex offenders as violent sexual predators.

Common Characteristics

Violent sexual predator statutes use the civil commitment process to continue to confine sex offenders after they have completed their prison sentences. Civil commitment has traditionally been used in the involuntary hospitalization of individuals who are at imminent risk to hurt themselves or others owing to severe mental disorders such as major depression, schizophrenia, or bipolar disorder. For example, individuals who are actively considering suicide can be civilly committed to mental health facilities until they are sufficiently recovered that they no longer pose an immediate risk to themselves. Civil commitment has traditionally been used to confine persons only briefly, providing safety to them and to society until their crises have passed and their conditions have stabilized.

Violent sexual predator statutes are an unusual application of the civil commitment process. Most sex offenders do not have severe mental disorders, nor do they have to be diagnosed with such disorders in order to be civilly committed under existing violent sexual predator statutes. Violent sexual predator statutes do not require offenders to be at imminent risk of harming others, nor are the periods of commitment intended to be brief. Instead, violent sexual predator statutes are meant to confine offenders who are likely to pose long-term risks to the community, and the periods of confinement are indefinite.

State laws vary in their definitions of which sex offenders are eligible for civil commitment and in the processes by which they assign the status of violent sexual predator to imprisoned offenders. In most states, to be designated as violent sexual predators, offenders must have committed violent sexual offenses against strangers (rather than friends or family members) and must be judged to have some kind of mental abormality or personality disorder that makes it likely they will commit similar offenses in the future.

Typically, a prosecutor must initiate civil commitment proceedings against an offender while the offender is still incarcerated. This process begins with a probable cause hearing. If probable cause is established, the offender undergoes a psychiatric evaluation; that is, mental health professionals are called upon to render opinions as to whether or not the offender meets the definition of a violent sexual predator as specified in the statute. If the evaluation indicates that the offender meets the definition, the case moves to a jury trial, where the offender has an opportunity to mount a defense and demonstrate that he or she is not a violent sexual predator. If the jury finds that the offender should be designated a violent sexual predator, the offender is transferred to a secure psychiatric facility upon completion of his or her original prison sentence. The period of confinement is not specified. The offender can petition for release when mental health professionals judge that the offender is no longer a danger to the community.

U.S. States Holding Persons Under Violent Sexual Predator Laws, 2006

State	*Number Held*
Arizona	414
California	558
Florida	942
Illinois	307
Iowa	69
Kansas	161
Massachusetts	121
Minnesota	342
Missouri	143
Nebraska	18
New Jersey	342
North Dakota	75
Pennsylvania	12
South Carolina	119
Texas	69
Virginia	37
Washington	305
Wisconsin	500
Total	4,534

Source: Data from Kathy Gookin, *Comparison of State Laws Authorizing Involuntary Commitment of Sexually Violent Predators: 2006 Update*. Olympia: Washington State Institute for Public Policy, August, 2007.

Legal Challenges

Since the inception of violent sexual predator statutes, critics have questioned the constitutionality of these measures. The issue was first heard before the U.S. Supreme Court in *Kansas v. Hendricks*. Hendricks, a convicted child molester, was the first offender confined in Kansas under that state's violent sexual predator statute. He challenged his psychiatric confinement, arguing that it amounted to a second incarceration for his sex offense, which would be a violation of the prohibition against double jeopardy found in the Fifth Amendment to the U.S. Constitution. The Supreme Court ruled against Hendricks in 1997, holding that violent sexual predator statutes do not qualify as punishment because their purpose is not to punish the offender but rather to protect the public. The case established the constitutionality of existing violent sexual predator statutes and paved the way for the enactment of such statutes in states where they were being considered.

A second ruling by the Supreme Court regarding violent sexual predator statutes, *Kansas v. Crane*, concerned the degree to which offenders must be unable to control their sexual behavior in order to be deemed violent sexual predators. Crane, a convicted sex offender confined under the Kansas statute, argued that the state had not successfully demonstrated that he was incapable of controlling his illegal sexual behavior. The Court ruled against Crane in 2002, holding that the state does not have to demonstrate that offenders are incapable of control; rather, the state need only demonstrate that offenders have serious difficulty controlling their illegal sexual behavior. This lower threshold for demonstrating offenders' dangerousness may make successful prosecution of violent sexual predator cases easier.

Challenges for Mental Health Professionals

The implementation of violent sexual predator statutes poses challenges to the mental health professionals who must evaluate sex offenders for their civil commitment trials and who must treat those offenders later designated as violent sexual predators. First, "violent sexual predator" is a legal term, not a diagnosable mental disorder, so no standard set of psychiatric signs and symptoms exists for mental health professional to assess while conducting an evaluation for civil commitment. Second, evaluating whether or not a sex offender should be designated a violent sexual predator requires the mental health professional to address the future dangerousness of the offender. Predicting the future actions of individuals with accuracy is difficult, and the prediction of dangerous actions that occur infrequently, such as sexual offenses, is especially difficult. Third, treating sex offenders committed under violent predator statutes is complicated by the fact that no psychotherapy has been scientifically demonstrated to treat this group of offenders effectively. Furthermore, offenders confined under violent sexual predator statutes are entitled to refuse treatment, but they still cannot be released until they are judged to pose no risk to the community.

Damon Mitchell

Further Reading

La Fond, John Q. *Preventing Sexual Violence: How Society Should Cope with Sex Offenders*. Washington, D.C.: American Psychological Association, 2005. Provides an overview and analysis of strategies used to manage sex offenders, including violent sexual predator statutes.

Mercado, Cynthia C., Robert F. Schopp, and Brian H. Bornstein. "Evaluating Sex Offenders Under Sexually Violent Predator Laws: How Might Mental Health Professionals Conceptualize the Notion of Volitional Impairment?" *Aggression and Violent Behavior* 10 (2005): 289-309. Presents an analysis of the impact of *Kansas v. Hendricks* and *Kansas v. Crane* on psychological evaluations conducted for violent sexual predator hearings.

Prentky, Robert A., Eric S. Janus, and Michael S. Seto, eds. *Sexually Coercive Behavior: Understanding and Management*. New York: New York Academy of Sciences, 2003. Collection of research articles discusses the reasons for sex offending and the treatment and assessment of sex offenders. Also analyzes various policies and strategies used to manage sex offenders.

Terry, Karen J. *Sexual Offenses and Offenders: Theory, Practice, and Policy*. Belmont, Calif.: Wadsworth, 2006. Textbook provides overviews of sex offender typology and treatment as well as discussion of public policies related to sex offending.

Winick, Bruce J., and John Q. La Fond, eds. *Protecting Society from Sexually Dangerous Offenders: Law, Justice, and Therapy*. Washington, D.C.: American Psychological Association, 2003. Collection presents legal and psychiatric analyses of the strategies and laws used to manage sex offenders, including violent sexual predator statutes.

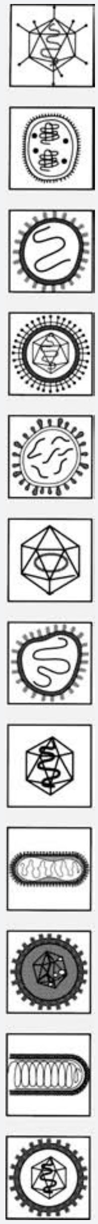
See also: Antianxiety agents; Forensic psychiatry; Forensic psychology; Internet tracking and tracing; Megan's Law; Rape; Sexual predation characteristics.

Viral biology

Definition: Subspecialty of biology that focuses on viruses, tiny nonliving microbes that serve as receptacles for nucleic acids (RNA or DNA) and are dependent on prokaryotic or eukaryotic hosts for replication.

Significance: Viral biologists have knowledge of the structure, genetics, and replication of viruses as well as the skills needed to identify associated viral pathology. These skills are becoming increasingly significant to forensic science, given growing threats of biocrime, acts of bioterrorism, and emerging and reemerging viral diseases. The domains of viral biology and forensic science appear to overlap in the areas of biosecurity and epidemiology of infectious disease.

Types of Viral Infection



Family	Conditions
Adenoviruses	Respiratory and eye infections
Arenaviruses	Lassa fever
Coronaviruses	Common cold
Herpesviruses	Cold sores, genital herpes, chickenpox, herpes zoster (shingles), glandular fever, congenital abnormalities (cytomegalovirus)
Orthomyxoviruses	Influenza
Papovaviruses	Warts
Paramyxoviruses	Mumps, measles, rubella
Picornaviruses	Poliomyelitis, viral hepatitis types A and B, respiratory infections, myocarditis
Poxviruses	Cowpox, smallpox (eradicated), molluscum contagiosum
Retroviruses	AIDS, degenerative brain diseases, possibly various kinds of cancer
Rhabdoviruses	Rabies
Togaviruses	Yellow fever, dengue, encephalitis

In contrast to the epidemiological and diagnostic requirements of public health and private practice, respectively, microbial forensics (the branch of forensic science that deals with microorganisms) demands more detailed characterization of microbes in order to determine the origins of pathogens or toxins (identification) and who or what organizations were responsible for their dissemination (attribution). Microbial forensic scientists use genetic and nongenetic assays to attribute a source or to discount one and to determine whether an event occurred naturally (for example, through the spread of an infectious disease) or as the result of an inadvertent release of a toxin or pathogen, a biocrime, or an act of bioterrorism.

Methods and Technologies

Forensic microbiological investigations are essentially similar to standard forensic investigations in that they involve crime scene investigation, attention to chain of custody, and strict adherence to protocols for evidence collection, preservation, and shipping. The evidence samples analyzed in relation to a suspected biocrime or act of bioterrorism may include liquids, powders, and organic matter as well as fingerprints, hair, and fibers. Given that the goal is to provide physical evidence for use in legal proceedings, an effective microbial forensics program mandates validation of each step in the investigation, from sample collection to interpretation of results, in order to guarantee that quality-assurance practices are being implemented.

In 1999, when West Nile virus disease was found in the state of New York, apparently the first time it had occurred in the United States, authorities worried that a biocrime had been committed. Microbial forensic techniques helped scientists determine that the emerging West Nile virus disease had been spread by mosquitoes and was a natural occurrence. The technologies scientists use in such cases include polymerase chain reaction (PCR) assays, which amplify samples, and sequencing to identify pathogens. Information obtained from PCR and sequencing of nucleic acids may then be evaluated through phylogenetic studies, which are used to infer relationships between organisms and may help characterize novel viral strains, as was demonstrated in 1999 when a new strain of the human immunodeficiency virus (HIV) was identified in Africa.

Phylogenetic studies may also help determine whether a viral strain was introduced through negligent or criminal action. For example, forensic scientists were able to identify the source of an HIV infection in a case of sexual abuse of a child even after several years had passed; they compared the nucleotide sequences of the child with those of her abuser and found that the strain of HIV

The National Biodefense Analysis and Countermeasures Center

The U.S. Department of Homeland Security's National Biodefense Analysis and Countermeasures Center (NBACC), created after the anthrax letter attacks perpetrated in the eastern United States in the fall of 2001, provides biosafety level 4 (BSL-4) laboratory space for biological threat characterization and bioforensic research. The NBACC describes its primary research areas as follows:

Biological Threat Characterization Center (BTCC) conducts studies and laboratory experiments to

- better understand current and future biological threats,
- assess vulnerabilities to the nation, and
- determine potential impacts to guide the development of countermeasures against these threats.

As mandated by Presidential Directive "Biodefense for the 21st Century," the BTCC will prepare a biennial risk assessment report comparing the risk from various biothreat agents.

National Bioforensic Analysis Center (NBFAC) conducts bioforensic analysis of evidence from biocrimes and terrorism to

- attain a "biological fingerprint" to identify perpetrators and
- determine the origin and method of attack.

NBFAC is designated in "Biodefense for the 21st Century" to be the lead federal facility to conduct and facilitate the technical forensic analysis and interpretation of materials recovered following a biological attack in support of the appropriate lead federal agency.

Biodefense Knowledge Center (BKC) supports collaboration and data sharing among policy makers, scientists, first responders, and other stakeholders requiring timely and authoritative biodefense information.

was the same. (Deoxyribonucleic acid, or DNA, and ribonucleic acid, or RNA, are composed of nucleotides.) Previously, a group of hemophiliac patients who had received pooled blood plasma and were later infected with HIV were shown to have been infected from the same source—that is, contaminated plasma. In another case, genetic analysis showed that a New Jersey dentist and five of his patients harbored the same strain of HIV, indicating that the dentist was the source of the infection.

Bioterrorism and Emerging Viral Diseases

Advances in sanitation, the discovery of vaccines for diseases such as smallpox, and, in the early 1940's, the development of penicillin as an antibiotic resulted in growing optimism in the public health community that infectious disease—the number one killer worldwide—would soon be controlled. In the late twentieth century, however, the world began to experience the greatest pandemic of all time, that of HIV and acquired immunodeficiency syndrome (AIDS). Within less than three decades, approximately fifty million persons had been infected worldwide and twenty million were dead, and HIV/AIDS, along with its cohort, tuberculosis, threatens to kill hundreds of millions more. Molecular epidemiologists are focusing on understanding drug-resistant strains of HIV and tuberculosis so that they can discover ways to combat them. Virologists are studying the blood from survivors of the catastrophic influenza epidemic of 1918 to understand why the flu was so deadly and to prepare for the possibility of another pandemic caused by the avian influenza virus H5N1.

At no time in history has the dilemma of the application of science for either the good or the detriment of humankind been more apparent as the specters of bioterrorism and emerging viral diseases underscore the need for biosecurity and biosurveillance around the world. (Emerging viral diseases may be caused by previously unknown viruses or by known viruses that have newly appeared or reappeared in particular locales or populations or have mutated, become drug-resistant strains, or developed new modes of transmission.) The National Institute of Allergy and Infectious Diseases (NIAID) has categorized agents responsible for the emergence and reemergence of highly virulent and contagious infectious viral diseases across the globe and has classified a host of pathogens as "agents with bioterrorism potential," including Ebola and Marburg hemorrhagic viruses, the smallpox virus and related pox viruses, hantaviruses, Lassa virus, and bacteria such as *Bacillus anthracis* (which causes anthrax) and *Yersinia pestis* (which causes plague), all of which may be weaponized.

The Laboratory Response Network—involving the Centers for Disease Control and Prevention (CDC), the Association of Public Health Laboratories, and the Federal Bureau of Investigation (FBI), with links to laboratories across the United States—was created specifically to respond to acts of bioterrorism and outbreaks of emerging infectious disease. In 2003, the U.S. Department of Homeland Security launched the National Bioforensic Analysis Center to serve as a resource for the analysis of microbial evidence derived from acts of bioterrorism.

Cynthia Racer

Further Reading

Budowle, Bruce, et al. "Quality Sample Collection, Handling, and Preservation for an Effective Microbial Forensics Program." *Applied and Environmental Microbiology* 72 (October, 2006): 6431-6438. Discusses the collection and preservation techniques required for a successful microbial forensic investigation and emphasizes the interactions among various governmental agencies in such an investigation.

Budowle, Bruce, Randall Murch, and Ranajit Chakraborty. "Microbial Forensics: The Next Forensic Challenge." *International Journal of Legal Medicine* 119 (November, 2005): 317-330. Provides a comprehensive review of the subfield of microbial forensics, including discussion of bioterrorism and biocrime, the pathogenic organisms used in these crimes, and the techniques employed to characterize them.

Carter, John B., and Venetia A. Saunders. *Virology: Principles and Applications*. Hoboken, N.J.: John Wiley & Sons, 2007. Presents a clear and accessible introduction to virology, explaining virus structure, replication, and genetics.

Ellison, D. Hank. *Handbook of Chemical and Biological Warfare Agents*. 2d ed. Boca Raton, Fla.: CRC Press, 2007. Excellent reference source for information on agents used in chemical and biological warfare, including blood agents.

Lederberg, Joshua, ed. *Biological Weapons: Limiting the Threat*. Cambridge, Mass.: MIT Press, 1999. Examines the dangers posed by biological weapons as well as the ways in which the United States has tried to decrease those dangers.

Nathanson, Neal. *Viral Pathogenesis and Immunity*. 2d ed. Burlington, Mass.: Elsevier Academic Press, 2007. Covers the essentials of viral biology: pathogenesis and host responses to viral infections as well as virus-host interactions.

See also: Anthrax; Anthrax letter attacks; Biological warfare diagnosis; Biological weapon identification; Biological Weapons Convention of 1972; Biotoxins; Ebola virus; Epidemiology; Hantavirus; Hemorrhagic fevers; Nipah virus; Pathogen genomic sequencing; Smallpox.

Voice alteration. *See* Electronic voice alteration

Voiceprints

Definition: Visual representations of individuals' voices based on biometric measurements.

Significance: Law-enforcement investigators use voiceprint analysis to determine the likelihood that particular individuals are the persons speaking in recorded conversations. In the United States, the admissibility of voiceprints as evidence varies from state to state.

The principle underlying the use of voiceprints, also called sound spectrograms, for identification is that each individual has a unique voice; that is, each person's voice has particular characteristics that allow the voice to be distinguished from every other voice. Each person's voice is affected by the size and shape of the person's vocal cords, mouth, throat, teeth, and nasal cavity. In addition, voice uniqueness derives from the movement of the tongue, lips, and jaw muscles during speech. When a speaker's voice is analyzed by an instrument known as a sound spectrograph, which maps the voice onto a graph to produce a visual representation, the resulting voiceprint is, according to proponents of the technology, as unique as a fingerprint. This technology is one of several that has been used to authenticate the claim that Osama Bin Laden is the speaker on audiotapes released by al-Qaeda.

History

In 1941, Bell Telephone Laboratories in New Jersey developed the sound spectrograph, a device that analyzes sound frequencies and wavelengths and creates visual records of sounds in the form of graphs. Although intelligence agencies were interested in the technology as a way to identify enemy agents from recorded telephone conversations, progress toward the identification of individual speakers was slow until the early 1960's. At that time, police in New York City became interested in using voice analysis to assist in identifying a caller who was repeatedly phoning in bomb threats to airlines. They asked Lawrence Kersta, a Bell Labs engineer, to determine whether a comparison of sound spectrograms, which Kersta later called voiceprints, could be used to identify a suspect positively as the caller. Kersta experimented with visual pattern matching of voiceprints and concluded that when an unknown voiceprint was compared with that of a known speaker, the likelihood of a match could be determined with more than 99 percent accuracy.

Kersta's results were not universally accepted, and other researchers found a lower degree of accuracy, but in the early 1970's, law-enforcement agencies began trying to enter voiceprints into evidence in criminal cases.

Some courts accepted voiceprint evidence; others threw it out on the grounds that the technology had not been adequately proven. Although the American Board of Recorded Evidence, an advisory board of the American College of Forensic Examiners, published standards in 1997 for the comparison of voice samples and certifies speaker identification examiners, voiceprint evidence is not uniformly admissible in American courts.

Controversies Surrounding Voiceprint Evidence

From the beginning, voiceprint evidence has been a topic of controversy. Although Kersta claimed almost perfect accuracy in identifying speakers, his experiments were performed under ideal conditions with high school girls as subjects. Other experimenters, working under different, less ideal conditions, reported lower accuracy rates. Currently, the results of voiceprint comparisons are classified, based on the numbers of similarities in the samples, as positive identification, probable identification, positive elimination, probable elimination, or unable to determine. In a study of two thousand forensic voiceprints, the Federal Bureau of Investigation (FBI) found 0.31 percent false identifications and 0.53 percent false eliminations.

Among the questions that have plagued voiceprint evidence are whether voiceprints of the same person change over time and whether a voice can be disguised to fool the spectrograph. Studies have shown quite conclusively that although a person's voice may sound different to listeners as the person ages, the frequency and wavelength of the sound remains essentially unchanged. Disguising or distorting the voice, however, can make voiceprint comparison invalid. A trained examiner will recognize that one voice sample has been artificially altered, and this may force an "unable to determine" finding. Courts have ruled that it is not a violation of suspects' rights to compel them to provide acceptable voice samples.

Standards and Training

Certain conditions must be met for the results of voiceprint comparisons to be considered valid. Several minutes of speech from both the known speaker and the unknown speaker must be available for analysis. Ideally, the samples should contain many of the same words and phrases. The style of speech in the samples must be similar—for example, one cannot be shouted and the other whispered. Relaxed, normal conversation produces the most accurate results. The quality of both recordings must be good (for instance, clear and free of excessive background noise). In addition, the analyst must be a trained voiceprint technician. The analyst should make both a visual comparison of the voiceprints and an auditory comparison of the samples to listen for vocal tics, phrasing, and accent similarities and differences.

Minimum training for a voiceprint technician involves completing a two- to four-week course, performing a minimum of one hundred voice comparisons under the direct supervision of an expert, and passing an examination given by experts in the field. Voiceprint technicians who serve as expert witnesses often have additional training, including academic research in forensic linguistics or forensic phonetics. The International Association of Forensic Linguists and the International Association of Forensic Phonetics and Acoustics publish the *International Journal of Speech Language and the Law*, which presents research findings and reports on legal cases involving speaker identification through voice samples.

Martiscia Davidson

Further Reading

Dornman, Andy. "Biometrics Becomes a Commodity." *IT Architect*, February 1, 2006, 46. Discusses the current state of biometric technology, including fingerprints and voiceprints.

"Forensic Science, No Consensus." *Issues in Science and Technology* 20 (Winter, 2004): 5-9. Forum with contributions by various scholars analyzes the problems associated with forensic laboratory work, including voiceprint analysis.

Hollien, Harry. *Forensic Voice Identification*. San Diego, Calif.: Academic Press, 2002. Covers the science behind voice identification and gives practical information on speech recordings, voice stress analysis, and speaker identification.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005. Basic introductory text presents information on all aspects of forensic science, including voice identification techniques.

Tanner, Dennis C. *Medical-Legal and Forensic Aspects of Communication Disorders, Voice Prints, and Speaker Profiling*. Tucson, Ariz.: Lawyers & Judges Publishing, 2007. An expert in the field of speech forensics details the science of speech production and how voice identification can be used in both routine situations and those involving individuals with accents, speech disorders, or intoxication.

See also: Biometric identification systems; Electronic voice alteration; Forensic linguistics and stylistics; *Frye v. United States*.

W

Water purity. *See* Air and water purity

Wildlife forensics

Definition: Analysis of animal tissues in addition to such traditional forensic evidence as fingerprints associated with wildlife poaching and smuggling.

Significance: Crimes committed against wildlife might remain unsolved without forensic evidence to prove connections among animal victims, human hunters, and scenes where animals were slain or captured. Scientific proof from bloodstains, antlers, and animal by-products enables law-enforcement personnel to identify and seek legal prosecution of suspects in crimes involving animals.

Forensic examination of wildlife-related evidence became crucial during the late twentieth century because of increased governmental awareness worldwide of the poaching and smuggling of endangered and protected species. As demand for exotic pets and animal goods led wildlife traders to expand their trafficking activities and populations of some species dwindled, the 1973 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) established uniform criteria for global enforcement of laws protecting vulnerable species. The United States enforced the Endangered Species Act of 1973 and forbade importation of Asian elephant ivory beginning in 1976 and African elephant ivory starting in 1989. Scholarly articles featuring wildlife forensics appeared in journals such as *Forensic Science International* and in conference proceedings.

Establishing Resources

Before the National Fish and Wildlife Forensics Laboratory was established in 1989, approximately 90 percent of wildlife poachers in the United States were not punished because evidence of their crimes was unavailable unless game wardens had witnessed their actions. Law-enforcement personnel needed scientific evidence that they could present in court if they were going to be able to prosecute crimes committed against wildlife. Most forensics laboratories did not pursue investigations related to wildlife crimes.

In 1979, the U.S. Fish and Wildlife Service hired Ken Goddard to serve as the agency's chief forensic investigator. Goddard, a biochemist who had worked in law-enforcement crime laboratories, applied his experience and expertise to the apprehension of poachers. He requested that the U.S. government establish a wildlife forensics laboratory so that he could perform his work more effectively. The result, the National Fish and Wildlife Forensics Laboratory in Ashland, Oregon, became the sole laboratory investigating wildlife crimes in the United States and globally.

Serving as director of the laboratory, Goddard recruited a staff of scientists who specialized in morphology, pathology, criminalistics, and toxicology. Differentiating between police forensic work, which focuses on one species, and wildlife forensic investigations, which may involve thousands of species, the National Fish and Wildlife Forensics Laboratory assembled sophisticated technology and a diverse collection of specimens, including skeletons, feathers, and blood, to aid in its work of identifying wildlife victims, particularly when evidence consists of only fragments or bloodstains. The laboratory also established a DNA (deoxyribonucleic acid) and protein database to aid in species identification.

The National Fish and Wildlife Forensics Laboratory's collaborative approach helped to establish an innovative scientific field, incor-

Ken Goddard, director of the National Fish and Wildlife Forensics Laboratory, displays gear and materials he used to develop protocols for criminal investigations on coral reefs. Goddard joined with the International Coral Reef Initiative to offer training in such investigations in October, 2006. *(AP/Wide World Photos)*

porating existing technologies and biological and chemical procedures and inventing methods to conduct original investigations. Forensic ornithologists, veterinarians, and wildlife specialists enhanced the laboratory's capabilities.

Scientific Investigations

For the forensic scientists at the wildlife laboratory, a case begins when a sample arrives and is cataloged. Wildlife forensic evidence takes varied forms, from entire carcasses to pieces of bone; it may include dried fluids, pelts, raw meat, and products made from animal materials. Morphologists evaluate specimens to identify their species; this work sometimes requires comparisons with samples from known species in the laboratory's collection. The scientists frequently use scanning electron microscopes to scrutinize samples for structures to determine species. Species identification clarifies whether or not the animal is legally protected; crocodiles, for example, are a protected species, whereas alligators are not.

Serologists analyze blood samples, using mass spectrometry to weigh hemoglobin protein molecules to identify species. Genetic fingerprinting is useful when bloodstains at scenes or on poachers' clothing are the sole available evidence. Investigators may use DNA analysis to connect the body parts of an animal recovered in separate locations. Wildlife forensic investigators also compare saw marks, such as on antlers and heads, to match severed wildlife pieces. DNA analysis may also be used to associate meat with a crime scene. Forensic scientists can determine whether poached animals were born in the wild or captively bred, as some hunters claim, if the DNA of the animals' alleged parents is available for testing. DNA evidence can also enable investigators to identify the weapons used to kill animals.

Pathologists at the wildlife forensics laboratory examine evidence to determine the causes of animals' deaths. Experts in criminalistics evaluate bullets found inside animals, tire tracks, and other evidence found at crime scenes to supplement the information acquired from biological and chemical examinations. Such evidence can link together an animal victim, a human suspect, and the place where the crime occurred.

Wildlife forensic scientists have devised techniques for evaluating animal goods. For example, Edgard O. Espinoza and Mary-Jacque Mann developed a simple way for customs agents to appraise the Schreger lines in ivory (lines that are visible in cross sections of ivory) by measuring the lines' angles to determine if the ivory came from an elephant's tusk or some other source. Ivory with Shreger line angles of 115 degrees or greater comes from banned sources, whereas ivory with line angles of 90 degrees or less is legal. This method has exposed poachers who had falsely identified their ivory as originating from legal sources and has resulted in a reduction in elephant poaching.

Wildlife forensics investigators have also analyzed bile acids to identify different kinds of animal bladders that have been harvested for folk medicines. It is illegal to kill bears for this purpose, but the harvesting of pig bladders is legal. Researcher Stephen Busack has been able to identify some reptiles by scale shapes and patterns even when tanning and dying processes have obliterated the skins' original pigments.

The National Fish and Wildlife Forensics Laboratory's successes have encouraged forensic investigators to establish similar facilities in other locations, including internationally, but the laboratory in Ashland remains the only one of its kind devoted entirely to wildlife.

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Further Reading

Espinoza, Edgard O'Niel, and Mary-Jacque Mann. *Identification Guide for Ivory and*

Determining New Species-Defining Characteristics

A writer for the National Fish and Wildlife Forensics Laboratory offers this explanation of one of the lab's most difficult tasks, determining new species-defining characteristics.

If the federal wildlife special agents and game wardens and conservation officers who comprise our user groups seized (for example) whole elephants as evidence, attached an evidence tag to their tails, and dragged them into a courtroom, we wouldn't need a $4.5 million wildlife crime laboratory.

You would recognize that animal as an elephant.

And we would recognize it as an elephant.

And I would wager that we could get the average jury of 12 to agree that it is an elephant, based upon certain commonly-accepted species-defining morphological characteristics, such as the trunk, the tusks, the large ears, the even larger rear end, the small tail, etc.

But the thing is, these wildlife officers don't seize whole elephants and send them to our laboratory for identification (a fact for which, I might add, we are all extremely grateful!); rather, they seize wildlife pieces, parts and products in which the commonly-accepted species-defining characteristics are no longer present.

So what we have to do, as a wildlife crime laboratory, is conduct an extensive amount of research to come up with new species-defining characteristics that will allow us to testify in court that this piece, part or product originated from a specific species of animal, and not from any other possible species in the entire world . . . which, if you stop to think about it, is quite a trick.

Oh yes, one other thing: there are no established cookbooks for our work. Wildlife forensics is very much in its infancy as a branch of forensic science, so we will be working with a lot of other wildlife experts and police-type forensic scientists to conduct our research and bring our profession forward to assist wildlife officers at the federal, state and international levels in enforcing wildlife laws.

Ivory Substitutes. 3d ed. Baltimore: World Wildlife Fund, 2000. Describes forensic techniques for differentiating ivory specimens originating from elephants and other animals.

Jackson, Donna M. *The Wildlife Detectives: How Forensic Scientists Fight Crimes Against Nature*. Photographs by Wendy Shattil and Bob Rozinski. Boston: Houghton Mifflin, 2000. Features the techniques used in the National Fish and Wildlife Forensics Laboratory's investigation of the 1993 poaching of an elk in Yellowstone National Park.

Knight, Jonathan. "Cops and Poachers." *New Scientist*, January 22, 2000, 40-43. Article about Goddard emphasizes the importance of species identification for wildlife forensic evidence.

Luoma, Jon R. "The Wild World's Scotland Yard." *Audubon* 102 (November/December, 2000): 72-80. Presents a detailed account of the achievements of the scientists at the National Fish and Wildlife Forensics Laboratory.

Repanshek, Kurt. "Tracking Poachers with Forensic Science." *Technology Review* 98 (August/September, 1995): 22-23. Focuses on technological applications developed to prove wildlife crimes.

See also: Animal evidence; Blood residue and bloodstains; Courts and forensic evidence; Crime laboratories; Direct versus circumstantial evidence; DNA analysis; DNA banks for endangered animals; Forensic botany; Hair analysis; Mass spectrometry.

World Trade Center bombing

Date: February 26, 1993

The Event: A car bomb exploded inside the parking garage below New York City's World Trade Center's north tower, killing six people and injuring more than one thousand. The explosion also disrupted public services and necessitated a massive cleanup effort.

Significance: An intense forensic investigation by agents of the Federal Bureau of Investigation led to the arrest and conviction of four suspects. In the absence of eyewitnesses to the bombing, the convictions rested mostly on forensic evidence extricated from the blast's rubble, telephone and bank records, and other documentary evidence. The bombing itself was regarded as an act of international terrorism that prompted changes in security measures in the United States.

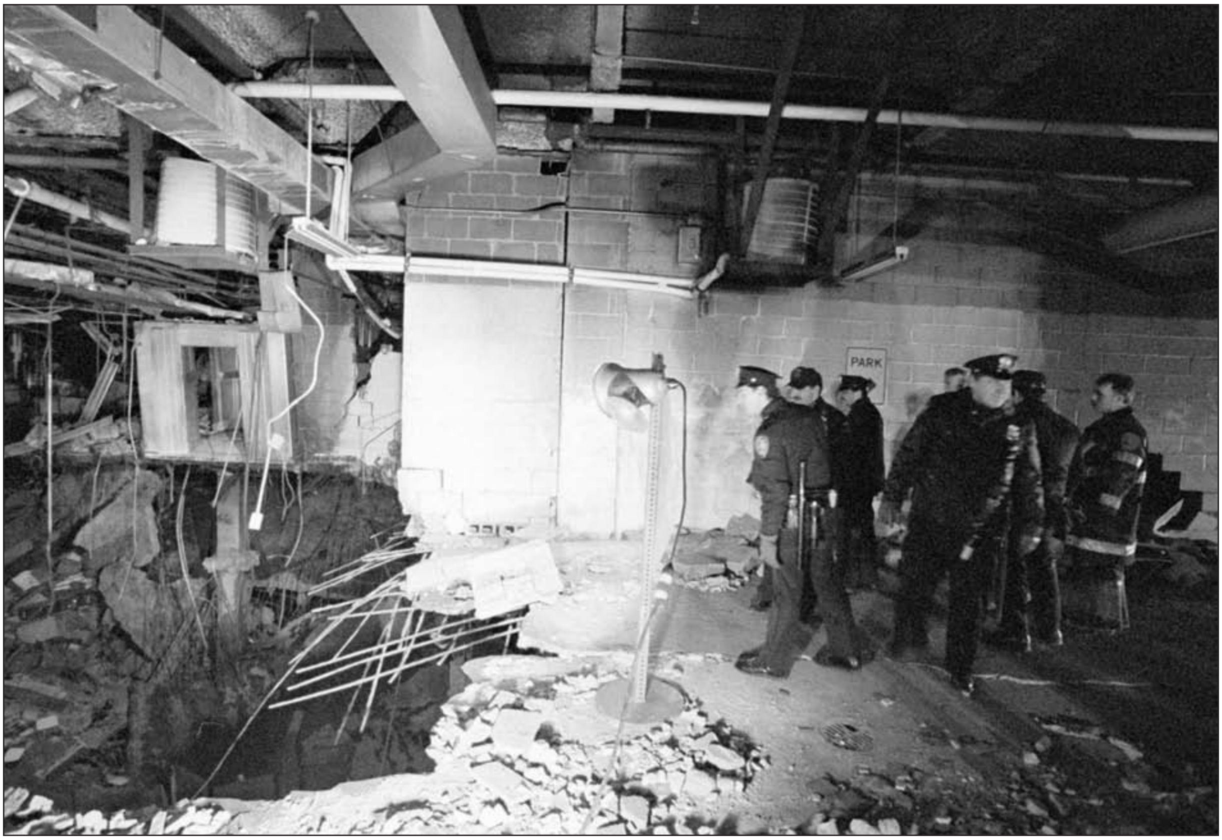
At 12:17 P.M. on February 26, 1993, a huge bomb exploded in the underground parking garage below the north tower of New York City's World Trade Center. Like its twin, the 110-story tower was part of a complex in which fifty thousand people worked on a typical day. The Trade Center complex also hosted as many as eighty thousand visitors a day.

The explosion blasted a hole almost one hundred feet wide that extended through four sublevels of concrete and ruptured sewer and water mains. The blast, which was felt several miles away, forced the evacuation of thousands of people from the building. It cut off telephone service to a large part of Lower Manhattan and ruptured nearby power lines. Without electrical power, most local radio and television stations could not broadcast throughout much of the following week.

In response to the chemical and biological hazards left in the wake of the blast, crews from the federal government's Environmental Protection Agency and Occupational Safety and Health Administration cleaned up the sewage, acid, fumes, and asbestos. The bomb itself had contained at least twelve hundred pounds of urea nitrate, a fertilizer that had been used only once in 73,000 explosions previously investigated by the Federal Bureau of Investigation (FBI).

The Investigation

Four days after the blast, *The New York Times* received a letter from a group calling itself the Liberation Army Fifth Battalion. The group was unknown to law-enforcement agen-



New York City police and firefighters inspect the bomb crater inside the World Trade Center parking garage on February 27, 1993, one day after the terrorist attack that killed six people and injured more than one thousand. *(AP/Wide World Photos)*

cies, but the FBI authenticated the letter as having come from a West Bank Palestinian named Nidal A. Ayyad. Its message called the bombing attack a response to the American support of Israel and American interference in Middle Eastern affairs. It also threatened further attacks if the U.S. government failed to change its Middle Eastern policies.

Many government agencies responded to the bombing by sending investigation teams to the site. The first team to arrive at the scene was composed of FBI agents and specialists from the FBI's explosives unit. During the seven days following the bombing, more than three hundred law-enforcement officers sifted through the 2,500 cubic yards of debris created by the blast. A bomb technician working for the federal Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) found the part of a nearly destroyed van with a vehicle identification number (VIN). That information made it possible to trace the van to the agency that had rented it and from there to the renter, another West Bank Palestinian named Mohammed A. Salameh.

Reconstructing the Crime

As law-enforcement investigators worked to reconstruct what had happened, other evidence pointed to the rental van as the source of the blast within the building. In addition to finding chemical residues in the air, ATF agents discovered physical evidence of "feathering," or stretching, of the van and dimpled metal near the van that had been liquefied by the heat of the blast and had shot out, leaving small indentations in nearby objects. This physical evidence indicated that the van itself was at the center of the blast.

Other forensic investigators collected detailed documents that would lead to the apprehension of the primary suspects in the case. In

The Fates of the Conspirators

Four West Bank Palestinian Muslim militants were eventually arrested and tried for their parts in the World Trade Center bombing. All four had been influenced by the blind Egyptian cleric Sheikh Omar Abdel Rahman, who had once been implicated in the 1981 assassination of Egyptian president Anwar el-Sadat. Most of the conspirators also had connections with El Sayyid A. Nosair, an Egyptian convicted of assault and weapons charges for a shooting at the time of militant Rabbi Meir Kahane's assassination in 1990.

On March 4, 1993, authorities made the first arrest, of Mohammed A. Salameh. Arrests of three other suspected conspirators—Nidal A. Ayyad, Mahmoud Abouhalima, and Ahmad M. Ajaj—followed. Abdul Rahman Yasin, an American of Iraqi heritage, was questioned by the FBI but afterward fled to Iraq. He was later indicted and in 2001 was placed on the FBI's most-wanted list. Since then, he has remained a fugitive. The five-month trial of the accused conspirators began in the U.S. federal district court in Manhattan in October, 1993. On March 4, 1994, all four were found guilty on thirty-eight counts of conspiracy to blow up the building, and each man was sentenced to 240 years in prison without the possibility of parole.

Long after the bombing, fugitives and additional suspects were apprehended, extradited, and eventually tried. Ramzi Yousef, a Kuwaiti national who was believed to be the mastermind of the bombing, was located in Pakistan and returned to New York in February, 1995. He was considered to be a trained professional terrorist, unlike those he recruited, entering countries under different aliases with false papers, cash, and connections. Eyad Ismail was traced to Jordan and returned to New York in July, 1995. Yousef and Ismail were subsequently tried and found guilty of conspiracy for their roles in the World Trade Center bombing. In 1996, Yousef was sentenced to life in prison, and in 1998, Ismail received a sentence of 240 years in prison; both sentences included no possibility of parole.

1991, a Kuwaiti national named Ramzi Yousef, who appeared to be the mastermind behind the bombing, apparently began planning the attack with his uncle, Khalid Shaikh Mohammed, a member of the radical Muslim group al-Qaeda who helped fund the conspiracy. Their goal was to cause one of the Trade Center's towers to fall on the other, maximizing the damage. Police later found bomb-making instructions in the luggage of Yousef's partner, Abdul Rahman Yasin, an American of Iraqi heritage.

The bomb contained urea pellets, sulfuric acid, aluminum azide, nitroglycerin, magnesium azide, and bottled hydrogen. The conspirators also added sodium cyanide to the mixture in the hope that cyanide gas would be disseminated throughout the building's ventilation system.

After the attack, inquiries into how it occurred found that security in the Trade Center garage had been seriously lacking, despite the fact that the Port Authority had identified the tower's garage as one of three places of security concern in 1985. Security in the Trade Center was afterward greatly improved. However, the enhanced measures would prove useless when hijacked jetliners were flown into the towers on September 11, 2001. On that occasion, the goals of the earlier bombing were achieved when the intense fire damage inflicted by the airplanes carrying large amounts of jet fuel caused both towers to collapse completely.

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Further Reading

Behar, Richard. "The Secret Life of Mahmud the Red." *Time*, October 4, 1993, 54-61. Describes the role of defendant Mahmoud Abouhalima in the World Trade Center bombing.

Caram, Peter. *The 1993 World Trade Center Bombing: Foresight and Warning*. London: Janus, 2001. Documents the long-term security risk of the building. Written by a police officer who was an antiterrorist officer.

Dwyer, Jim, Deidre Murphy, Peg Tyre, and David Kocieniewski. *Two Seconds Under the World: Terror Comes to America—The Conspiracy Behind the World Trade Center*

Bombings. New York: Crown, 1994. Discusses some conspiracy theories surrounding the bombing while accounting for the facts of the crime through the use of information and police data about the act as well as interviews with confidential sources.

Pellowski, Michael J. *The Terrorist Trial of the 1993 Bombing of the World Trade Center: A Headline Court Case*. Berkeley Heights, N.J.: Enslow, 2003. Details the events leading up to the bombing as well as the capture of the suspects and their trials.

Reeve, Simon. *The New Jackals: Ramzi Yousef, Osama Bin Laden, and the Future of Terrorism*. Boston: Northeastern University Press, 1999. Explains how Yousef and Bin Laden, who were trained militarily, have used terrorism for religious and political purposes.

Simon, Jeffrey D. *The Terrorist Trap: America's Experience with Terrorism*. 2d ed. Bloomington: Indiana University Press, 2001. Examines the history of terrorist acts against the United States. Chapter 1 treats the 1993 World Trade Center bombing under the title "Welcome to Reality."

Weaver, Mary Anne. "The Trail of the Sheikh." *The New Yorker*, April 12, 1993, 71-89. Discusses the shadowy, blind Muslim cleric Sheikh Omar Abdel Rahman, mentioned as a key figure in various terrorist plots, and examines his Egyptian connections.

See also: Blast seat; Bomb damage assessment; Bombings; Bureau of Alcohol, Tobacco, Firearms and Explosives; Driving injuries; Federal Bureau of Investigation; Federal Bureau of Investigation Laboratory; First responders; Improvised explosive devices; Oklahoma City bombing; Paper; September 11, 2001, victim identification; Structural analysis.

Writing instrument analysis

Definition: Examination of documents and writing instruments with the aim of determining which specific instruments were used to create the documents of interest.

Significance: Handwritten documents often play important roles in criminal investigations and court cases. Through writing instrument analysis, forensic scientists can gather information about documents (such as wills, ransom notes, or threatening letters) that can help investigators link the documents to suspects.

Law-enforcement investigators sometimes encounter pieces of written evidence that can potentially provide important information about individuals or crimes. In some instances, a document may be integral to the case, such as a ransom note or forged document. At other times, a scribbled note might be a clue to the identity of a criminal for whom investigators are searching. In these cases, any information that can be gathered about the documents and how they were produced can be helpful to investigators. Information linking a suspect to a written document may also be used as evidence during a trial. Although the numbers of handwritten documents figuring prominently in law-enforcement investigations have diminished over time, as first the widespread adoption of typewriters and later the common use of computers and printers greatly reduced the frequency with which many people handwrite any documents, writing instrument analysis remains an important function of forensic science.

Types of Writing Instruments

Many different types of writing instruments may be used in the creation of a document. These include objects that are generally thought of as writing instruments, such as pens and pencils, as well as less commonly used instruments, such as crayons, spray paint, or lipstick. Anything that can be used to create a mark on a surface may be considered a writing instrument.

The most common writing instruments are mass-produced pens and pencils. For many years, the fountain pen was the most common writing instrument, but it was largely replaced in 1954, when the ballpoint pen was introduced. Fiber-tip or porous-point pens, roller-ball pens, and gel pens are also commonly used types of pens. Available pencil types include traditional graphite pencils, colored pencils, and mechanical pencils. Each pencil type is available in a wide range of lead sizes and softnesses. Each type of pen or pencil leaves specific, telltale signs of its identity on any document it is used to create.

Identification Techniques

The techniques used in identifying a writing instrument depend on the goal of the investigation and the availability of writing samples. In some cases, the goal of the investigator is to determine whether a particular document could have been created using a certain writing instrument. In such a case the writing instrument is generally available to create sample documents for comparison. The examiner then compares the original and sample documents, using the naked eye as well as the microscope, and conducts any relevant chemical tests.

If no suspected writing instrument has been identified, the examiner must try to determine as much information as possible using the available document. The first step in the attempt to determine what specific writing instrument was used is a visual inspection of the document. This inspection can usually provide information about the type of writing instrument used, such as whether the writing was created with a pen, pencil, highlighter, crayon, or other instrument.

The next step is to use a microscope to examine the document in more detail. Under the microscope, clues to the identity of the writing instrument that are not apparent to the naked eye become visible. For example, different types of writing instruments can be identified by the lines, marks, and indentations they leave in the writing surface. A pen that uses a ball to disperse ink leaves indentations from the ball in the paper that are visible under the microscope. A pen that does not use a ball, such as a fountain pen or a felt-tip pen, does not leave such indentations.

In some cases, an examiner is able to determine only the type of pen or other writing instrument that was used. In other cases, however, the examiner may be able to identify a specific writing instrument based on imperfections specific to that instrument. A pen tip that is bent or cracked, for example, will produce writing that is likely to show individual characteristics that can be identified by an expert.

The type of ink used can also help the examiner to determine the writing instrument that was used to create a given document. Inks may be tested in many different ways. Some tests involve wetting the sample with a solution and examining the way the ink spreads. An examiner may need to avoid such methods in some cases—for instance, if the goal of the examination is to validate a historic document or only a very small amount of sample is available to study—as they effectively destroy a section of the sample.

Helen Davidson

Further Reading

Bauchner, Elizabeth. *Document Analysis*. Philadelphia: Mason Crest, 2006. Provides an overview of the various components associated with forensic document analysis and includes chapters on important cases, such as the investigation of documents purported to be Adolf Hitler's diaries.

Brunelle, Richard L., and Kenneth R. Crawford. *Advances in the Forensic Analysis and Dating of Writing Ink*. Springfield, Ill.: Charles C Thomas, 2003. Discusses the forensic uses of ink identification and dating, with sections on the admissibility of evidence and chemical techniques.

Ellen, David. *Scientific Examination of Documents: Methods and Techniques*. 3d ed. Boca Raton, Fla.: CRC Press, 2006. Presents information about all aspects of the forensic analysis of handwritten and typewritten documents, including analysis of typewriters, computer printers, and photocopiers. Also describes how this type of evidence functions in the courtroom.

Koppenhaver, Katherine Mainolfi. *Forensic Document Examination: Principles and Practice*. Totowa, N.J.: Humana Press, 2006. Comprehensive text discusses the various steps involved in document, handwriting, and writing instrument analysis, including information on preparing reports and equipping a laboratory.

Nickell, Joe. *Pen, Ink, and Evidence: A Study of Writing and Writing Materials for the Penman, Collector, and Document Detective*. New Castle, Del.: Oak Knoll Press, 2003. Pro-

vides an in-depth look at different types of writing instruments and inks, including discussion of the history and development of writing instruments.

See also: Check alteration and washing; Chromatography; Document examination; Fax machine, copier, and printer analysis; Forensic linguistics and stylistics; Forgery; Handwriting analysis; Hitler diaries hoax; Paper; Questioned document analysis; Typewriter analysis.

Wrongful convictions

Definition: Cases in which persons who are in fact not guilty of the crimes of which they are accused are nonetheless convicted of those crimes.

Significance: Judges and juries must weigh all the evidence placed before them when they make decisions about defendants' guilt or innocence. It is important to recognize that the intentional misuse or unintentional misinterpretation of forensic evidence can lead to the criminal conviction of innocent persons.

Forensic science has made significant contributions to attempts to rectify the problem of wrongful convictions in the United States. Modern understanding of DNA (deoxyribonucleic acid) and advances in DNA analysis technology, in particular, can be credited with aiding the courts in exonerating hundreds of innocent individuals who had been wrongly convicted. Ironically, these exonerations have often involved the use of one form of forensic evidence (particularly DNA evidence) to discredit earlier findings based on other forms of forensic evidence (such as blood typing, fingerprints, ballistics, bite marks, foot prints, or hair comparisons). In cases of exoneration, what typically occurs is that evidence preserved from the incarcerated person's original trial is reanalyzed using modern DNA technology, and this new analysis proves conclusively that the individual is not linked to the crime.

Researchers have studied the case files of many persons proved to have been wrongfully convicted to understand the ways in which the criminal justice system can malfunction. This work has provided a wealth of information on the factors associated with wrongful conviction.

The Double-Edged Sword

For the criminal justice system, forensic science is a double-edged sword. On one hand, when properly used, it can be a powerful tool that serves justice; forensic scientists help police, prosecutors, defense attorneys, judges, and juries do what they are supposed to do—that is, exonerate the innocent and convict the guilty. On the other hand, when the forensic evidence presented in a courtroom is faulty, it can mislead the judge or jury and result in the conviction of an innocent person. The stakes are high when forensic science enters the courtroom, as it is often the testimony of forensic scientists that ultimately sways the judge or jury in the determination of guilt or innocence.

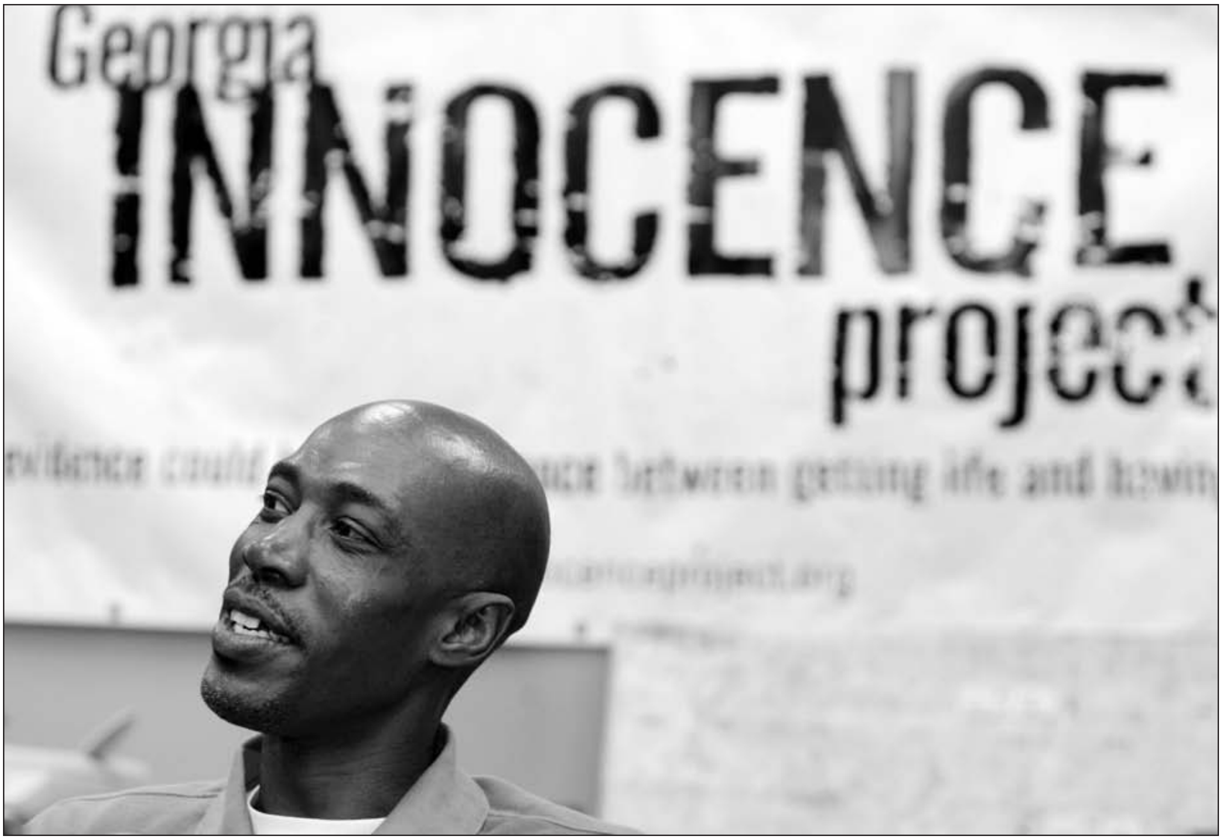
Although some criminal cases are tried without the benefit of forensic evidence, possibly with only eyewitness testimony, the vast majority of criminal cases rely on the expert testimony of forensic scientists, who present to the court their opinions regarding what the physical evidence means in terms of the defendant and the crime. Because evidence involving genetic materials (such as blood, skin, and semen) is available in less than 20 percent of all cases, the most powerful tool available to forensic science—DNA analysis—is not used in more than 80 percent of criminal cases. In cases where genetic material is not available for analysis, scientists are usually called upon to analyze fingerprints, handwriting, ballistics, tool marks, and samples of materials such as paints, plastics, glass, and fibers.

It has been found that in many cases of wrongful conviction, a forensic scientist who appeared as an expert witness for the prosecution played a pivotal role, presenting erroneous and damning conclusions about the evidence. Such faulty forensic science is particularly harmful to an innocent suspect because judges and jurors assign great importance to the testimony of laboratory scientists who swear to the accuracy of the evidence they present. Jurors routinely give such evidence much more weight than other evidence. An expert who testifies that the forensic evidence essentially identifies the accused as the perpetrator of a crime often exhibits the same type of influence on the judge or jury as does an eyewitness who points at the accused in the courtroom and says, "That's the person I saw do the crime." The testimony of a forensic scientist can often mean the difference between conviction and acquittal to a wrongly accused defendant.

Misrepresentation of Scientific Findings

Faulty forensic science can contribute to a wrongful conviction in two ways: through unintentional or intentional misrepresentation of the scientific findings. Forensic scientists can unintentionally present faulty findings in the courtroom for a variety of reasons. Research into cases of wrongful conviction has found that the work of forensic technicians in some police crime laboratories is plagued by uneven training and questionable objectivity. Poorly trained or lazy technicians can conduct forensic tests that yield inaccurate results.

Forensic scientists can also commit unintentional errors in the form of inadvertent mislabeling or switching of samples, mistaken recording of data, inaccurate transcription of results, and loss of evidence. Sometimes the results of scientific tests are themselves accurate but unintentional misinterpretation of the data harms the wrongfully accused. In sum, faulty scientific testimony resulting from either erroneous lab tests or erroneous conclusions based on valid lab tests can lead to wrongful convictions.



Willie "O" Pete Williams answers a question during a news conference at the office of the Georgia Innocence Project in Atlanta on January 25, 2007. The project presented DNA evidence to free Williams from prison after he had served twenty-one years following a wrongful conviction for rape. *(AP/Wide World Photos)*

Repercussions of Wrongful Convictions

Wrongful convictions carry high personal and social prices. First, they compromise public safety. When a falsely accused person is convicted of a crime, that individual is punished in place of the one who actually committed the offense. Therefore, for virtually every person wrongfully convicted of a crime, a corresponding guilty person has not been brought to justice and may continue to commit crimes.

Wrongful convictions also undermine the public's confidence in the criminal justice system. Media stories about individuals who have been exonerated after languishing in prison for years can shake citizens' faith in the ability of the system to separate the innocent from the guilty and to do justice. The resulting damage to the symbolic status of the criminal justice process and loss of confidence in the criminal justice system can have serious and widespread negative consequences. For example, if jurors become skeptical of police testimony or prosecutorial judgment, they may be more likely to acquit guilty individuals. A loss of confidence in the criminal justice system may also lead to an increase in vigilantism.

In addition, when innocent persons are convicted of crimes and incarcerated, several separate injustices occur. Primarily, the wrongfully convicted suffer unjustly, subjected to the horrors of prison life, perhaps facing execution. The families of persons who are wrongfully convicted also suffer, enduring separations—husbands from wives, parents from children, and brothers from sisters—as well as public shame and often substantial losses in income. Moreover, family members typically exhaust all their available resources in attempting to correct their relatives' wrongful convictions. Other participants in the criminal justice process may also suffer. Jurors, witnesses, police officers, prosecutors, defense attorneys, and judges often experience significant distress when they discover that their actions contributed to sending innocent persons to prison.

Sometimes forensic experts intentionally misrepresent the scientific findings in court. In a study of sixty-two wrongful convictions, the Innocence Project (a nonprofit organization founded at the Benjamin N. Cardozo School of Law to assist prisoners who could be proven innocent through DNA testing) found that so-called rigged lab tests often contributed to erroneous convictions. The study determined that "fraudulent science" (intentional fabrication of evidence by a forensic specialist) contributed to 33 percent of the wrongful conviction cases analyzed. Several wrongfully convicted individuals have been exonerated because it was eventually discovered that the forensic scientists who testified at their trials had "made up" or "dry labbed" their results to satisfy the prosecutors and advance their own careers. ("Dry labbing" refers to the practice among corrupt scientists of writing reports regarding scientific findings without conducting any tests.)

Intentional misrepresentation of scientific findings can also occur when forensic experts cross the line from science to advocacy in their testimony, perhaps by exaggerating the results of their tests in ways that are devastating to defendants. Defense attorneys often make no effort to investigate the validity of experts' testimony or to challenge their findings, sometimes because they lack the resources to perform needed tests and sometimes because they are lazy or incompetent.

Indirect Effects of Forensic Error

It has been recognized for years that faulty forensic science can contribute directly to wrongful conviction, but for a long time little attention was paid to the degree to which faulty forensic science can indirectly lead to wrongful conviction by contaminating seemingly independent nonscientific evidence. For example, eyewitnesses who have misidentified a criminal suspect may become increasingly confident in their identification once they discover that forensic scientific tests (whether erroneous or not) have verified their statements. Given that "witness confidence" has been demonstrated to have a strong influence on jurors' perceptions that identification testimony is correct, erroneous conclusions by forensic scientists in such cases are particularly dangerous. In sum, faulty forensic findings may influence and encourage other participants in a trial (witnesses, police officers, prosecutors) to rely more strongly on their own erroneous conclusions.

The damage done by faulty forensic science not only affects the original trials of wrongfully suspected individuals but also continues to plague them when their cases are being appealed. Even when it is discovered that erroneous scientific testimony was offered at trial, the prosecutor will typically say that the testimony amounts to "harmless error" and that the conviction would have occurred even if the faulty evidence had not been presented. The prosecutor will usually suggest that other evidence presented at the trial—such as eyewitness testimony or the defendant's lack of a provable alibi—is enough to legitimate the conviction. What is often unrecognized (and sometime unrecognizable) at the appellate level is the effect that the erroneous expert testimony had on the other witnesses in the trial.

Reducing Forensic Error

Given that human beings will always make mistakes, the phenomenon of wrongful conviction is unlikely ever to be eliminated totally. It is, however, possible to reduce the amount of faulty forensic science presented in courtrooms and thereby reduce the likelihood of wrongful convictions. Forensic science is subject to the influence of human error at every step, beginning with the collection of evidence and on through the storing, testing, and interpretation of that evidence. Forensic scientists must diligently apply their training and ensure that the testimony they offer in court is as scrupulously accurate as humanly possible. Forensic experts who intentionally misrepresent their data should be prosecuted to the fullest extent of the law.

Government standards regarding the training of forensics laboratory personnel and the preservation and handling of evidence have been strengthened in the United States over the years, and aggressive enforcement of these standards should reduce error. Also, lawyers have the responsibility and obligation to their clients to challenge flawed scientific testimony; law schools and continuing education seminars should promote training for attorneys that will help them better recognize and challenge specious forensic testimony.

Robert J. Ramsey

Further Reading

Connors, Edward, Thomas Lundregan, Neal Miller, and Tom McEwan. *Convicted by Juries, Exonerated by Science: Case Studies in the Use of DNA Evidence to Establish Innocence After Trial*. Washington, D.C.: National Institute of Justice, 1996. Government research report discusses a study initiated to identify and review cases in which convicted persons were released from prison as a result of posttrial DNA testing of evidence.

Gross, Samuel R., et al. "Exonerations in the United States, 1989 through 2003." *Journal of Criminal Law and Criminology* 95, no. 2 (2005): 523-560. Analyzes 340 individual exonerations during the period covered. Notes that the data suggest that the total number of miscarriages of justice in the United States in the preceding fifteen years must run to the thousands, perhaps tens of thousands, in felony cases alone.

Huff, C. Ronald, Arye Rattner, and Edward Sagarin. *Convicted but Innocent: Wrongful Conviction and Public Policy*. Thousand Oaks, Calif.: Sage, 1996. Examines the full range of cases in the United States in which innocent people have been falsely accused, convicted, and incarcerated and describes the variety of missteps in the criminal justice system that can lead to unjust imprisonment.

Radelet, Michael L., Hugo Adam Bedau, and Constance E. Putnam. *In Spite of Innocence: Erroneous Convictions in Capital Cases*. Boston: Northeastern University Press, 1992. Useful collection of case studies reveals the factors commonly associated with wrongful conviction. Includes a glossary of legal terms.

Ramsey, Robert J., and James Frank. "Wrongful Conviction: Perceptions of Criminal Justice Professionals Regarding the Frequency of Wrongful Conviction and the Extent of System Errors." *Crime and Delinquency* 53 (July, 2007): 436-470. Presents an analysis of data from a survey of criminal justice professionals—including prosecutors, defense attorneys, and judges—that solicited their perceptions of the causes and extent of wrongful convictions.

Scheck, Barry, Peter Neufeld, and Jim Dwyer. *Actual Innocence: Five Days to Execution, and Other Dispatches from the Wrongly Convicted*. New York: Random House, 2000. Describes some of the most prominent and successful cases taken on by Scheck and Neufeld's Innocence Project. Also offers commentary on the shortcomings of the American system of criminal justice.

Zalman, Marvin. "Cautionary Notes on Commission Recommendations: A Public Policy Approach to Wrongful Convictions." *Criminal Law Bulletin* 41, no. 2 (2005): 169-194. Discusses the need to create state-level blue-ribbon committees to examine wrongful convictions and make recommendations. Also addresses other strategies for understanding and reducing wrongful convictions, such as expansion and strengthening of interest groups and policy networks concerned with wrongful conviction and reforms of appellate procedures.

See also: CODIS; Crime scene investigation; Criminalistics; *Daubert v. Merrell Dow Pharmaceuticals*; DNA analysis; Ethics; Evidence processing; Eyewitness testimony; False memories; *Frye v. United States*; Innocence Project; Postconviction DNA analysis; Questioned document analysis; Trace and transfer evidence.

X

X-ray diffraction

Definition: Technique for studying crystal structure by deflecting X rays off the atomic planes of a substance.

Significance: Because each crystalline substance has a unique X-ray diffraction pattern, this technique allows forensic scientists to analyze the "fingerprints" of evidence found at crime scenes and related locations.

X-ray diffraction (XRD) is a significant tool for the analysis of solid materials encountered in forensic science. Analysis of trace amounts of materials, including fibers, hair, minerals, metals, dust, pollens, blood, drugs, dyes, polymers, explosives, firearms discharge residues, soil, and paint, can help establish links between suspects and victims and between suspects and crime scenes; conversely, such analysis can eliminate some persons from suspicion.

Crystal structures serve as three-dimensional diffraction gratings for X rays. Most X rays impinging on a crystal pass straight through, but some are scattered from the crystalline planes and form an interference pattern on exposed film that is uniquely related to the atomic arrangement and subsequent identity of the substance. In addition to enabling the analysis of large amounts of a material, XRD can be employed to analyze small samples, smears, and minute contact traces of a substance. The way a sample is prepared for XRD analysis and the XRD method employed are determined by the type, amount, and consistency of the trace specimen; the involved surface where the specimen was found; and the forensic questions raised by the criminal offense.

The majority of physical evidence materials recovered at crime scenes and related locations are typically crystalline or semicrystalline in nature; thus forensic scientists can analyze and identify them using XRD methods. Other evidence can be converted to crystalline form. With blood evidence, for example, iodine is used for this purpose; other compounds are used to convert other kinds of specimens to crystalline form. Samples of recovered evidential materials are typically converted to powder form for study using an X-ray powder diffractometer. Nonpowder samples can also be analyzed using XRD.

Forensic scientists use XRD patterns as a screening tool to examine fiber trace evidence and to sort the evidence into groups based on type of fiber. This discriminates the type of fiber and preserves the fabric, which may contain stains of evidential value. The nondestructive nature of XRD analysis is a very important advantage of this technique when the forensic evidence must be preserved.

Among other advantages of XRD methods in forensic science are their ability to identify the unique character of patterns produced by crystalline material, their ability to distinguish between elements and their oxides, and their ability to identify chemical compounds, polymorphic forms, and mixed crystals in a nondestructive manner. In many cases, XRD methods are the only methods that allow detailed differentiation of crime scene materials under laboratory conditions.

With advances in computer automation, the analysis of X-ray diffraction patterns has become increasingly easy and fast. The International Center for Diffraction Data has more than forty thousand digitized diffraction patterns in its database that forensic scientists can use to help identify critical specimens found at crime scenes and related locations.

Alvin K. Benson

Further Reading

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005.

Mozayani, Ashraf, and Carla Noziglia, eds. *The Forensic Laboratory Handbook: Procedures* *and Practice*. Totowa, N.J.: Humana Press, 2006.

Robertson, James, and Michael Grieve, eds. *Forensic Examination of Fibres*. 2d ed. Philadelphia: Taylor & Francis, 1999.

See also: Analytical instrumentation; Art forgery; Blood residue and bloodstains; Fax machine, copier, and printer analysis; Forensic toxicology; Gunshot residue; Nuclear spectroscopy; Spectroscopy.

Y

Y chromosome analysis

Definition: DNA analysis technique that focuses on the Y chromosome, which determines male sex in human beings.

Significance: Analyses of Y chromosome markers and mitochondrial (maternally inherited) DNA are important for forensic, genealogical, archaeological, and anthropological studies because they can be conducted even with very small or degraded samples of genetic material.

The Y and the X chromosomes are sex chromosomes. Within the twenty-three pairs of human chromosomes, one pair in a female human has two X chromosomes and one pair in a male human has an X and a Y chromosome. The Y chromosome is the smallest human chromosome—about fifty million base pairs, or 2 percent of the total DNA (deoxyribonucleic acid) in cells.

Two small regions (called the pseudoautosomal regions) at the tips of the X and Y chromosomes are homologous. The pseudoautosomal regions of the X and Y chromosomes pair during meiosis. The rest of the Y chromosome (95 percent) is present in just one copy (is haploid) and does not have a homologous copy with which to pair, so there is no genetic recombination for the majority of the Y chromosome. Because no genetic recombination occurs, the Y markers can be tracked through generations.

The nonrecombining portion of the Y chromosome has been shown to have different kinds of polymorphisms that mutate at different rates. Short tandem repeats (STRs) on the Y chromosome are such polymorphic markers. These short sequences are three to five nucleotides long and are repeated a variable number of times (five to thirty times) in different individuals. Polymerase chain reaction (PCR), a DNA amplification method, is used to amplify the particular Y-STR through the use of primers specific for that STR. A large number of different STRs are amplified in a single reaction through the use of primers specific to each STR (multiplex PCR). The amplified DNA is sized using gel electrophoresis to enable the identification of which allele (copy of a gene) of the Y-STR an individual has. Single nucleotide polymorphisms (SNPs) are also used. Kits to PCR-amplify Y-STRs are commercially available, and numerous Y sequences have been collected for comparisons in the Y Chromosome Haplotype Reference Database.

Y-STRs are important to extract male-specific information from a sample when sperm are not present. Such a sample from a crime scene may take the form of a mixture of blood from a male perpetrator and a female victim or male saliva on a female victim. Y chromosome markers are also used in paternity testing and in missing persons investigations. Further, the lack of recombination makes Y markers useful in human migration and evolutionary studies comparing male humans over lengthy periods.

Because PCR can amplify a small amount of DNA, small and degraded samples can be analyzed for Y-STRs. One disadvantage of Y chromosome analysis is that loci are not independent of one another, so haplotypes (the alleles at all the tested loci) must be examined. Also, unless a mutation has occurred, paternal lineages have the same Y-STR haplotype, so fathers, sons, brothers, uncles, and paternal cousins cannot be distinguished from each other by Y-STR analysis.

Susan J. Karcher

Further Reading

Gusmão, Leonor, et al. "DNA Commission of the International Society of Forensic Genetics (ISFG): An Update of Recommendations on Use of Y-STRs in Forensic Analysis." *Forensic Science International* 157 (2006): 187-197.

Hanson, Erin K., and Jack Ballantyne. "Comprehensive Annotated STR Physical Map of Human Y Chromosome: Forensic Implications." *Legal Medicine* (Tokyo) 8 (March, 2006): 110-120.

Kobilinsky, Lawrence F., Louis Levine, and Henrietta Margolis-Nunno. *Forensic DNA Analysis*. New York: Chelsea House, 2007.

Willuweit, Sascha, and Lutz Roewer. "Y Chromosome Haplotype Reference Database (YHRD): Update." *Forensic Science International: Genetics* 1, no. 2 (2006): 83-87.

See also: DNA database controversies; DNA extraction from hair, bodily fluids, and tissues; DNA typing; Ethics of DNA analysis; Mitochondrial DNA analysis and typing; Polymerase chain reaction; Short tandem repeat analysis.

Appendixes & Indexes

Guide to Internet Resources

The sites listed below were visited by the editors of Salem Press in April, 2008. Because URLs frequently change and sites move, the accuracy of these addresses cannot be guaranteed; however, long-standing sites—such as those of university departments, national organizations, and government agencies—generally maintain links when sites move or otherwise upgrade their offerings.

General

Crime and Clues
http://www.crimeandclues.com
Crime scene technician Daryl W. Clemens maintains this site, which provides introductory-level material for people interested in forensic science. The site, which is updated frequently, features full-text articles on various forensic science topics written by experts. The topics covered range from general discussions to descriptions of specific techniques and types of evidence.

Forensic-Evidence.com
http://www.forensic-evidence.com
This information center is maintained by Andre A. Moenssens, Douglas Stripp Missouri Professor of Law Emeritus at the University of Missouri, Kansas City, School of Law. The site focuses on the legal and evidentiary aspects of forensic science as applied in courts and educational systems and includes discussion of personal privacy issues. The information provided may be especially useful to lawyers, forensic scientists, and educators.

Kruglick's Forensic Resource and Criminal Law Search Site
http://www.bioforensics.com/kruglaw
Created by Kim Kruglick and sponsored by Forensic Bioinformatics, this site is devoted primarily to the legal aspects of applied forensic science. The site includes the text of court opinions and statutes as well as links to sites that focus on criminal law and the death penalty, links to legal search engines, and information on general research links. The site also offers helpful "primers" to help students and nonscientists understand the technical aspects of forensic science.

National Forensic Science Technology Center
http://www.nfstc.org
This site describes the programs of the National Forensic Science Technology Center, which is an independent, nonprofit corporation established in 1995 by the American Society of Crime Laboratory Directors to provide high-quality systems support, training, and education to American forensic science professionals.

Reddy's Forensic Page
http://www.forensicpage.com
Maintained by Reddy P. Chamakura, a retired forensic scientist who spent thirty-six years with the New York City Police Department Police Laboratory, this site highlights news stories involving forensic science. It also provides an extensive compilation of links to resources including associations, journals, mailing lists, and job opportunities as well as Web sites devoted to subspecialties in forensic medicine, applications, investigative techniques, research programs, and laboratories.

Zeno's Forensic Site
http://forensic.to/forensic.html
This site, maintained by Zeno Geradts, a forensic scientist with the Digital Evidence Section of the Netherlands Forensic Institute, is particularly helpful for locating articles on forensic science topics by professionals in the field. It also includes information on multiple subareas of forensic science, medicine, psychology, and psychiatry, as well as more general information resources.

Forensic Subspecialties

Accredited Psychiatry and Medicine: Medical and Psychiatric Experts
http://www.forensic-psych.com

This site is devoted to discussion of the work of forensic psychiatrists, particularly in their role as expert witnesses in legal matters. Topics addressed include employment litigation, product liability, and professional ethics. The site includes the full text of the American Academy of Psychiatry and the Law's Ethical Guidelines for the Practice of Forensic Psychiatry.

Bloodspatter.com
http://www.bloodspatter.com

This site, maintained by J. Slemko Forensic Consulting, provides information on actual cases involving blood evidence as well as links to sites with related subject matter. The site also features a tutorial on bloodstain pattern analysis.

C.A.S.T. Website: Shoe Print and Tire Track Examination Resources
http://members.aol.com/varfee/mastssite/home.html

Chesapeake Area Shoeprint and Tire Track (C.A.S.T.), a consortium of forensic footwear and tire-track examiners, maintains this site, which is devoted to promoting the analysis of footwear and tire-track evidence at crime scenes. The site provides links to databases and to manufacturers, experts, vendors, trade associations, and professional societies connected to this forensic discipline.

Emily J. Will, Forensic Document Examiner
http://www.qdewill.com

Will, a certified document examiner, includes on her site introductory information about the work of forensic document examiners and handwriting identification experts. Articles on the site discuss the instruments that document examiners use (such as infrared equipment and digital microscopes) as well as the techniques they employ. An article on famous cases involving document analysis is included, as are links to sites with related material.

Ethics in Science
http://www.chem.vt.edu/chem-ed/ethics

This site lists links to articles describing selected cases of misconduct by scientists as well as links to science ethics resources and essays on ethics in science. A section of the site is devoted to ethics-related articles in forensics written by D. H. Garrison, Jr., who works in the Forensic Services Unit of the Grand Rapids, Michigan, Police Department.

FirearmsID.com
http://firearmsid.com

Maintained by Scott Doyle, who works for the Kentucky State Police as a firearms and toolmark examiner, this site presents informative articles about specific firearms and their uses, firearms safety procedures, and other topics related to firearms. It also features discussion forums and information about careers in forensic science.

Forensic Art
http://www.forensicartist.com

This site provides information on and case examples of many aspects of forensic art, including two- and three-dimensional facial reconstruction, computer-enhanced reconstruction, and composite drawing. It also features links to many sites with related content as well as a link to the Doe Network, a volunteer organization dedicated to the identification of missing persons and cold-case crime victims in North America, Australia, and Europe.

Forensic Botany
http://myweb.dal.ca/jvandomm/forensicbotany

Created in 2002 by Jennifer Van Dommelen for a class at Dalhousie University in Halifax, Nova Scotia, this site provides wide-ranging information on the field of forensic botany, which entails the application of the science of botany to the resolution of legal questions. The site reviews the techniques used by scientists in the subdisciplines of palynology, anatomy and dendrochronology, limnology, systematics, ecology, and molecular biology. It also provides links to sites featuring related material.

Forensic Dentistry Online
http://www.forensicdentistryonline.org

This site serves as a comprehensive information center for professionals in forensic odontology. It features numerous articles on the various applications of forensic dentistry as well as links to professional organizations and journals.

Forensic DNA Glossary
http://www.forensicdna.com/emailforms/DNAGlossary.html

The work of Norah Rudin and Keith Inman, two widely respected experts in the field, this glossary provides helpful basic information about the uses and applications of DNA analysis in forensic science.

Forensic Entomology: Insects in Legal Investigations
http://www.forensicentomology.com

Dr. J. H. Byrd created this site to "assist in the education of crime scene technicians, homicide investigators, coroners, medical examiners, and others involved in the death investigation process." The site features articles that describe the use of entomology as a tool of forensic science, detailing the activities of forensic entomologists. It also provides a list of relevant literature, a list of board certified forensic entomologists, and links to sites containing related material.

Forensic Mathematics
http://dna-view.com

This site, maintained by Charles H. Brenner, a consultant in forensic mathematics, provides extensive technical information concerning the mathematics involved in the interpretation of DNA analysis results.

How Do Bullets Fly?
http://www.nennstiel-ruprecht.de/bullfly

This well-illustrated article by Ruprecht Nennstiel details the basics of bullet motion and explains bullet trajectories and impacts. It also includes discussion of experimental techniques for the observation of small arms fire.

Latent Print Examination: Fingerprints, Palmprints, and Footprints
http://onin.com/fp

Maintained by Ed German, a forensic scientist with more than thirty years of experience working in government crime laboratories, this site offers an abundance of information on latent print analysis as well as helpful links to sites covering related material.

Molecular Expressions
http://micro.magnet.fsu.edu

This site is maintained by the Optical Microscopy Division of the National High Magnetic Field Laboratory, a joint venture of the Florida State University, the University of Florida, and the Los Alamos National Laboratory. It provides in-depth information on optical microscopy and includes collections of color photographs taken through optical microscopes.

Ridges and Furrows
http://ridgesandfurrows.homestead.com

This site contains excellent introductory material about fingerprint analysis as well as more technically oriented material on topics such as skin anatomy and the histology of thick skin, enhancement of latent prints using digital technology, and latent print identification. Numerous links to sites with related material are also provided.

Scientific Working Group on Friction Ridge Analysis, Study and Technology
http://www.swgfast.org

The Scientific Working Group on Friction Ridge Analysis, Study and Technology (SWGFAST) is one of several scientific working groups sponsored by the Federal Bureau of Investigation Laboratory Division that are devoted to improving forensic science practices and building consensus among federal, state, and local forensic laboratories and practitioners. This site provides numerous documents produced by SWGFAST concerning guidelines and standards for friction ridge examination, also known as latent print examination.

Short Tandem Repeat DNA Internet Data Base (STRBase)
http://www.cstl.nist.gov/biotech/strbase

This site, created by John M. Butler and Dennis J. Reeder of the Biochemical Science Division of the National Institute of Standards and Technology, features highly technical information on topics related to the use of short tandem repeat (STR) analysis for genetic mapping for identity testing, including sequence information on each STR system, population data, and commonly used multiplex STR systems. The site provides a comprehensive listing of addresses of scientists and organizations as well as materials and techniques used.

World Wide Web Virtual Library: Forensic Toxicology
http://home.lightspeed.net/~abarbour/vlibft.html

This segment of the World Wide Web Virtual Library is maintained as a public service by Alan D. Barbour, a Fellow of the American College of Forensic Examiners and a consulting forensic toxicologist. The site is primarily a list of links to numerous sites devoted to forensic science, including forensic toxicology sites, general forensic science sites, and sites providing education and career guidance in forensic science fields.

Indexes to Periodical Publications

AFTE Journal Keyword Index
http://www.afte.org/ExamResources/journalindex.htm

Rocky Stone of the Albuquerque, New Mexico, Police Department compiled this keyword index of articles that have been published in the journals of the Association of Firearm and Tool Mark Examiners (AFTE). The site makes the index available for download in two formats.

American Journal of Forensic Medicine and Pathology
http://www.amjforensicmedicine.com

The "Archive" section of this site provides listings of the articles published in the *American Journal of Forensic Medicine and Pathology* since 1996. Abstracts of the articles may be viewed for free; fees are charged for access to the articles themselves. This journal features original articles on new examination and documentation procedures, focusing on forensic scientists' expanding role in medicolegal practices.

Canadian Society of Forensic Science Journal
http://ww2.csfs.ca/csfs_journal.aspx

This site provides an index to original papers, commentary, and reviews in the various branches of forensic science published by the *Canadian Society of Forensic Science Journal* since 1995. Abstracts of the articles may be viewed for free; fees are charged for access to the articles themselves.

FBI Law Enforcement Bulletin
http://www.fbi.gov/publications/leb/leb.htm

This site makes available past issues of the Federal Bureau of Investigation's monthly publication dating from 1996. Full issues are available for either HTML or PDF download.

Forensic Science Communications
http://www.fbi.gov/hq/lab/fsc/current/index.htm

The "Back Issues" section of this site provides access to all articles that have appeared in *Forensic Science Communications* since the journal began publishing in 1999. This peer-reviewed journal is published quarterly by the Federal Bureau of Investigation Laboratory Division.

Information Bulletin for Shoeprint/Toolmark Examiners
http://www.intermin.fi/intermin/hankkeet/wgm/home.nsf

An index to past issues of the *Information Bulletin for Shoeprint/Toolmark Examiners* is available in the "IBSTE" section of this site, which is maintained by the bulletin's publisher, the Expert Working Group Marks (EWGM), one of the forensic science working groups of the European Network of Forensic Science Institutes. The EWGM focuses on such impression evidence as tool marks, shoe prints, tire marks, marks made by bare feet, and manufacturing marks. Full issues of the bulletin are available for PDF download on the site.

Journal of Forensic Sciences
http://www.aafs.org

The "Journal of FS" section of this official site of the American Academy of Forensic Sciences (AAFS) provides access to a searchable index of issues of the *Journal of Forensic Sciences* from 1972 through 2005 (information on more recent issues is available online only to AAFS fellows, members, and affiliates). Abstracts of the articles may be viewed for free; fees are charged for access to the articles themselves.

National Criminal Justice Reference Service Abstracts Database
http://www.ncjrs.gov/abstractdb/search.asp

This site provides access to summaries of many thousands of resources housed in the National Criminal Justice Reference Service (NCJRS) Library, including reports from all levels of government, research reports, books, and journal articles. It is also the only comprehensive collection that includes the *Journal of Forensic Identification* in its index. This database has direct access only to abstracts, but when full texts of items are available online, links are provided.

Professional Organizations and Government Agencies

American Academy of Forensic Sciences
http://www.aafs.org

American Board of Forensic Document Examiners
http://www.abfde.org

American Board of Forensic Odontology
http://www.abfo.org

American Board of Forensic Toxicology
http://www.abft.org

American Society of Crime Laboratory Directors
http://www.ascld.org

American Society of Questioned Document Examiners
http://www.asqde.org

Armed Forces Institute of Pathology
http://www.afip.org

Association of Firearm and Tool Mark Examiners
http://www.afte.org

Bureau of Alcohol, Tobacco, Firearms and Explosives, U.S.
http://www.treas.gov

Bureau of Legal Dentistry
http://www.boldlab.org

Canadian Society of Forensic Science
http://ww2.csfs.ca

Centers for Disease Control and Prevention
http://www.cdc.gov

Drug Enforcement Administration, U.S.
http://www.usdoj.gov/dea/index.htm

Environmental Measurements Laboratory
http://www.eml.st.dhs.gov

European Network of Forensic Science Institutes
http://www.enfsi.eu

Federal Bureau of Investigation
http://www.fbi.gov

Federal Law Enforcement Training Center
http://www.fletc.gov

Food and Drug Administration, U.S.
http://www.fda.gov

Forensic Science Service
http://www.forensic.gov.uk

Forensic Science Society
http://www.forensic-science-society.org.uk

International Association for Craniofacial Identification
http://www.forensicartist.com/IACI

International Association for Identification
http://www.theiai.org

International Association of Bomb Technicians and Investigators
http://www.iabti.org

International Association of Forensic Nurses
http://www.iafn.org

International Association of Forensic Sciences
http://www.iafs2005.com

International Association of Forensic Toxicologists
http://www.tiaft.org

Interpol
http://www.interpol.int

National Institute of Justice
http://www.ojp.usdoj.gov/nij

National Transportation Safety Board
http://www.ntsb.gov

Secret Service, U.S.
http://www.secretservice.gov

Society of Forensic Toxicologists
http://www.soft-tox.org

Dwight G. Smith

Television Programs

American Justice (Documentary, A&E, 1997-). This long-running nonfiction crime series, hosted by journalist Bill Kurtis, presents evidence from various criminal cases and challenges the viewer to think critically about law-enforcement investigative techniques, the facts of each case, and the constitutional rights of the accused. The cases featured are often controversial, and the program aims to stimulate critical analysis of the evidence and the judicial process, calling into question the snap judgments that casual observers often make about the innocence or guilt of suspects.

Anatomy of a Crime (Documentary, Court TV, 2000-2002). This show went behind the scenes to look at the fast-paced lives of criminal investigators, often featuring dramatic footage such as the point of view from a police car during a high-speed chase. The program depicted the procedures carried out by police in the course of investigating various kinds of crimes, including human trafficking and drug smuggling. It also raised issues regarding the news and entertainment media's coverage of crime and related events.

Arrest & Trial (Documentary, USA, 2000-2001). Each episode of this series used both reenactments and actual footage to follow the stories of real-life crimes from their commission through their investigation and prosecution. The investigative portion of each episode described the uses of forensic science in the case. This program was created by Dick Wolf, who also created the *Law & Order* dramatic crime series.

Autopsy (Documentary, HBO, 1994-). This program features Dr. Michael Baden, former chief medical examiner of New York City, who has been involved as an expert witness in a number of famous criminal cases, including the O. J. Simpson murder trial. In each episode, Baden explains the autopsy results and other forensic evidence related to a particular death.

Bones (Drama, Fox, 2005-). This series features the criminal cases that come before Dr. Temperance Brennan, a forensic anthropologist, and her team of forensic experts—each a specialist in a particular area—at the fictional Jeffersonian Institute in Washington, D.C. In solving crimes, the team works with Special Agent Seeley Booth of the Federal Bureau of Investigation. The crimes that Dr. Brennan and her team investigate are often unusual, and the technologies they use to examine the evidence are highly sophisticated.

Cold Case (Drama, CBS, 2003-). This program focuses on the work of a special team within the Philadelphia Police Department that investigates cold cases—that is, cases in which the leads or evidence trails have gone cold. Many of the crimes investigated in the show are years or even decades old. In each episode, an unsolved crime is somehow brought to the team's attention, and the investigators take a new look at the old evidence, which can sometimes be reexamined with forensic techniques that have been developed since the crime was committed. The types of forensic evidence that have figured into the program's plots have included fingerprint analysis, DNA analysis, ballistics, and blood evidence.

Cold Case Files (Documentary, A&E, 1999-). This program, hosted by journalist Bill Kurtis, shows the hard work that police investigators put into solving real-life cases that have eluded solution for years, sometimes for decades. Many of the cases featured, which are described through interviews with participants, have been solved through the application of forensic techniques that were not available to investigators at the times the crimes were committed, particularly DNA analysis.

Crime and Punishment (Documentary, NBC, 2002-2004). This program, created by Dick Wolf, who also created the dramatic crime series *Law & Order* and its spin-offs, followed the work of district attorneys in San Diego, California, as they prepared and prosecuted actual criminal cases. Unlike many true-crime programs, it used no narration, interviews, or reenactments. Instead, the attorneys were seen carrying out their actual work of interviewing witnesses, gathering evidence, and presenting their cases in court.

Crime 360 (Documentary, A&E, 2008-). This program features the re-creation of crime scenes and the depiction of the likely sequences of events that took place at the scenes through computer-generated imagery (CGI). The details portrayed in the CGI animated segments are based on the information gathered from scientific examination of the evidence in each case.

Criminal Minds (Drama, CBS, 2005-). In this program, a team of specialists within the Federal Bureau of Investigation's Behavioral Analysis Unit employs criminal personality profiling to aid local police departments in apprehending serial rapists and murderers. The team members examine crime scenes, analyze victimology, and interview witnesses to understand the motivations and emotional triggers of the criminal perpetrators.

Crossing Jordan (Drama, NBC, 2001-2007). This series focused on the crime-solving efforts of medical examiners and other specialists working at the Boston medical examiner's office. In addition to analyzing evidence from autopsies as well as materials found on the bodies that entered their morgue, the characters often visited crime scenes and interviewed witnesses to further their investigations. Many different forensic science techniques and technologies were featured in the program.

CSI: Crime Scene Investigation (Drama, CBS, 2000-). This is the program credited with bringing cutting-edge forensic science into American homes while at the same time glamorizing and distorting the work of forensic scientists in the minds of the public. Each episode follows forensic scientists of the Las Vegas Crime Lab as they collect and examine the evidence from one or more crimes and then interpret the evidence to aid the police investigations. The focus is on the use of forensic techniques to determine how the crimes were committed, in contrast to many crime dramas' emphasis on other investigative techniques. The success of *CSI* led to two spin-off series: *CSI: Miami* (2002-) and *CSI: NY* (2004-).

Dr. G: Medical Examiner (Documentary, Discovery Health Channel, 2004-). Featuring Dr. Jan Garavaglia, a forensic pathologist who works out of a county medical examiner's office in Orlando, Florida, this show demonstrates the various forensic procedures used to investigate mysterious or suspicious deaths, including toxicology screening and autopsy. Most of the cases described relate to criminal events.

The First 48 (Documentary, A&E, 2004-). The title of this program refers to the importance of speed in police efforts to solve crimes or find missing persons. Each episode offers unprecedented access to homicide detectives during the first forty-eight hours after a murder is committed, following the investigators and observing their evidence-gathering techniques during this crucial period.

Forensic Files (Documentary, Court TV, 2000-). Each episode of this program discusses the forensic techniques used in the analysis of evidence from a given crime or mysterious death. Using dramatic reenactments and interviews, the program shows how forensic science provides investigators with the information they need to solve cases.

In Justice (Drama, ABC, 2006). Inspired by the work of the Innocence Project, this short-lived series was a departure from other crime-based dramas in that it focused on the cases of persons convicted of crimes they did not commit. The investigators and attorneys of the fictional National Justice Project attempted in each episode to overturn the conviction of a wrongfully incarcerated person. Team members reinvestigated the crime, sometimes finding new evidence. They also reexamined old evidence, in some cases applying forensic techniques that had been unavailable at the time of the person's original trial, particularly DNA analysis.

Law & Order (Drama, NBC, 1990-). This program, the longest-running crime show in television history, explores the two major sides of the American criminal justice system's response to crime: The first half of each episode is devoted to the police investigation of a crime, usually a homicide, and the second half focuses on the legal issues involved in the prosecution of the suspect arrested by the police. In the first half, the New York City police detectives are usually guided in their investigation, at least in part, by an autopsy report on the victim from a forensic pathologist as well as reports from various crime lab technicians regarding their analyses of the evidence gathered from the crime scene (such as ballistic evidence and fingerprints). The courtroom scenes in the second half of the show often touch on issues of evidence admissibility and the presentation of forensic evidence by expert witnesses.

Law & Order: Criminal Intent (Drama, NBC, 2001-). This spin-off series focuses on psychological techniques of criminal investigation, which include behavioral profiling and forensic psychology. Although the detectives of the New York City Police Department's Major Case Squad also rely on autopsy reports and other information provided by forensic specialists who examine physical evidence in their cases, this program is concerned primarily with the motivations of persons who commit crimes and the need for investigators to understand those motivations.

Law & Order: Special Victims Unit (Drama, NBC, 1999-). This spin-off series depicts the work of a special New York Police Department unit that is devoted to the investigation of sexually based crimes, such as rape, incest, and child pornography. The program highlights how medical personnel use rape kits to gather evidence from victims following sexual assault and how DNA analysis and other forensic techniques can be applied to the conviction of sexual offenders.

Medical Detectives (Documentary, TLC, 1995-1999). This program featured real cases in which medical investigators attempted to solve criminal cases with very little information to go on. In 2000, Court TV (now truTV) picked up this series and widened its scope to create *Forensic Files*.

NCIS (Drama, CBS, 2003-). This program features the work of a team from the Naval Criminal Investigative Service, which investigates crimes involving members of the U.S. Navy or Marines. The team includes a forensic specialist, a computer scientist, and a medical examiner, and their analyses of the evidence play a large role in guiding each investigation.

The New Detectives (Documentary, Discovery Channel, 1996-1999). This program featured the work of world-renowned forensic scientists and depicted how they used everything from anthropological data to high-tech forensic screening devises to solve crimes around the United States.

Quincy, M.E. (Drama, NBC, 1976-1983). One of the first programs to deal with forensic science, this show focused on the crime-solving activities of a medical examiner who worked to collect evidence on suspicious deaths that occurred in the Los Angeles area. The lead character's skills enabled him to uncover clues from the smallest pieces of evidence. Although it originally presented stories involving typical criminal events, many later episodes emphasized political and social injustices in the American criminal justice system.

Snapped (Documentary, Oxygen, 2004-). This series focuses on the cases of real-life women who committed horrendous crimes, including the murders of their husbands, their husbands' mistresses, and their children. Although much of each episode is devoted to discussion of the drama surrounding the lives of the women who committed these crimes, some attention is given to the investigative techniques used by law-enforcement agencies to solve the crimes.

Unsolved Mysteries (Documentary, NBC, 1987-2002). This program, hosted by actor Robert Stack, presented the known facts related to a variety of unsolved criminal cases as well as cases of missing persons and paranormal phenomena. It featured interviews with persons involved in the cases as well as dramatic reenactments. Viewers were encouraged to contribute any information that could help solve the cases presented, and many did. It has been estimated that nearly 40 percent of the cases featured on the program were solved through help from viewers.

Women's Murder Club (Drama, ABC, 2007-2008). This program, set in San Francisco, featured a group of four women—a police inspector, an assistant district attorney, a reporter, and a medical examiner—who worked together to solve cases of homicide. The information provided by the medical examiner often played an important role in guiding the investigations.

Jennifer L. Christian

Key Figures in Forensic Science

Victor Balthazard (1872-1950). A Paris, France, native whose innovative work with ballistics and hair follicles aided forensic investigations, Balthazard studied at the École Polytechnique prior to becoming an artillery officer in 1893. Interested in medical research, by 1904 he quit his military career to focus on forensic medicine endeavors, and he subsequently was named Paris's chief medical examiner. A 1909 murder initiated Balthazard's scientific study of hair when he found hair evidence on the victim. Using a microscope, Balthazard compared that evidence with hair collected from a suspect; the comparison resulted in the first forensic use of human hair evidence offered as proof of a suspect's guilt. Balthazard contributed to the knowledge of ballistics in forensic science: He asserted that not only bullets but also casings and cartridges are marked by the guns that fire them, and he proved his hypothesis by making microscopic comparisons of those objects. Forensic investigators accepted Balthazard's ideas, which offered them options to study the variety of ballistics evidence found at crime scenes. Balthazard also examined blood spatter patterns to investigate crimes.

William M. Bass (1928-). Creator of the University of Tennessee's Anthropological Research Facility, informally called the Body Farm, Bass was born in Staunton, Virginia. He studied psychology at the University of Virginia, where he also enrolled in anthropology classes. After completing a bachelor of arts degree in 1951, Bass served in the U.S. Army until 1953, then began graduate work at the University of Kentucky, where he earned a master of science degree in anthropology by 1956. Continuing his academic training at the University of Pennsylvania, Bass received his doctoral degree in 1961 and began teaching as an anthropology professor at the University of Kansas. In 1971 he became the head of the Anthropology Department at the University of Tennessee in Knoxville, and in 1972 he established the Body Farm. The facility, located near the university's hospital, offers forensic scientists and students in forensic anthropology the opportunity to study in depth the process of the decomposition of the human body.

Alphonse Bertillon (1853-1914). Best known for his pioneering work applying science to criminal identification, Bertillon was born in Paris, France, where his father, Louis Adolphe Bertillon, was a prominent physician and anthropologist. Bertillon began working for the Parisian police department in 1878. Assigned tasks related to arrest records describing criminals, Bertillon dismissed written and photographic techniques as ineffective. He devised a system of anthropometry—that is, measurement of skulls, arms, feet, fingers, and other body parts—to supplement photography of criminals' faces. Despite initial rejection of his idea, Bertillon convinced the police to try his method, and in 1883 it helped to establish a standardized identification for a man who had used various aliases when previously arrested. In 1892, Bertillon gained international recognition when his measurement method identified a wanted fugitive suspected of bombing a judge's home. The Bertillon system, also known as *bertillonage*, later lost favor for identification because it was often impractical for use in identifying suspects at crime scenes, measurements were inconsistently recorded, and it was useless to describe the measurements of twins and other skeletally similar criminals—such persons could be distinguished from one another only through fingerprinting.

Edgard O. Espinoza (1953-). An innovator in wildlife forensic science, Espinoza was born in Concepción, Chile. In 1975, he emigrated to California, where he studied medical technology at Loma Linda University, earning a bachelor of science degree in 1978. Enrolling in graduate school at the University of California, Berkeley, Espinoza focused on forensic science studies, completing master's and doctoral degrees in 1984 and 1988, respectively. He taught forensic sciences at

Sacramento State University and provided forensic expertise to aid law-enforcement investigations. Employed at the National Fish and Wildlife Forensics Laboratory since 1989, he held various positions, including chief of the Criminalistics Section. With colleague Mary-Jacque Mann, Espinoza determined how to evaluate Schreger lines in ivory to aid customs agents in distinguishing banned elephant ivory imports from legal ivory sources, and Espinoza and Mann published *Identification Guide for Ivory and Ivory Substitutes* in 1991. Espinoza also developed a technique using mass spectrometry to analyze minute amounts of blood evidence to identify the animal species from which the blood came according to the hemoglobin proteins present.

Henry Faulds (1843-1930). A pioneer in fingerprint analysis, Faulds was born at Beith in Ayrshire, Scotland. He studied at the University of Glasgow and Anderson's College, aspiring to become a physician and a medical missionary. Faulds pursued missions in India and then in Japan, starting a mission hospital in the Tsukiji district of Tokyo. He became intrigued by fingerprints pressed into pottery and began collecting fingerprints; subsequently, his examination of fingerprints led to solutions in two criminal cases. After a theft near his home, Faulds identified a servant as the culprit by comparing fingerprint evidence on a cup with prints in his collection. In another case, Faulds compared the fingerprints of an arrested suspect with fingerprints from the crime scene and found they did not match; another person was identified whose fingerprints were those at the crime scene. In an article published in the October, 1880, issue of the journal *Nature*, Faulds stressed the value of fingerprint analysis for apprehending criminals. Experimenting with removing fingerprints, he noted that the ridges on fingers are resilient and do not change despite trauma. In 1905, Faulds published *Guide to Finger-Print Identification*. His efforts to convince European police to adopt fingerprinting as a method of identification were largely unsuccessful, however.

Francis Galton (1822-1911). An English scientist who contributed basic fingerprint information to forensic science, Galton was born in Birmingham, England. After reading the commentary on fingerprint identification published in the scientific journal *Nature* by Henry Faulds and William James Herschel, Galton wanted to create a classification method for fingerprints. He wrote to Herschel, who gave Galton his collection of fingerprints. Galton also collected fingerprints from people in London. Examining those samples, he realized that all ten fingerprints on a person vary, that aging does not affect fingerprints' patterns, and that every fingerprint is distinctive, with duplication impossible even in twins. Galton suggested classifying fingerprints simply according to their loops, arches, and whorls. In 1892, he published a book on the topic titled *Finger Prints*. As a result of Galton's work, British law-enforcement authorities began considering securing suspects' fingerprints in addition to using anthropometry, the measurement method of identification created by Alphonse Bertillon. Realizing that his fingerprint classification was not fully functional for effective forensic use, Galton stopped his work in this area, and most law-enforcement personnel continued to use anthropometry.

Alexander O. Gettler (1883-1968). Known for establishing innovative forensic toxicology methods, Gettler was born in Austria and emigrated to the United States when he was a child. He earned a diploma from City College of New York in 1904 and then attended Columbia University, completing a master's degree in chemistry in 1910 and a doctorate in chemistry in 1912. He became chief chemist at Bellevue Hospital in 1915, and in 1918, medical examiner Charles Norris named Gettler chief toxicologist at the New York City Medical Examiner's Office. Analyzing evidence chemically, Gettler conducted research assessing levels of alcohol in blood and how alcohol consumption influences driving ability. He also developed a method for measuring chloride in blood to determine whether drowning was the cause of death when bodies were found in water. Forensic investigators worldwide adopted that technique. Gettler created the first graduate forensic toxicology program in the United States at New York University, where he taught chemistry until 1950, when he became professor emeritus. Gettler retired as chief toxicologist in April, 1959. During his career, he wrote numerous scholarly articles on toxicology and testified in court many times regarding his analyses of forensic evidence. The American Academy of Forensic Sciences named an award in Gettler's honor.

Calvin Goddard (1891-1955). An innovator in the forensic examination of ballistics evidence, Goddard was born in Baltimore, Maryland. After earning a bachelor's degree at The Johns Hopkins University in 1911, Goddard completed his medical degree there in 1915 and then joined the U.S. Army Medical Corps. Five years later, he was honorably discharged and took the position of assistant director of The Johns Hopkins Hospital. In 1924, Goddard left Maryland for a Cornell Medical School professorship. A year later, Goddard, a gun enthusiast, moved to New York City to work at the Bureau of Forensic Ballistics, where he initiated methods to connect guns with fired bullets by comparing the unique marks etched on bullets as they are discharged from firearms. Goddard next directed Northwestern University's Scientific Crime Detection Laboratory, aspiring to provide educational and laboratory resources for law-enforcement personnel nationwide. At Northwestern's law school, Goddard taught courses featuring police science, an emerging academic subject. He established the innovative *American Journal of Police Science* in 1930. His later career involved military laboratory work in the United States and Asia, extending his influence on forensic ballistics.

Ken Goddard (1946-). A wildlife forensics pioneer, Goddard was born in San Diego, California. He enrolled at the University of California, San Diego, in 1964, and later transferred to the University of California, Riverside, where he completed a bachelor of science degree in 1968. While he studied biochemistry in graduate school at California State University, Los Angeles, where he earned a master's degree in 1971, Goddard realized that research did not appeal to him. He decided to pursue forensic work, so that his scientific knowledge would aid law enforcement. He worked as a crime laboratory forensic scientist for several California sheriff's and police departments until 1978, when he applied for a position to oversee a national forensics program for the U.S. Fish and Wildlife Service. Goddard became director of the National Fish and Wildlife Forensics Laboratory in 1989. In addition to his work in wildlife forensics, he has written crime novels that incorporate elements of forensic science.

Bernard Greenberg (1922-). Considered a founder of forensic entomology, Greenberg was born in New York City. He earned a bachelor of arts degree from Brooklyn College in 1944 and then served in the U.S. Air Force until 1946. He then undertook graduate studies at the University of Kansas, where he completed a master of arts degree in 1951 and his doctorate three years later. He accepted a position teaching biology as an assistant professor at the University of Illinois Medical Center in Chicago. Eventually, Greenberg's research concerning flies resulted in law-enforcement personnel seeking his expertise, starting with a 1976 murder case. Greenberg consulted and testified regarding forensic evidence involving insects and cadavers, particularly the use of insect evidence to determine time since death, establishing the scientific basis for forensic entomology. Greenberg published the two-volume work *Flies and Disease* (1971-1973) and cowrote, with John Charles Kunich, *Entomology and the Law: Flies as Forensic Indicators* (2002). In 1981, Greenberg served as scientific governor of the Chicago Academy of Sciences. He retired as professor emeritus in 1990.

Hans Gross (1847-1915). An innovative jurist who recognized the value of the scientific examination of evidence to the legal process, Gross, born in Graz, Austria, pursued education that qualified him to accept a position as an examining judge. Realizing that law-enforcement officers of his time, the mid-nineteenth century, focused on policing civil unrest more than they did on investigating crimes, Gross took it upon himself to secure and examine the evidence in the cases before him so he could deliver effective legal judgments. He relied on scientific approaches to evaluate suspects and the evidence associated with their alleged crimes. Gross also applied science when considering legal proceedings for civil issues. In 1893, Gross published *System der Kriminalistik* (*Criminal Investigation*, 1906), which was based on his forensic insights and work. The book gained him global recognition for his views regarding science as an effective investigation technique. Gross, who lectured at the University of Graz and the University of Prague, urged scientists and law-enforcement personnel to seek improved forensic methods using proven technology and scientific developments instead of relying on obsolete techniques and tools. Sir Arthur Conan Doyle studied Gross's ideas for details he elaborated in his Sherlock Holmes stories.

Edward R. Henry (1850-1931). A forensic fingerprint pioneer, Henry, born in London, worked for the Indian Civil Service in Calcutta as police inspector. Frustrated by the limitations of the measurement system of identification created by Alphonse Bertillon (anthropometry, also known as *bertillonage*), Henry knew that palm prints and fingerprints were used in India to notarize legal documents. He had read about the ideas of Henry Faulds and Francis Galton concerning fingerprints, and he had met Galton in England. Henry gathered fingerprint data and contemplated how best to organize them. He had an epiphany in December, 1896, and created a classification system that differentiated fingerprints by whorls, radial and ulnar loops, and plain and tented arches, recognizing their variations, as well as by the numbers of ridges composing those shapes. Henry compared fingerprinting with *bertillonage* measurements and proved that fingerprinting, with his classification method, identified criminals more accurately. In 1897, Henry's fingerprint technique became the standard identification process used in India, and the Indian government published his work *Classification and Uses of Fingerprints*. Henry subsequently took the position of police commissioner in London. Police in the United States and Europe soon appropriated and improved on aspects of Henry's classification techniques.

Alec Jeffreys (1950-). The originator of DNA (deoxyribonucleic acid) fingerprinting, Jeffreys was born in Oxford, England. Jeffreys's father, an inventor, encouraged Jeffreys's scientific interests by buying him a chemistry set and microscope. Jeffreys enrolled in Oxford's Merton College, completing his biochemistry degree in 1972. He pursued graduate work in genetics and earned his doctoral degree in 1975. Jeffreys conducted postdoctoral genetic research at the University of Amsterdam until 1977, when he returned to England to conduct research on DNA in the University of Leicester's genetics department. While experimenting with DNA components in September, 1984, Jeffreys realized that DNA bands differ significantly and could be useful for purposes of identification, much like fingerprints. His work in genetic fingerprinting led to significant changes in the field of forensic science. DNA comparisons were first used publicly to resolve issues of identification in immigration and paternity cases. Law-enforcement authorities then requested that Jeffreys use so-called DNA fingerprinting in two unsolved 1980's murders; the resulting analysis identified the killer and exonerated another suspect. Jeffreys and other scientists subsequently improved on Jeffreys's original methods with techniques such as polymerase chain reaction (PCR).

Paul L. Kirk (1902-1970). A pioneer in criminalistics in the United States, Kirk was born in Colorado Springs, Colorado. He graduated from Ohio State University with a bachelor's degree in 1924 and then earned a master's degree at the University of Pittsburgh the following year. In 1927, he completed a doctorate in biochemistry at the University of California, Berkeley. Kirk stayed at Berkeley to teach and conduct research in criminalistics, and he also agreed to serve as an adviser to California's state crime laboratory, the first such lab established by a state government in the United States. Kirk helped the university to develop a criminology program that came to be influential in forensic practices. He urged law-enforcement investigators to acquire scientific knowledge and to learn about the varied kinds of forensic evidence they might encounter and consider how such evidence might be connected to crime victims. Kirk wrote several books, including *Crime Investigation: Physical Evidence and the Police Laboratory Interscience* (1953). He also developed a transportable forensic laboratory that inspired the creation of similar kinds of equipment for use by law-enforcement personnel.

Alexandre Lacassagne (1843-1924). Sometimes referred to as the father of forensic science, Lacassagne was born in Cahors, France. Trained as a physician, he traveled to North Africa to treat military troops; during his time there, he examined soldiers' injuries caused by bullets and realized that tattoos could be used to identify soldiers who had been killed. When he returned to France, Lacassagne taught forensic medicine as a pathology professor at the University of Lyon. As a result of his research and experiences, Lacassagne devised useful methods of identifying unidentified bodies by examining their skeletal and dental conditions. By 1889, Lacassagne concluded that bullets could be connected to the firearms that discharged them based on the grooves etched into bullets by the weapons' barrels, providing the theoretical basis for the science of ballistics. Lacassagne also investigated the physical evidence used to prove that people were dead, noting that the skin appears purple when blood stops circulating. His investigations of rigor mortis and body temperature contributed to the forensic techniques used to calculate time since death when bodies are discovered.

Karl Landsteiner (1868-1943). A scientist who recognized the forensic value of basic blood characteristics, Landsteiner was born in Vienna, Austria. He began his unexpected forensic medical achievements when he enrolled at the University of Vienna, aspiring to become a physician. Completing a degree in 1891, he focused his research on serology. His aim was to improve the techniques of blood transfusion, which was a very risky practice for patients receiving blood. Landsteiner discovered the existence of four human blood groups—a discovery with practical applications, as patients requiring transfusions could receive blood that matched their types and would not cause dangerous reactions. Forensic investigators recognized the value of Landsteiner's discovery for the identification of crime victims and suspects through the testing of blood evidence for type. After completing his blood type research, Landsteiner studied viruses and poliomyelitis. When World War I ended, he moved to the Netherlands and then to New York City, where he conducted research with Alexander S. Wiener to detect blood's rhesus (Rh) factor; this work also enhanced forensic identification methods. Landsteiner won the 1930 Nobel Prize in Physiology or Medicine for his research concerning blood types.

John A. Larson (1892-1965). Known for innovating the basic elements of a forensic polygraph tool, Larson was born in Shelbourne, Nova Scotia. He acquired his education in the United States, studying at Boston University, where he completed a bachelor's degree by 1914 and a master's degree the next year. Moving to California, Larson enrolled in graduate school at the University of California, Berkeley, to pursue doctoral work to become a criminologist. He earned a doctoral degree in 1920, followed by a medical degree in 1928 from Rush Medical College. In addition to pursuing his education, Larson secured employment with the police department in Berkeley, qualifying for the rank of sergeant. Berkeley police chief August Vollmer assigned Larson the task of creating a machine that could evaluate the truthfulness ofa person being interviewed. Larson created a prototype polygraph that included a band that wrapped around the interviewee's arm to note fluctuating blood pressure. Vollmer served as Larson's first subject, showing how his lies affected the polygraph. Inspired by Larson's device, a number of inventors subsequently designed more complex polygraphs.

Leone Lattes (1887-1954). A contributor to the science of the forensic analysis of blood evidence, Lattes was born in Turin, Italy. He advanced his medical studies by visiting European universities, particularly in Germany, where he became intrigued with investigating blood after he met with serological researcher Max Richter. Returning to Turin, where he conducted research at the Institute of Forensic Medicine, Lattes focused on learning about blood types. In 1915, a man whose wife thought his bloody shirt proved he had been unfaithful asked Lattes to determine the source of the blood on the shirt. Lattes acquired the shirt three months after it had been stained. Because no technique for analyzing bloodstains yet existed, Lattes assessed the stain by wetting it to identify the blood type. The type matched that of the man, and Lattes concluded that the man had bled on his shirt. Later, while experimenting with blood flakes mixed with fresh blood, Lattes noted that the blood became lumpy if the samples were not of the same blood type. Forensic scientists recognized the value of Lattes's method for quick assessment of bloodstains, and that technique has retained its investigative value.

Edmond Locard (1877-1966). Originator of the principle of forensic science that holds that "every contact leaves a trace," Locard was born in France. As a young adult, intrigued by the incorporation of science into Sir Arthur Conan Doyle's Sherlock Holmes stories, Locard decided to pursue criminology professionally. He enrolled in the University of Lyon, where he took courses from Alexandre Lacassagne and Alphonse Bertillon. After completing degrees in legal and medical studies, Locard began employment with Lacassagne, where he remained through 1910, when he became director of the Lyon police laboratory. He used forensic evidence and techniques to prove the guilt of thieves, counterfeiters, and murderers. Despite an accused murderer's alibi in 1912, Locard evaluated skin cells he collected from the suspect's fingernails and detected the presence of a unique cosmetic the victim had worn. That forensic evidence caused the suspect to admit he had lied. Locard focused on dust as essential forensic trace evidence, studying variations and specifying how investigators should collect it. He also developed poroscopy, or the assessment of the distribution of pores in fingerprints.

James Marsh (1794-1846). An English chemist, Marsh devised a technique and testing device that forensic investigators could use to determine whether arsenic was present in organisms. The technique, known as the Marsh test, employed zinc and either sulfuric or hydrochloric acid to form hydrogen gas, which reacts with arsenic. During the early nineteenth century, arsenic was a favored poison used by murderers, and law-enforcement authorities needed an accurate way to prove whether that toxin had caused deaths. Starting in 1822, Marsh lived in Woolwich and worked as the Royal Arsenal's chemist. He also secured employment assisting Michael Faraday, evaluating weaponry for the Royal Military Academy. In 1836, Marsh testified at a legal proceeding, using his toxicology testing expertise to present evidence convincingly. An article he wrote describing his test for arsenic appeared in the October, 1836, issue of the *Edinburgh New Philosophical Journal*. Marsh's peers recognized the value of the test and adapted it when needed; such significant forensic toxicologists as Matthieu-Joseph-Bonaventure Orfila are known to have employed the technique. Marsh's testing procedure remained useful into the twentieth century, but it was rendered obsolete when more advanced toxicological tests were developed.

Alan R. Moritz (1899-1986). A prominent forensic pathologist, Moritz was born in Hastings, Nebraska. He earned three degrees at the University of Nebraska: a bachelor of science degree in 1920, a master's degree the next year, and a medical degree in 1923. He subsequently moved to Cleveland, Ohio, where he held several pathology positions during his career at Lakeside Hospital and Western Reserve University School of Medicine. Moritz accepted a professorship at Harvard University in 1937. That year, he discovered that by applying a mixture of amyl acetate and nail polish to hair follicles on microscope slides, he could create a clearer microscopic view of the follicles in the dried chemicals than was possible with the raw follicles alone. He provided his pathology expertise to investigations conducted by the Massachusetts State Police Force until 1949, when he returned to Cleveland. Moritz's widely read article "Classical Mistakes in Forensic Pathology" appeared in the December, 1956, issue of the *American Journal of Clinical Pathology*. Moritz testified regarding forensic evidence in such notable trials as the Sam Sheppard murder case and served on the Warren Commission, which was established to investigate the assassination of President John F. Kennedy in 1963.

Matthieu-Joseph-Bonaventure Orfila (1787-1853). An important figure in the development of forensic toxicology, Orfila was born in Mahón on Spain's island of Minorca. After completing courses in chemistry and other sciences in his native country, Orfila moved to Paris, France, to complete his medical studies. Teaching at the University of Paris medical school, Orfila also investigated the chemistry of such poisons as arsenic. He wrote *Traité des poisons tirés des règnes minéral, végétal et animal: Ou, Toxicologie générale* (1813-1815; treatise on poisons drawn from the mineral, plant, and animal kingdoms, or general toxicology), which was the first text to examine scientifically the physiological and psychological effects of poisons and to explain how medical and legal personnel could determine whether persons had been poisoned and what toxins had damaged their systems. Because of his expertise in poisons, Orfila was called upon to testify at the 1840 murder trial of Marie Lafarge, who was accused of poisoning her husband, Charles. After criticizing a chemist's testimony regarding circumstantial arsenic evidence in the victim's home, Orfila used the Marsh test to examine the victim's internal organs for arsenic. The results of the test were positive, and Marie Lafarge was convicted.

Albert S. Osborn (1858-1946). A pioneer in the field of forensic document examination, Osborn was born in Sharon, Michigan, and grew up on his parents' farm. Uninterested in becoming a farmer, Osborn studied penmanship at a Lansing, Michigan, college and then accepted a teaching position at the Rochester Business Institute in New York in 1882. Osborn soon became a legal consultant, evaluating documents for evidence of forgery; he established an office in New York City. He became frustrated when judges dismissed his insights regarding the documents he evaluated, so he began writing essays describing his techniques to educate legal professionals. His reputation as a document expert was enhanced when he testified regarding typed documents concerning the federal government's deployment of naval vessels in 1908. In 1910, he published *Questioned Documents*, now considered a classic source in the field. In 1935, Osborn testified in court regarding his evaluation of the messages sent to the famous aviator Charles A. Lindbergh demanding ransom for Lindbergh's kidnapped son; he stated that suspect Bruno Hauptmann's handwriting matched the notes, contributing to the prosecution's successful conviction of Hauptmann.

Sydney Alfred Smith (1883-1969). Born in New Zealand, Smith influenced the practices of forensic science on several continents during his career. He enrolled at the University of Edinburgh after moving to Scotland in 1908. Completing his degree with honors in 1912, Smith began to pursue graduate work with Scottish forensic medicine expert Harvey Littlejohn. He earned a public health diploma and master's degree by 1914, then served during World War I. Following the war, he worked for the Egyptian Ministry of Justice and initiated a forensic medicine program at the University of Cairo. Smith helped to create an internationally renowned forensic medicine laboratory there and became an expert in bullet wounds and ballistics. He created a comparison microscope for use in his ballistics investigations. In 1925, Smith published *Forensic Medicine: A Text-Book for Students and Practitioners*, and in 1928 he became a forensic medicine professor at his alma mater when Littlejohn died. He remained at the University of Edinburgh for the next quarter century. Smith emphasized that forensic scientists should master specialties within the field and collaborate, sharing their diverse skills and knowledge to evaluate criminal evidence effectively.

Clyde Snow (1928-). An innovator in the field of forensic anthropology, Snow was born in Fort Worth, Texas. As a child, he observed his physician father and a deputy as they determined the identity of a human skeleton they found while hunting. Snow graduated from New Mexico Military Institute in 1947, then completed a bachelor of science degree four years later at Eastern New Mexico University. He took medical courses at Baylor University and pursued zoology graduate work at Texas Tech University, where he earned a master's degree in science in 1955. In 1967, he received a doctoral degree in anthropology from the University of Arizona. Named director of the Federal Aviation Administration's Physical Anthropology Laboratory in 1968, Snow worked on identifying the victims of airplane crashes by assessing skeletal remains. He expedited searches for information by creating computer databases of victim descriptions and descriptions of skeletal evidence. After he retired in 1979, he worked with human rights groups to identify the remains exhumed from mass graves worldwide, gathering evidence to prosecute war criminals. Snow's achievements contributed to the acknowledgment of the field of forensic anthropology by the American Academy of Forensic Sciences and encouraged many anthropologists to pursue forensic investigations.

Bernard Spilsbury (1877-1947). Born in Leamington Spa, Warwickshire, England, Spilsbury helped to influence public opinion concerning the value of forensic science. He studied natural science at Oxford University's Magdalen College, earning a bachelor's degree in 1899. He then took medical courses at St. Mary's Hospital Medical College, intending to become a general practitioner. Instead, he became interested in forensic science, largely owing to the influence of St. Mary's Hospital toxicologists and pathologist Augustus Joseph Pepper, who hired Spilsbury to conduct pathology and anatomy work. By 1905, Spilsbury completed his medical studies and began to pursue a career as a resident assistant pathologist working with Pepper, who frequently assisted law-enforcement personnel with forensic investigations. In 1908, Spilsbury became the Home Office chief pathologist after Pepper's retirement from that position. Spilsbury gained acclaim for his forensic skills and expertise as he testified in notable court cases; he specialized in poisoning cases, particularly cases involving arsenic. His testimony helped to convict murderers who might otherwise have been acquitted, and this increased the public's acceptance of the value of forensic science.

Alfred Swaine Taylor (1806-1880). An important contributor to the shaping of forensic legal perceptions, Taylor was born in Northfleet, Kent, England. He served as an apprentice in London and then took medical courses at Guy's Hospital and St. Thomas' Hospital; he also studied briefly in Paris, France, in 1925, earning a degree three years later. He traveled to advance his medical experiences, returning to England in 1831 after studying injuries caused by firearms during Paris revolts. In London he taught forensic medicine at Guy's Hospital. Applying his medical expertise to legal issues, Taylor published *Elements of Medical Jurisprudence* (1843), *Medical Jurisprudence* (1845), and *The Principles and Practice of Medical Jurisprudence* (1865). Valued for his expertise, Taylor appeared frequently in courtrooms to offer testimony about his evaluation of evidence. At an 1859 trial, Taylor stated that a murdered woman had been poisoned with arsenic. The defendant's attorneys disputed Taylor's testimony, noting that his forensic investigation included copper tools that might have been the source of the arsenic in the tested sample. Taylor's flawed testing method resulted in the defendant's being exonerated, and this led to some distrust of forensic investigations among the public and questioning of the competence of forensic professionals.

Mildred Trotter (1899-1991). A forensic anthropology innovator, Trotter was born in Monaca, Pennsylvania. Enrolling at Mount Holyoke College in 1916, she studied zoology, earning a bachelor's degree in 1920. Trotter accepted a research fellowship at Washington University School of Medicine in St. Louis, Missouri, while attending graduate school to become an anatomist. She received a master of science degree in 1921 and a doctorate three years later. Trotter studied physical anthropology at the University of Oxford for a year before returning to teach and conduct research at Washington University, where she became the first woman to hold the rank of full professor. Starting in 1948, she assisted the American Graves Registration Service's Central Identification Laboratory in Hawaii and provided her anthropological expertise to the U.S. Army in the Philippines during 1951. She focused on researching the human skeleton, investigating maturation and skeletal variations affected by gender and ethnicity. Her findings initiated the method used by forensic anthropologists to determine the approximate height of a deceased person through measurement of the femur (thighbone) when only partial remains are available.

Paul Uhlenhuth (1870-1957). A native of Hannover, Germany, Uhlenhuth studied medicine and became a surgeon for German troops during the late nineteenth century. In 1900, he moved to Berlin to work at the Institute for Infectious Diseases, where he conducted research with renowned bacteriologist Robert Koch, who investigated tuberculosis. Koch encouraged Uhlenhuth to focus on serological research, and Uhlenhuth detected how proteins varied in blood samples from diverse animal subjects. He developed a serum, containing antibodies, to test blood, noting that animal serum clotted with human blood. His findings provided forensic investigators with a technique to determine whether blood evidence, fresh or dried, originated from humans or animals, thus enabling law-enforcement authorities to disprove some suspects' claims that blood found on their garments and weapons came from animals rather than humans. Uhlenhuth conducted his test for the trial of Ludwig Tessnow, who was accused of killing some children. Tessnow claimed that the stains police found on his clothing were wood dye, not blood, but Uhlenhuth determined that they were human blood, and this testimony resulted in Tessnow's conviction. After that legal success, many forensic investigators employed Uhlenhuth's serum analysis.

August Vollmer (1876-1955). An influential figure in the development of forensic science in the United States, Vollmer was born in New Orleans, Louisiana. He served in the U.S. Army during the Spanish-American War, deployed as a scout in the Philippines, prior to moving to Berkeley, California. As chief of the Berkeley Police Department during the early twentieth century, Vollmer valued forensic science and was interested in developments in the field. He hired college-educated personnel who had scientific experience and encouraged police officers to use science in their investigations. He established a police school specifically to train officers in how to collect and assess evidence that could be useful for the legal prosecution of cases. In 1916, Vollmer assisted professors at the University of California at Berkeley in creating a pioneering criminology program. In 1921, he helped initiate research into polygraphy when he asked Berkeley police sergeant John A. Larson to build a machine that could detect when interviewees were lying. Vollmer established a crime laboratory at Berkeley in 1923 that became a resource for forensic investigation for both Berkeley police and other law-enforcement groups. Throughout his career, Vollmer mentored police officers who later became police chiefs across the United States and incorporated the use of forensic science in their departments.

Alexander S. Wiener (1907-1976). A serology expert, Wiener was born in Brooklyn, New York. After completing a bachelor's degree in biology at Cornell University in 1926, Wiener earned a medical degree four years later at Long Island College of Medicine. He then served as director of the blood transfusion division at the Jewish Hospital in Brooklyn. In 1938, New York's chief medical examiner, Thomas Gonzales, named Wiener to direct the state's first laboratory devoted to serology investigations, a position he held until 1976. Wiener collaborated with Karl Landsteiner in comparing blood antigens in humans with those produced by monkeys, resulting in the 1940 finding of the rhesus (Rh) factor. Emphasizing serology as a forensic tool, Wiener evaluated evidence for law enforcement, identifying suspects based on blood types. He wrote several books, including *Blood Groups and Blood Transfusion* (1935). Wiener and his father, attorney George Wiener, contributed to the drafting of state legislation regarding blood group evidence in paternity and criminal cases.

Jeffries Wyman (1814-1874). Frequently credited as the founder of forensic anthropology, Wyman was born in Chelmsford, Massachusetts. Growing up in Charlestown, where his physician father oversaw the McLean Asylum for the Insane, Wyman was fascinated by scientific topics. He studied at Harvard College, earning a degree in 1833, then enrolled at Harvard Medical School, graduating four years later. Wyman subsequently taught anatomy at Harvard and became curator of the Peabody Museum of Archaeology and Ethnology. Wyman's involvement in forensic activities began when a janitor found body parts, bones, and dentures scattered in an anatomy vault and in the office of Harvard medical professor John White Webster. Wyman guided investigators to evaluate the evidence to determine whether they were the remains of Dr. George Parkman, who had vanished on November 23, 1849, around the time he had attempted to collect a debt Webster owed him. Wyman and his colleagues concluded that the bones and dentures were similar to Parkman's physique and jaw shape, and Webster was convicted of the killing.

Paolo Zacchia (1584-1659). Considered a forensic medicine pioneer, Zacchia was employed as the Vatican's physician, providing medical care for popes. Historians credit him with writing the first known scientific text discussing issues that formed the foundation of forensic medicine. From 1651 onward, Zacchia recorded his experiences with a variety of medical processes associated with forensic science, including wound analysis, autopsies, and testing fluids from victims and criminals, and he related his legal concerns in eleven volumes he collectively titled *Quaestiones medico-legales* (questions of legal medicine). Zacchia comprehensively discussed medical and legal aspects of historical and contemporary cases that occurred during the Renaissance in his innovative work, which retained usefulness among forensic researchers through the eighteenth century.

Elizabeth D. Schafer

Time Line

Year	*Event*
1194	The Office of the Coroner is established by King Richard I in England as a means of collecting fines owed to the Crown. The work of the office includes determining causes of deaths, as murder and suicide are illegal.
1198	Pope Innocent III issues a proclamation condemning the forging of papal bulls and threatening forgers with excommunication. The proclamation outlines six elements that judges should look for in detecting forgeries.
1248	Perhaps the first book applying medical knowledge to legal situations, *Xi Yuan Ji Lu* (various English translations of the title include *The Washing Away of Wrongs* and *Collected Cases of Injustice Rectified*), by scholar Song Ci (Sung Tz'u), is published in China.
1662	Londoner John Graunt collects mortality statistics and becomes the first to quantify patterns of disease in a population.
1686	Italian anatomist Marcello Malpighi notes the presence of consistent patterns on human fingertips.
1747	Scottish physician James Lind applies epidemiological observations in identifying the causation of scurvy and suggesting treatment for the disease.
1761	Italian anatomist Giovanni Battista Morgagni publishes the first medical text on autopsies, *De Sedibus et Causis Morborum per Anatomen Indagatis* (*The Seats and Causes of Diseases Investigated by Anatomy*, 1769).
1775	Paul Revere identifies the remains of General Joseph Warren by examining Warren's dentures, which Revere had made.
1813	Spanish chemist Matthieu-Joseph-Bonaventure Orfila publishes the first volume of a work on toxicology that addresses testing for poisons, *Traité des poisons tirés des règnes minéral, végétal et animal: Ou, Toxicologie générale* (1813-1815; treatise on poisons drawn from the mineral, plant, and animal kingdoms, or general toxicology).
1818	British book illustrator Thomas Bewick uses engravings of his own finger- and thumbprints as a means of identifying his work.
1823	Bohemian physiologist Jan Evangelista Purkyně writes a paper describing a number of friction ridge patterns found in a variety of fingerprints.
1835	British policeman Henry Goddard matches a bullet used in a murder back to its weapon by identifying a defect in the mold in which the bullet was made.
1840	The Marsh test, developed by James Marsh in 1836 as a means of detecting arsenic, becomes the first analytical method of toxicology introduced during a criminal trial.
1843	The M'Naghten rule is formulated. It states that defendants are not criminally responsible if at the times of their crimes they suffered from diseases of the mind that rendered them unable to discern the difference between right and wrong or were delusional and justified their criminal behavior as legitimate self-defense.

1848 British anesthetist John Snow begins his research into cholera; by 1854, his findings lead to the understanding of the causation of the disease.

1850's Englishman Sir William James Herschel begins using fingerprints as a means of identification on contracts during his work in India.

1865 The U.S. Secret Service is created to protect American currency and to investigate and combat counterfeiting.

1866 Dynamite is first developed, made from nitroglycerin, diatomaceous earth, and sodium carbonate wrapped in distinctive red paper.

1871 Italian criminologist Cesare Lombroso theorizes that criminals can be identified by their physical traits. Although most of his theory centers on the sizes of skulls and the lengths of bones, Lombroso later comes to be known as the father of criminal profiling.

1874 English chemist C. R. Alder Wright first produces heroin while conducting laboratory experiments with morphine.

1878 U.S. anatomist Thomas Dwight publishes the first work on forensic anthropology, an essay titled "Identification of the Human Skeleton: A Medico-legal Study."

1882 French criminologist Alphonse Bertillon begins to develop a system of identification based on the measurement of many dimensions of individuals' bodies.

1882 Scottish scientist Henry Faulds begins studying fingerprints after noticing those left on clay sculptures by artists. He concludes that every fingerprint is unique.

1889 French criminologist Alexandre Lacassagne matches a bullet to the gun that fired it by comparing the rifling marks on the bullet to those in the barrel of the firearm.

1890's The findings of experiments conducted by James McKeen Cattell, Alfred Binet, William Stern, and others suggest that eyewitness testimony is often unreliable and incomplete.

1891 Englishman Sir Edward R. Henry is appointed inspector-general of police in Bengal, India, where he develops a system to classify and analyze fingerprints and to apply such analyses to criminal prosecutions. In 1897, the Indian government publishes Henry's work *Classification and Uses of Fingerprints*.

1892 English anthropologist Sir Frances Galton regroups Jan Evangelista Purkyně's fingerprint categories into four basic patterns in his book *Finger Prints*.

1893 Austrian criminologist Hans Gross, in his book *System der Kriminalistik* (*Criminal Investigation*, 1906), expresses the importance of trace evidence in criminal investigations.

1897 George A. Dorsey becomes the first anthropologist to apply osteology in a criminal trial when he testifies regarding fragments of human bone found in a vat at the Luetgert sausage factory in Chicago.

1898 British mathematician Karl Pearson uses bone measurements to estimate an unidentified individual's antemortem height.

1900 Albert Llewellyn Hall publishes an article titled "The Missile and the Weapon" in the *Buffalo Medical Journal*, in which he presents the first analysis of the marks imparted to bullets by the rifling in gun barrels.

1900 Austrian biologist Karl Landsteiner identifies three human blood groups, which he names A, B, and C. The groups are later labeled A, B, and O.

1901 The use of the chemical phenolphthalein in presumptive tests for blood is introduced.

1901 The Fingerprint Branch at New Scotland Yard is created.

1903 Russian botanist Mikhail Semyonovich Tsvet invents chromatography as a tool for helping him to separate plant pigments. The technique is later applied to the separation of many different kinds of chemical mixtures into their individual components.

1904 The use of the chemical benzidine in presumptive tests for blood is introduced.

1906 The Food, Drug and Insecticide Administration (later named the Food and Drug Administration) is established in the United States.

1908 The Bureau of Investigations (renamed the Federal Bureau of Investigation in 1935) is created.

1908 With the publication of his book *On the Witness Stand: Essays on Psychology and Crime*, Hugo Münsterberg helps to popularize the notion that the application of psychology could be an asset for the legal system.

1908 German chemist Georg Popp becomes the first to use forensic geoscience in a criminal investigation when he compares soil samples from a crime scene to the soil on a suspect's shoes to disprove the suspect's alibi.

1910 French criminologist Edmond Locard establishes the first modern scientific laboratory for the investigation of crime in Lyon, France.

1912 The use of the chemical orthotolidine, also known as o-tolidine, is introduced in presumptive tests for blood.

1913 Psychological services are provided to inmates at a U.S. correctional facility for the first time.

1914 The U.S. Congress passes the Harrison Narcotic Drug Act, which regulates the manufacturing and distribution of heroin and other drugs.

1915 The International Association for Identification is formed.

1916 Joseph Goldberger of the U.S. Public Health Service begins two years of studies to identify the causation of pellagra.

1917 Lewis Terman becomes the first American psychologist to use psychological testing in the selection process for police officers.

1917 Mustard gas, a blister agent, is first employed as a weapon by Germany during World War I.

1920's William Moulton Marston becomes the first professor of legal psychology at American University.

1920 Two Italian immigrant laborers, Nicola Sacco and Bartolomeo Vanzetti, are arrested for the armed robbery and murder of two people in South Braintree, Massachusetts. Ballistics evidence plays an important role in their conviction and eventual execution for the crime.

1921 American medical student and police officer John A. Larson develops a continuous polygraph machine, which he calls a cardio-pneumo-psychograph.

1921 Philip O. Gravelle invents the comparison microscope, which allows forensic scientists to conduct simultaneous microscopic side-by-side comparisons of two objects.

1923 The ruling of the Court of Appeals for the District of Columbia in *Frye v. United States* introduces a new standard for the admissibility of new or novel scientific evidence in court. According to this "general acceptance" standard, expert testimony is admissible only if the scientific principle, theory, or discovery on which it is based is "sufficiently established to have gained general acceptance in the particular field in which it belongs."

1923 The first American police department criminal laboratory is established in Los Angeles, California, by August Vollmer.

1923 The International Criminal Police Commission (later renamed the International Criminal Police Organization) is established in Vienna, Austria. Commonly known as Interpol, it becomes the largest international police organization in the world.

1924 The Federal Bureau of Investigation (FBI) establishes a central database of fingerprints against which law-enforcement agencies can seek to match prints found in their local investigations.

1925 Sir Austin Bradford Hill studies the difference in mortality rates between people living in urban settings and those living in rural environments.

1925 The Geneva Protocol outlaws the use of biological weapons.

1931 Harold E. Burtt publishes *Legal Psychology*, the first textbook on the subject.

1931 French criminologist Edmond Locard publishes the first volume of his magnum opus *Traité de criminalistique* (1931-1936; treatise on criminalistics), a six-volume work in which he proposes the idea that becomes known as Locard's exchange principle, concerning the transfer of trace evidence.

1932 The Federal Bureau of Investigation Laboratory is established in the United States.

1932 The infant son of pioneer aviator Charles A. Lindbergh is abducted from the nursery of the family's home. Handwriting exemplars and forensic evidence concerning wood are pivotal in the eventual arrest and conviction of Bruno Hauptmann for the crime.

1934 The National Firearms Act of 1934 requires owners of firearms to register the devices with the federal government.

1936 Tabun, the earliest and most easily manufactured nerve gas, is discovered in Germany during experiments to develop new insecticides.

1938 The nerve agent sarin, which is about twice as deadly as tabun, is invented in Germany.

1938 German physicist Manfred von Ardenne invents the scanning electron microscope, which is capable of distinguishing objects three nanometers apart.

1939 American anthropologist Wilton Marion Krogman illustrates the importance of osteology to law enforcement with the publication of his article "A Guide to the Identification of Human Skeletal Material."

1940 Russian paleontologist Ivan Yefremov coins the term "taphonomy" and describes this field as the study of events that occur to organisms after death.

1944 The nerve agent soman is first prepared in Germany as part of that nation's chemical warfare program.

1947 The Environmental Measurements Laboratory is established by the U.S. Health and Safety Division of the Atomic Energy Commission to monitor local and global radiation levels and operate an emergency response group.

1948 The American Academy of Forensic Sciences is formed.

1949 J. G. Humble describes the mechanism by which petechial hemorrhages occur.

1950's The Identi-Kit is introduced for use in the composite drawing of suspects' faces based on information provided by eyewitnesses; this tool features numerous transparencies with choices for face shape, eyes, nose, and so on, to be used in creating composite images.

1951 F. H. Allen describes the Kidd blood grouping system, which is used for typing blood based on specific proteins, known as the Kidd blood antigens.

1952 The first edition of the American Psychiatric Association's *Diagnostic and Statistical Manual of Mental Disorders* is published; the work provides an authoritative scheme that mental health professionals use to classify psychological disorders.

1954 In *Holland v. United States*, the U.S. Supreme Court upholds the use of circumstantial evidence as a basis for conviction in a criminal case.

1957 Australian aeronautical researcher David Warren creates the first flight data recorder that can record data from all of an aircraft's basic operating systems.

1957 The International Association of Forensic Sciences is established.

1960's Martin Reiser of the Los Angeles Police Department becomes one of the first full-time police psychologists in the United States.

1960's Correctional psychology becomes recognized as a profession as a result of the efforts of Stanley Brodsky, Robert Lewinson, and Asher Pacht.

1960's Leland C. Clark develops the first enzyme electrodes, an achievment that eventually leads to the creation of more advanced versions for applications in biotechnology and forensic science.

1960 In *Dusky v. United States*, the U.S. Supreme Court rules that to be deemed competent to stand trial, individuals must have a minimum level of understanding of the legal proceedings and the ability to assist their attorneys in their own defense.

1962 Forensic anthropologist Wilton Marion Krogman publishes *The Human Skeleton in Forensic Medicine*, a work that expands on his seminal 1939 article on the topic of the identification of human skeletal material.

1962 The American Law Institute drafts the Model Penal Code, which includes an important formulation of an insanity defense standard.

1963 The U.S. Supreme Court rules in *Townsend v. Sain* that information acquired during interrogation after the use of a "truth serum" is not admissible in court in criminal cases.

1963 The first patent issued for a flight data recorder in the United States is granted to James Ryan.

1963 U.S. president John F. Kennedy is assassinated in Dallas, Texas. Lee Harvey Oswald is charged with the crime but is never tried, as he is murdered by Jack Ruby two days later. Forensic science plays an important role in the investigation of this high-profile crime, particularly in the autopsy and in the determination of the trajectories of the bullets fired.

1963 The International Association of Forensic Toxicologists is founded.

1964 American police official Alfred V. Iannarelli publishes *The Iannarelli System of Ear Indentification*, in which he asserts that external ears have unique shapes and that ear features can be classified with a system similar to that used to classify fingerprints.

1965 All U.S. commercial airlines are required to install in their aircraft cockpit voice recorders that can capture the last thirty minutes of crew voice communications and noise on any flight.

1966 In *Miranda v. Arizona*, the U.S. Supreme Court rules that individuals in law-enforcement custody must be informed of their Fifth Amendment right against self-incrimination and their Sixth Amendment right to counsel before any questioning can take place.

1966 The International Reference Organization in Forensic Medicine is established by William G. Eckert.

1967 The National Crime Information Center, a central U.S. database for crime-related information maintained by the FBI, begins operations.

1967 The National Transportation Safety Board is established in the United States.

1969 In *Frazier v. Cupp*, the U.S. Supreme Court rules that police or other law-enforcement agents can lie to suspects in order to further their investigations.

1969 The National Institute of Justice is established in the United States.

1969 The U.S. Army Medical Research Institute of Infectious Diseases is founded.

1969 The U.S. National Central Bureau of Interpol is established to facilitate cooperation between American law-enforcement agencies and Interpol.

1969 President Richard M. Nixon issues an executive order outlawing research into offensive biological weapons in the United States.

1970 The Controlled Substances Act establishes rules and regulations for the federal control of drugs in the United States in terms of drug classifications and punishments for violations of the legislation's provisions.

1970 The Federal Law Enforcement Training Center is founded in the United States.

1972 British army troops attack civilian protesters during a march of the Northern Ireland Civil Rights Association in Londonderry, and fourteen protesters die as a result. Later forensic investigations into the events seek to determine whether the soldiers involved were attacked with firearms and nail bombs before they began shooting.

1972 Forensic anthropology becomes an established area of study with the creation of the Physical Anthropology Section of the American Academy of Forensic Sciences.

1972 The Anthropological Research Facility, which soon comes to be known as the Body Farm, is created at the University of Tennessee under the leadership of forensic anthropologist William M. Bass.

1972 The Biological Weapons Convention is opened for signature; the international agreement is intended to end the production of biological weapons worldwide.

1972 Pediatric radiologist John Caffey coins the term "whiplash shaken infant syndrome" to describe the injuries caused in young children by violent shaking; the syndrome later comes to be widely known as shaken baby syndrome.

1972 The Bureau of Alcohol, Tobacco and Firearms (ATF) is established as a division of the U.S. Department of the Treasury; it is later renamed the Bureau of Alcohol, Tobacco, Firearms and Explosives.

1973 The Drug Enforcement Administration is established in the United States.

1974 The use and manufacture of the carcinogenic chemical benzidine, long employed in presumptive tests for blood at crime scenes, are banned in the United States by the Environmental Protection Agency.

1974 The American Society of Crime Laboratory Directors is founded.

1975 The California court case *People v. Marx* helps to establish evidentiary standards for the use of forensic odontology in trials.

1976 A will purportedly handwritten by billionaire Howard Hughes and left anonymously at the headquarters of the Church of Jesus Christ of Latter-day Saints in Salt Lake City, Utah, is filed with a county court in Las Vegas, Nevada, a few weeks after Hughes's death. The will, which includes a provision giving $156 million to Melvin Dummar, owner of a small Utah gas station, is challenged in court and, after evidence is presented regarding fingerprint analysis and analyses of handwriting and ink, is ruled a forgery.

1976 Whitfield Diffie and Martin Hellman develop an algorithm that allows two people to create a shared symmetric computer encryption key.

1976 *Quincy, M.E.*, a fictional television drama about a coroner who uses forensics to solve crimes, premieres on NBC.

1977 The FBI begins using the first computerized automated fingerprint identification system.

1978 American forensic scientists Brian Wraxall and Mark Stolorow develop the multisystem method, which enables the simultaneous analysis of three different blood isozymes from a single bloodstain.

1978 Ted Kaczynski, who will become known as the Unabomber, sends his first bomb through the U.S. mails. He continues sending bombs, primarily to people associated with universities and airlines, until 1995. Forensic scientists study the bombs for clues to the bomber's identity.

1978 Georgi Markov, a defector from Communist Bulgaria, is poisoned with ricin in London, England. Forensic science is instrumental in determining the cause of death and the method used in the murder.

1979 The U.S. Fish and Wildlife Service hires American biochemist Ken Goddard to serve as the agency's first forensic investigator.

1979 Bite-mark evidence plays a crucial role in the first trial of serial killer Ted Bundy for murders committed at Florida State University's Chi Omega sorority house. Bundy is found guilty and sentenced to death.

1980 English forensic investigator Stuart Kind performs calculations relating the locations and times of thirteen murders purportedly committed by the Yorkshire Ripper.

1980 During the Iran-Iraq War (1980-1988), Iraq uses the nerve agent tabun against Iranian troops. The use of the chemical weapon is confirmed in 1984 when a United Nations team finds tabun in an unexploded Iraqi bomb within Iranian borders.

1981 The FBI establishes its Forensic Science Research and Training Center.

1982 Forensic scientists begin using cyanoacrylate vapors to visualize and preserve latent fingerprints and palm prints.

1983 American chemist Kary Mullis develops the polymerase chain reaction (PCR) method for copying strands of DNA.

1983 German journalist Gerd Heidemann claims to have come across diaries kept by Nazi chancellor Adolf Hitler during the period 1932-1945. The diaries are initially authenticated by World War II historians but are ultimately proven to be forgeries when tests show that the paper and ink used were not available during Hitler's lifetime.

1984 The Computer Fraud and Abuse Act is passed in the United States, making it a federal offense to cause damage to a computer connected to the Internet.

1985 British geneticist Alec Jeffreys discovers the use of DNA markers (restriction fragment length polymorphisms, or RFLPs) for personal identification while searching for disease markers in DNA. He recognizes the potential for the method's use in criminal and civil investigations and coins the term "DNA fingerprinting."

1986 The space shuttle *Challenger* explodes in flight, killing all seven crew members. The forensic investigation that follows determines that the accident was caused by the failure of an O-ring seal.

1986 American physician Harry McNamara describes "living forensics," the application of clinical medicine to cases of trauma that require forensic investigation.

1986 The University of Tennessee at Knoxville establishes the Forensic Anthropology Data Bank to centralize the information available on skeletal remains in modern publications.

1987 Englishman Colin Pitchfork is the first criminal offender to be caught as the result of mass DNA screening.

1989 The National Fish and Wildlife Forensics Laboratory is established in the United States.

1990 Washington State enacts the Community Protection Act, which is regarded as the first modern violent sexual predator statute.

1990 The U.S. Congress passes the Anabolic Steroid Control Act of 1990, which criminalizes the nonmedical use of anabolic steroids.

1990 The FBI establishes the Combined DNA Index System (CODIS).

1991 The first U.S. patent is issued for a counterfeit-detection pen, which uses ink that changes color through a chemical reaction when it comes into contact with counterfeit bills.

1991 Remains suspected to be those of Russian czar Nicholas II and his family, executed in 1918, are sent from Russia to the Forensic Science Service laboratory in England and to Carnegie Mellon University in the United States. DNA testing results in a 95 percent certainty that the remains are those of the Russian imperial family.

1991 American geneticist C. Thomas Caskey develops the short tandem repeat (STR) method, a type of polymerase chain reaction process for DNA strand replication.

1991 The FBI selects short tandem repeat analysis over restriction fragment length polymorphism analysis as the preferred method of DNA evidence analysis.

1991 The body of Zachary Taylor, twelfth president of the United States, is exhumed by coroner Richard Greathouse so that tests can be performed to find out whether Taylor was in fact poisoned more than 140 years previously. Although arsenic is detected in the remains, the levels found are well below the levels considered to be toxic to human beings.

1991 The Integrated Ballistics Identification System (IBIS), a searchable database that enables identification of firearms through comparisons of ballistic fingerprints, is developed in Canada.

1991 The Forensic Science Service is established in England.

1992 The professional title "forensic nurse" is established at a meeting of a group of sexual assault nurse examiners (SANEs) in Minneapolis, Minnesota. From this meeting, the International Association of Forensic Nurses (IAFN) is formed to promote and support forensic nursing.

1992 An FBI proposal to expand federal wiretapping laws to include intercepting suspects' computer and online activities is defeated because of objections from groups concerned with protecting civil liberties.

1992 The Innocence Project is founded at the Benjamin N. Cardozo School of Law at Yeshiva University; the organization is devoted to helping wrongfully convicted prisoners use DNA evidence to prove their innocence.

1993 In *Daubert v. Merrell Dow Pharmaceuticals*, the U.S. Supreme Court rules that trial judges have the responsibility for determining the admissibility of expert testimony on scientific evidence, based on the credibility and relevance of the evidence.

1993 The civil case *Anderson v. PG&E* (the so-called Erin Brockovich case) begins. The suit deals with claims that the Pacific Gas and Electric Company illegally dumped chemicals and contaminated the drinking water in Hinkley, California, with hexavalent chromium.

1993 The U.S. government establishes ten regional Disaster Mortuary Operational Response Teams (DMORTs) to provide local agencies with added expertise in the location, recovery, and identification of deceased individuals after disasters.

1993 The Chemical Weapons Convention is opened for signature; the international agreement bans the manufacture and storage of chemical weapons such as soman and tabun.

1993 Kirk Bloodsworth becomes the first wrongfully convicted person in the United States to escape a death sentence as the result of postconviction DNA analysis. His 1984 conviction for the rape and murder of a child is overturned when DNA testing proves his innocence.

1994 Bite-mark evidence provides important corroboration in the trial of Jesse Timmendequas when a bite mark on Timmendequas's hand is shown to match the dentition pattern of seven-year-old Megan Kanka. Timmendequas is found guilty of murdering the child.

1994 The Substance Abuse and Mental Health Services Administration establishes guidelines for the drug testing of federal employees in the United States.

1994 The first evidentiary use of nonhuman DNA occurs in Canada when investigators find the hairs of a cat on the jacket of a man accused of murdering his wife, disproving the suspect's alibi.

1994 The first of the statutes known as Megan's Law is enacted, requiring convicted sex offenders to register with authorities for the purpose of community notification.

1995 The American Nurses Association officially recognizes forensic nursing as a nursing subspecialty.

1995 Timothy McVeigh uses a variation of an ammonium nitrate/fuel oil explosive to attack the Alfred P. Murrah Federal Building in Oklahoma City; the explosion kills 168 people and injures more than 600 others. Investigators are able to collect enough evidence to tie McVeigh and his coconspirators to the bombing.

1995 The Aum Shinrikyo religious cult uses homemade sarin to attack subway commuters in Tokyo, Japan. Nearly five thousand people are hospitalized as a result, and twelve deaths are attributed to the attack. Within two hours of the attack, investigators are able to collect a sample of the substance used, and forensic scientists use gas chromatography-mass spectrometry to identify it as sarin.

1995 The European Network of Forensic Science Institutes is created.

1995 The remains of a fully clothed mummy are discovered on Mount Ampato, Peru. Forensic anthropologists later determine that the girl was most likely about fourteen years old when she died, probably as a result of a human sacrifice, in the fifteenth century.

1995 Former football star O. J. Simpson faces charges of murdering two people in a highly publicized criminal trial that brings forensic science, and DNA testing in particular, into popular consciousness.

1995 *Medical Detectives*, a television series portraying actual forensic cases, premieres on TLC (The Learning Channel).

1996 The Church Arson Task Force is formed to coordinate federal, state, and local law-enforcement efforts to address an increase in arson cases involving churches attended by African Americans.

1996 Prehistoric human remains are found on the bank of the Columbia River near Kennewick, Washington. Forensic examination of the remains reveals that they are approximately 9,800 years old and raises some mysteries as to their origins.

1997 The Joint Commission on Accreditation of Healthcare Organizations begins requiring that hospital staff be trained in the identification of victims of abuse, violence, and neglect and in the collection and preservation of physical evidence from victims for potential legal proceedings.

1997 The Federal Aviation Administration requires that all flight data recorders on U.S. planes be capable of recording at least eighty-eight points of flight data.

1997 In *Kansas v. Hendricks*, the U.S. Supreme Court rules that violent sexual predator statutes that use the civil commitment process to continue to confine sex offenders after they have completed their prison sentences do not qualify as punishment because their purpose is not to punish offenders but to protect the public.

1997 In *General Electric v. Joiner*, the U.S. Supreme Court emphasizes the discretion of trial judges in making decisions to exclude or admit expert testimony.

1998 Mitochondrial DNA analysis is used to identify the remains of the Vietnam War service person interred in the Tomb of the Unknowns at Arlington National Cemetery as First Lieutenant Michael Blassie of the U.S. Air Force.

1998 The FBI's DNA Analysis Units are formed.

1998 The FBI establishes the National DNA Index System.

1998 Retired professor Eugene A. Foster leads a team in testing DNA samples in an attempt to determine whether Thomas Jefferson, third president of the United States, fathered any children by Sally Hemings, one of his slaves. The tests results indicate that a male in Jefferson's line, possibly Thomas Jefferson himself, was the father of at least one of Hemings's children.

1999 The Identity Theft and Assumption Deterrence Act makes identity theft a felony.

1999 In *Kumho Tire Company v. Carmichael*, the U.S. Supreme Court extended trial judges' authority in determining the admissibility of expert testimony by expanding the areas of consideration from scientific methods to all cases in which technical expertise is involved.

1999 The term "forensic epidemiology" is first used in an official context during the presentation of an epidemiologist as an expert witness during a legal proceeding.

1999 Microbial forensic techniques help scientists determine that the first U.S. outbreak of the West Nile virus is a natural occurrence and not an act of bioterrorism.

1999 The FBI launches the Regional Computer Forensics Laboratory in San Diego, California, to assist state, local, and federal law-enforcement agencies in evaluating electronic evidence.

1999 The FBI launches the largest computer forensic case to date when the Melissa virus attacks commercial, government, and military computer systems. David L. Smith of Aberdeen, New Jersey, is arrested for the crime.

1999 The FBI's Integrated Automated Fingerprint Identification System becomes operational.

2000 The American Academy of Forensic Sciences establishes the Forensic Specialties Accreditation Board to accredit the certifiers of forensic fields.

2000 William Walsh, chief scientist at the Pfeiffer Treatment Center in Warrenville, Illinois, tests hair samples from composer Ludwig van Beethoven (who died in 1827) and finds extremely heavy lead deposits. Walsh surmises that lead poisoning may have caused Beethoven's many illnesses and death.

2000 *Forensic Files*, a television series focusing on actual forensic cases, premieres on Court TV.

2000 Scientists announce that mitochondrial DNA analysis has positively identified a heart that had been kept in a jar near Paris, France, since the late eighteenth century as that of King Louis XVII, who died at the age of eight.

2000 *CSI: Crime Scene Investigation*, a fictional television drama about a team of investigators who use forensics to solve crimes, premieres on CBS. The show becomes so popular that it spawns two spin-off series, *CSI: Miami* in 2002 and *CSI: NY* in 2004.

2001 In the case of *People v. Lee*, the New York Court of Appeals holds that the decision regarding whether or not to admit expert testimony at trial regarding the reliability of eyewitness identification is at the discretion of the trial court judge.

2001 Terrorists crash hijacked airliners into the twin towers of the World Trade Center in New York City, into the Pentagon in Arlington, Virginia, and into a field near Shanksville, Pennsylvania, killing approximately three thousand people in all. Forensic odontology and DNA testing play major roles in the process of identifying the victims.

2001 Several letters containing spores of *Bacillus anthracis*, the bacterium that causes anthrax, are mailed by an unknown assailant to news media offices and to two U.S. senators, and ultimately five of the twenty-two people who become infected with anthrax die. Biosensors enable early detection of the anthrax bacterium in letters sent to the Hart Senate Office Building in Washington, D.C., and those potentially exposed there receive prophylactic treatment with antibiotics. Eventually, DNA testing finds that the strain of anthrax used matches a strain produced at Fort Detrick in Frederick, Maryland.

2001 The American Psychological Association stipulates that education for a forensic psychology specialty should be in applied psychology and recommends areas of specialization in clinical psychology, counseling psychology, neuropsychology, and school psychology, with advanced instruction in law and justice.

2002 In the wake of the previous year's anthrax letter attacks, the American Academy of Microbiology formulates standards for evidence collection and analysis of molecular tests for microbial forensics.

2002 The FBI establishes the Scientific Working Group for Microbial Genetics and Forensics to facilitate the identification of organisms used in biocrimes or bioterrorist attacks.

2002 In *Kansas v. Crane*, the U.S. Supreme Court rules that states are not required to show that criminals have no control over their sexual impulses in order to label them violent sexual predators; rather, states need only demonstrate that offenders have serious difficulty controlling their illegal sexual behavior.

2002 *Time* magazine names three forensic auditors—Cynthia Cooper, Coleen Rowley, and Sherron Watkins—as joint "Persons of the Year."

2003 The space shuttle *Columbia* disintegrates during reentry, killing all seven crew members. DNA testing and forensic odontology play important roles in the identification of the remains.

2003 The FBI, in partnership with the U.S. Department of Homeland Security, launches the National Bioforensic Analysis Center to serve as a resource for the study of microbial evidence linked to acts of bioterrorism.

2004 More than thirteen hundred children and adults are held hostage in a middle school in Beslan, a town in the Russian Federation republic of North Ossetia-Alania, by a group of armed terrorists demanding the withdrawal of Russian troops from Chechnya. On the third day of the siege, Russian security forces storm the school, and the resulting fight destroys the building and leaves nearly four hundred people dead. DNA analysis plays an important role in identifying the victims, many of whom are badly burned.

2004 A massive earthquake triggers tsunamis that devastate the coastlines of several Asian countries and kill as many as 250,000 people. Forensic odontology becomes pivotal in the process of identifying the victims.

2004 The U.S. Congress passes the Justice for All Act, which stipulates that all convicts with reasonable claims of innocence must be granted the opportunity to prove their cases in court using DNA testing.

2004 The U.S. Congress passes the Anabolic Steroid Control Act of 2004, which strengthens legal penalties for the distribution and possession of anabolic steroids and encourages education for children regarding the dangers of steroid abuse.

2005 In London, England, bombings in the public transit system kill fifty-two passengers and injure more than seven hundred others. The explosive used is determined to be triacetone triperoxide, which is made from common ingredients that may be obtained relatively easily and is almost undetectable by substance-detection dogs or by conventional bomb-detection systems.

2005 A survey conducted by the National Association of Counties finds that 58 percent of U.S. county law-enforcement agencies list methamphetamine as their number one drug problem.

2005 Turkish and Moroccan hackers release the Zotob Internet worm to steal credit card numbers from infected computers worldwide. Investigators gather data (including IP addresses, e-mail addresses, names linked to those addresses, and hacker nicknames), and less than eight days after the worm hits the Internet, two suspects are arrested.

2006 A forensic team led by Spanish geneticist José Antonio Lorente uses mitochondrial DNA analysis to identify remains held at the Cathedral of Seville, Spain, as those of fifteenth century explorer Christopher Columbus.

2008 Russian forensic scientists who had performed analyses on DNA extracted from teeth, bones, and other fragments of remains recovered in 2007 near the site where remains of members of the last Russian imperial family were found in 1991 announced that they had positively identified the remains as those of Czar Nicholas II's children Alexei and Maria.

2008 The FBI's Integrated Automated Fingerprint Identification System begins development of the Next Generation Identification (NGI) system to increase the efficiency of identifying criminals, suspected terrorists, and undocumented aliens attempting to enter the United States. The NGI will incorporate such biometric identification features as facial recognition, iris scans, palm authentication, and possibly applications using DNA data.

Russell S. Strasser

Bibliography

Contents

General Studies

Block, Eugene B. *Science vs. Crime: The Evolution of the Police Lab*. San Francisco: Cragmont, 1979. Tribute to the evolution of criminal investigation includes chapters that focus on such aspects of forensic science as fingerprints, hair analysis, ballistics, bloodstain characteristics, and document analysis.

DiMaio, Vincent J., and Dominick DiMaio. *Forensic Pathology*. 2d ed. Boca Raton, Fla.: CRC Press, 2001. Explains the theory and science behind all types of techniques applied in the practice of forensic pathology. Topics covered include time of death, premortem violence, blunt trauma to the head and body, airplane casualties, deaths in nursing homes, and suicide.

Evans, Colin. *The Casebook of Forensic Detection: How Science Solved One Hundred of the World's Most Baffling Crimes*. Updated ed. New York: Berkley Books, 2007. Describes the world of forensic scientists and the investigative methods that were used in specific criminal cases. The one hundred case studies presented are categorized according to the forensic techniques that were most useful in solving the cases. Within categories, the cases are arranged in chronological order. Very entertaining and informative.

Gardner, Ross M. *Practical Crime Scene Processing and Investigation*. Boca Raton, Fla.: CRC Press, 2005. Demonstrates the author's expertise in forensic science investigation, honed over the course of his career with the U.S. Army Criminal Investigation Division. Outlines an eighteen-step crime scene investigation process.

Geberth, Vernon J. *Practical Homicide Investigation Checklist and Field Guide*. Boca Raton, Fla.: CRC Press, 1997. Instructional guide, useful for both experts and beginners, has been called the bible of homicide investigation and is used by many U.S. law-enforcement agencies. Explains in detail the process by which forensic analysts solve crimes. Includes graphic pictures of crime scenes and bodies of homicide victims.

Genge, N. E. *The Forensic Casebook: The Science of Crime Scene Investigation*. New York: Ballantine, 2002. Focuses primarily on crime scene investigation but also discusses the analysis of bodies, explosives, computer crimes, animal examiners, and forensic photography. Informative appendixes include a listing of forensic science degree programs in the United States.

Gerber, Samuel M., ed. *Chemistry and Crime: From Sherlock Holmes to Today's Courtroom*. Washington, D.C.: American Chemical Society, 1983. Collection of essays begins with discussion of crimes featured in fictional works that involve a knowledge of chemistry. Subsequent chapters focus on the history of forensic science and on specific chemistry-related techniques scientists use to analyze evidence samples. The final chapter presents the results of a two-year study of physical evidence used in police investigations.

Gerstenfeld, Phyllis B., ed. *Criminal Justice*. 3 vols. Pasadena, Calif.: Salem Press, 2006. Comprehensive reference work provides clear and authoritative treatment of all aspects of the American criminal justice system, including the role of forensic science in the work of law enforcement and the courts.

Gilbert, James N. *Criminal Investigation*. 7th ed. Upper Saddle River, N.J.: Pearson Prentice Hall, 2007. Well-organized volume begins with chapters on the history of criminal investigation and basic concepts before discussing the investigative method, the writing of reports, and law-enforcement interviewing techniques. Individual chapters are then devoted to the forensic investigation of specific kinds of crimes: burglary, robbery, homicide and aggravated assault, sexual assault, larceny, drug investigation, and gang investigation. Suspect identification and courtroom proceedings are also addressed, and the final chapter offers insights into likely future developments in criminal investigation.

Girard, James E. *Criminalistics: Forensic Science and Crime*. Sudbury, Mass.: Jones & Bartlett, 2008. Provides clear explanations of the basic chemistry and biology involved in the processes of forensic science for readers with no scientific background. Individual sections are devoted to criminalistics, trace evidence, pattern evidence, chemical evidence, biological evidence, and terrorism.

Houck, Max M., and Jay A. Siegel. *Fundamentals of Forensic Science*. Burlington, Mass.: Elsevier Academic Press, 2006. Good general textbook offers basic introductions to all areas of the forensic sciences, including crime scene investigation, forensic analytical tools, and the methods and techniques used in forensics laboratories.

James, Stuart H., and Jon J. Nordby, eds. *Forensic Science: An Introduction to Scientific and Investigative Techniques*. 2d ed. Boca Raton, Fla.: CRC Press, 2005. Respected introductory text presents clear information on all aspects of forensic science as well as discussion of the positions and expectations of forensic scientists within society.

Karagiozis, Michael Fitting, and Richard Sgaglio. *Forensic Investigation Handbook: An Introduction to the Collection, Preservation, Analysis, and Presentation of Evidence*. Springfield, Ill.: Charles C Thomas, 2005. Reviews the history and basic principles of forensic science and its relationship to the American criminal justice system before addressing specific areas of the field, such as biological evidence, criminal profiling, and death investigation. Features informative appendixes and an extensive glossary.

Lee, Henry C., and Jerry Labriola. *Dr. Henry Lee's Forensic Files*. Amherst, N.Y.: Prometheus Books, 2006. As a criminalist who has worked on many high-profile cases, Lee offers an insider's view of the examination of forensic evidence and the presentation of such evidence in court. Interesting book reviews five of Lee's most famous cases, including the Scott Peterson and Elizabeth Smart murder cases.

Miller, Hugh. *What the Corpse Revealed: Murder and the Science of Forensic Detection*. New York: St. Martin's Press, 1999. Reviews the forensic investigations behind sixteen murders that led to identification of the perpetrators. This engaging and interesting work has received some criticism because a number of the real-life facts of the cases have been altered, but the investigative techniques depicted are accurate and well explained.

Nickell, Joe, and John F. Fischer. *Crime Science: Methods of Forensic Detection*. Lexington: University Press of Kentucky, 1999. Covers an impressive number of topics, from the history of forensic science to the modern science laboratory. Each topic is addressed in a fairly basic manner, and a practical and informative case study appears at the end of each chapter.

Peterson, Joseph L., ed. *Forensic Science: Scientific Investigation in Criminal Justice*. New York: AMS Press, 1975. Collection of articles by experts in various subspecialties of forensic science and criminal justice addresses such topic areas as the role of science in a legal system, the development of forensic science laboratories, and the availability of science in the administration of criminal justice.

Platt, Richard. *Crime Scene: The Ultimate Guide to Forensic Science*. New York: Dorling Kindersley, 2003. Introductory work serves to explain to nonscientists a wide range of topics in forensic science, including assessment of crime scenes, body identification, evidence analysis, and identification of suspects. Case studies help to illustrate important points.

Saferstein, Richard. *Criminalistics: An Introduction to Forensic Science*. 9th ed. Upper

Saddle River, N.J.: Pearson Prentice Hall, 2007. Excellent introductory textbook provides clear and concise explanations of the technical terms, complex tests, and theories involved in forensic science. Presents comprehensive coverage of both the basics and the advanced methods used during forensic investigations.

_______, ed. *Forensic Science Handbook*. 2d ed. 2 vols. Upper Saddle River, N.J.: Prentice Hall, 2002-2005. Amazingly complete work discusses nearly every method and technique used by forensic scientists, including those related to toxicology tests, DNA analysis, document examination, drug identification, fiber examination, and firearms identification. An excellent resource for beginners in the field and seasoned scientists alike.

Wilkes, Roger, ed. *The Giant Book of Murder: Real Life Cases Cracked by Forensic Science*. London: Constable & Robin, 2000. Collection describes the forensic science applied in thirty-two true murder cases, highlighting the advances that have been made in the field over time.

Zonderman, Jon. *Beyond the Crime Lab: The New Science of Investigation*. Rev. ed. New York: John Wiley & Sons, 1999. Illuminates the history behind modern techniques of forensic science and discusses the various kinds of investigative cases that have particularly benefited from advances in the science. Ends with a discussion of the ethical and constitutional implications of the use of some modern tools of surveillance and identification.

Ballistics

Dodd, Malcolm J. *Terminal Ballistics: A Text and Atlas of Gunshot Wounds*. Boca Raton, Fla.: CRC Press, 2006. Sections focus on "hardware," or the inner workings of many types of firearms; on the injury patterns to skin, bones, and internal organs associated with specific types of firearms; and on the techniques that forensic scientists use in ballistics analysis. Includes a glossary.

Heard, Brian J. *Handbook of Firearms and Ballistics: Examining and Interpreting Forensic Evidence*. New York: John Wiley & Sons, 1997. Describes different types of firearms and ammunition and explains clearly the forensic examination of ballistics and firearms evidence. Includes discussion of the testimony of expert witnesses in cases involving such evidence.

Hueske, Edward E. *Practical Analysis and Reconstruction of Shooting Incidents*. Boca Raton, Fla.: CRC Press, 2006. Comprehensive work addresses nearly all aspects of crime scene analysis involving firearms. Begins by explaining the theory of reconstruction and the mathematics behind ballistics and then introduces the equipment, tests, and techniques used to collect and examine firearms evidence. Also includes discussion of firearms wound characteristics, blood spatter analysis, and ricochet phenomena and presents examples from actual cases.

Meyers, Charles. *Silent Evidence: Firearms (Forensic Ballistics) and Toolmarks—Cases from Forensic Science*. Boone, N.C.: Parkway, 2004. Presents thorough coverage of firearms forensics by describing and explaining the ballistics evidence from thirteen real-world cases. Addendum titled "A Primer on Firearms and Toolmark Identification" presents background on the forensic discipline of ballistics.

Warlow, Tom. *Firearms, the Law, and Forensic Ballistics*. 2d ed. Boca Raton, Fla.: CRC Press, 2005. Begins with an introduction to different types of explosives and firearms and then presents up-to-date information on legislation in the United States concerning firearms. The chapters that follow address specific aspects of forensic ballistics analysis, both in the laboratory and at the crime scene, and the presentation of ballistics evidence in court.

Bloodstain Evidence

Bevel, Tom, and Ross M. Gardner. *Bloodstain Pattern Analysis with an Introduction to Crime Scene Reconstruction*. 3d ed. Boca Raton, Fla.: CRC Press, 2008. Well-illustrated, interesting work focuses on the reproduction of the scenes of violent crimes. Explains different types of bloodstains and how they are caused and also describes the computer technology used to re-create crime scenes based on bloodstains and blood spatter.

Haag, Lucien C. *Shooting Incident Reconstruction*. Burlington, Mass.: Academic Press, 2006. Comprehensive volume covers the philosophy and theory behind studies of bloodstain and blood spatter analysis as well as the science of ballistics and the trajectory of moving objects, illustrating why bloodstain analysis is such a respected area of forensic science. Includes an extensive glossary.

James, Stuart H., and William G. Eckert. *Interpretation of Bloodstain Evidence at Crime Scenes*. 2d ed. Boca Raton, Fla.: CRC Press, 1999. Excellent reference work presents a history of the discipline of bloodstain analysis and then walks readers through the entire process of dealing with blood evidence at crime scenes, using specific case studies to illustrate important points. A valuable resource for law-enforcement personnel.

James, Stuart H., Paul E. Kish, and T. Paulette Sutton. *Principles of Bloodstain Pattern Analysis: Theory and Practice*. Boca Raton, Fla.: CRC Press, 2005. Provides complete discussion of bloodstain and blood spatter analysis, including information on testing techniques, chemical treatment, report writing, and applications of the findings of analyses in the court system. Useful appendixes include trigonometric tables, scene and laboratory checklists, and information on court decisions related to blood analysis and testing.

Wonder, A. Y. *Blood Dynamics*. New York: Academic Press, 2001. Focuses on the accurate identification of eight bloodstain pattern types. Introductory chapter discusses blood characteristics and probable and possible bloodstain patterns.

DNA Analysis

Brown, T. A. *Gene Cloning and DNA Analysis: An Introduction*. 5th ed. Malden, Mass.: Blackwell, 2006. Explains in clear language the science of DNA analysis and the techniques used in such analysis. Excellent resource for students or professionals.

Butler, John M. *Forensic DNA Typing: Biology, Technology, and Genetics of STR Markers*. 2d ed. Burlington, Mass.: Elsevier Academic Press, 2005. Provides an overview of some introductory-level basics, but is primarily intended for readers with some scientific background. Discusses DNA typing systems, the Y chromosome, mitochondrial DNA markers, statistical genetic analysis of DNA data, and technological development in DNA analysis. Uses examples from high-profile cases in discussing specific techniques.

Robertson, J., A. M. Ross, and L. A. Burgoyne, eds. *DNA in Forensic Science: Theory, Techniques, and Applications*. New York: Ellis Horwood, 1990. Begins with a primer on DNA and then delves into topics such as isolation techniques, DNA probing techniques, human identification through DNA typing, and paternity testing. Closes with a discussion of the legal implications of DNA profiling.

Rudin, Norah, and Keith Inman. *An Introduction to Forensic DNA Analysis*. 2d ed. Boca Raton, Fla.: CRC Press, 2002. Basic introductory work explains the techniques and procedures of DNA analysis in terms that nonscientists can understand. Includes case studies and discussion of U.S. Supreme Court decisions related to DNA analysis.

Document Analysis

Ellen, David. *Scientific Examination of Documents: Methods and Techniques*. 3d ed. Boca Raton, Fla.: CRC Press, 2006. Provides in-depth discussion of handwriting elucidation and analysis as well as the analysis of instruments used to create documents, including typewriters, printers, and photocopiers. Also covers the examination of incidental marks, the functions of photography in document examination, and the role of the document examiner as an expert presenting evidence in a court of law.

Herbertson, Gary. *Document Examination on the Computer: A Guide for Forensic Document Examiners*. Berkeley, Calif.: WideLine, 2002. Focuses on techniques of document examination involving digital image processing, which the author, a former document examiner for the Federal Bureau of Investigation, asserts will almost wholly replace techniques using photography and microscopic analysis in the future. Includes chapters on the restoration of documents and on the analysis of forgeries.

Koppenhaver, Katherine M. *Forensic Document Examination: Principles and Practice*. Totowa, N.J.: Humana Press, 2007. Describes the history of document examination from early work in handwriting analysis through modern techniques for evaluating altered, photocopied, and disguised documents. Includes a helpful final chapter that discusses court cases and provides informative appendixes and glossaries.

Levinson, Jay. *Questioned Documents: A Lawyer's Handbook*. New York: Academic Press, 2001. Explains the basics behind the document analysis process for lawyers who need to address document examination evidence. Chapters cover such topics as handwriting, printers, seals, photography, writing utensils, document alterations, and fingerprints. Helpful appendixes include examples of questions for courtroom testimony and a list of organizations concerned with document examination.

Vastrick, Thomas W. *Forensic Document Examination Techniques*. Altamonte Springs, Fla.: Institute of Internal Auditors Research Foundation, 2004. Following an informative primer on document analysis, individual chapters focus on specific topic areas, such as forgery, alterations, counterfeiting, writing instruments, and anonymous messages. Also discusses the qualifications of forensic document examiners and how document analysts prepare to present their findings in court. Includes a helpful glossary.

Drug Analysis

Cole, M. D., and B. Caddy. *The Analysis of Drugs of Abuse: An Instruction Manual*. New York: Ellis Horwood, 1995. Textbook provides easily understood information on how drugs of abuse affect the human body and how chemists test for the presence of these drugs. Opens with an overview of the use of forensic science in the investigation of drug-related crimes. Each chapter includes student exercises.

Gough, Terry A., ed. *The Analysis of Drugs of Abuse*. New York: John Wiley & Sons, 1991. Chapters in the first part of this collection provide thorough discussion of the techniques that forensic scientists use in drug analysis, including spectrometry, chromatography, and immunoassay tests. Those in the second section emphasize the cooperation of forensic analysts, customs agents, and law-enforcement officers in efforts to address drug-related crime.

Kintz, Pascal, ed. *Analytical and Practical Aspects of Drug Testing in Hair*. Boca Raton, Fla.: CRC Press, 2007. Collection includes an introduction explaining how drug components can infiltrate human hair, followed by chapters written by specialists that describe the testing of hair for evidence of the use of cocaine, opioids, cannabinoids, amphetamine, and pharmaceutical drugs. The techniques of testing are described, and the situations in which evidence from hair analysis may be useful are discussed.

Smith, Frederick P., ed. *Handbook of Forensic Drug Analysis*. Burlington, Mass.: Elsevier Academic Press, 2005. Brief opening chapter presents background on the types of drugs forensic scientists commonly analyze, methods of drug analysis, and the importance of the findings of such analysis to legal cases. The chapters that follow discuss types of analytic methods in great technical detail as well as types of drug groups and their respective detection and testing processes.

Wong, Raphael C., and Harley Y. Tse, eds. *Drugs of Abuse: Body Fluid Testing*. Totowa, N.J.: Humana Press, 2005. Focuses on the different kinds of drug tests conducted with samples of saliva, sweat, urine, and hair. Includes discussion of trends in drug testing and the relationship of drug testing to the criminal justice system in the United States.

Ethics

Barnett, Peter D. *Ethics in Forensic Science: Professional Standards for the Practice of*

Criminalistics. Boca Raton, Fla.: CRC Press, 2001. Addresses the need for the establishment of a code of ethics for forensic science professionals, outlining the kinds of conflicts that inevitably arise within such a profession and identifying key components of what an ideal code of ethics should entail. Presents examples of possible resolutions for conflicts within the field and identifies the strengths and weaknesses of each.

Candilis, Philip J., Robert Weinstock, and Richard Martinez. *Forensic Ethics and the Expert Witness*. New York: Springer, 2007. Thorough discussion first introduces the ethical gray area that is debated among scientists and lawyers and provides examples of legal cases in which these are illuminated. Ethical behavior approaches and theories are then described, and real court cases are used to show the applications of these approaches. Includes an appendix of the ethics codes of organizations related to forensic science.

Resnick, David B. *The Price of Truth: How Money Affects the Norms of Science*. New York: Oxford University Press, 2007. Asserts that scientists' sources of funding can have profound effects on the evidential outcomes of particular studies. After clear discussion of the concepts of objectivity, disclosure, intellectual property, and accountability in science and government, presents an argument for the vital importance of "truth and integrity in research."

Shiffman, Melvin A., ed. *Ethics in Forensic Science and Medicine: Guidelines for the Forensic Expert and the Attorney*. Springfield, Ill.: Charles C Thomas, 1999. Clarifies the expectations of established codes of ethics in fields related to forensic science, including those in areas such as confidentiality, the definition of an expert, attorney preparation for cases involving these professionals, and the validity and use of scientific evidence. Also includes guidelines regarding instances of drug abuse, brain injury, and abuse of forensic sciences.

Impression Evidence

Ashbaugh, David R. *Quantitative-Qualitative Friction Ridge Analysis: An Introduction to Basic and Advanced Ridgeology*. Boca Raton, Fla.: CRC Press, 1999. Offers a brief history of identification using fingerprint analysis and then explains the histology and growth of the skin before describing fingerprint identification techniques and processes. Also includes discussion of reports on the findings of fingerprint analysis.

Bodziak, William J. *Footwear Impression Evidence: Detection, Recovery, and Examination*. 2d ed. Boca Raton, Fla.: CRC Press, 2000. Provides thorough discussion of the process of the examination of footprint evidence. Describes each stage, from detection, photography, and casting at the crime scene to examination of prints in the laboratory. Covers lifting, enhancement, sizing, print comparisons, and wear characteristics, among other topics. Uses examples from real cases to illustrate important points.

Cole, Simon A. *Suspect Identities: A History of Fingerprinting and Criminal Identification*. Cambridge, Mass.: Harvard University Press, 2001. Follows the science of criminal identification through fingerprinting from its earliest stages through the evolution of techniques using photography to the development of modern automated systems. Addresses how the concept of individuality, issues of law-enforcement power, and varying levels of scientific certainty in the use of fingerprints have overlapped throughout history.

McDonald, Peter. *Tire Imprint Evidence*. Boca Raton, Fla.: CRC Press, 1993. Comprehensive text offers a lengthy introduction to tire construction and the basics of tire tread patterns before turning to crime scene investigation. Topics covered include imprint recording, proper measurement techniques, identification systems, and the implications of tire imprint evidence in legal investigations. The types of cases addressed include those in which a suspect's vehicle is not present, those in which a suspect's vehicle is present, and traffic accidents. Real-world case studies are presented to illustrate important points.

Robbins, Louise M. *Footprints: Collection, Analysis, and Interpretation*. Springfield, Ill.: Charles C Thomas, 1985. Focuses on the anatomy and morphology of the human foot, explaining how these apply to the analysis of footprint evidence to identify or rule out suspects in criminal investigations. Discusses the collection of footprints at crime scenes only briefly.

Legal Issues

Brown, Michael F. *Criminal Investigation: Law and Practice*. 2d ed. Boston: Butterworth-Heinemann, 2001. Focuses on the relationship between criminal investigation and the workings of the legal system in the United States in describing the steps taken by investigators. Discusses the processing of crime scenes, the analysis of different kinds of evidence at forensic laboratories, and the procedures law-enforcement investigators follow in interviewing witnesses, interrogating suspects, and following leads. Also addresses how investigators and forensic scientists prepare to present courtroom testimony.

Hanzlick, Randy. *Death Investigation: Systems and Procedures*. Boca Raton, Fla.: CRC Press, 2007. Describes the principles and concepts of death investigations from a legal point of view, discussing the steps that must be taken throughout such cases as established by law. Topics covered include the different types of death investigations, the roles of coroners and medical examiners, the contents of autopsy reports, and the testimony of expert witnesses.

Kiely, Terrence F. *Forensic Evidence: Science and the Criminal Law*. 2d ed. Boca Raton, Fla.: CRC Press, 2006. Provides a brief history of forensic science and its involvement in the criminal justice system and then addresses the presentation in courtrooms of specific kinds of evidence, including hair analysis evidence, evidence concerning ballistics and tool marks, and evidence involving footprints and tire impressions. Each kind of evidence is discussed generally, and then specific examples from legal cases are offered.

Lissitzyn, Christine Beck. *Forensic Evidence in Court: A Case Study Approach*. Durham, N.C.: Carolina Academic Press, 2008. Uses case studies to illuminate the many aspects of forensic science and to show how intricately intertwined the various types of forensic evidence can become and their potential impacts in courtroom trials. Covers a plethora of topics, from DNA evidence to polygraph testimony.

Pyrek, Kelly M. *Forensic Science Under Siege: The Challenges of Forensic Laboratories and the Medico-legal Investigation System*. Burlington, Mass.: Elsevier Academic Press, 2007. Well-organized volume focuses on criticisms that have been directed toward forensic science laboratories, including allegations of incidents of false reporting of test results and failures to preserve and test evidence samples properly. Takes a direct approach in explaining problematic issues and in discussing the causes of quality-related shortcomings at some forensic labs.

Semikhodskii, Andrei. *Dealing with DNA Evidence: A Legal Guide*. New York: Routledge, 2007. Explains for defense attorneys the strategies they can use to try to minimize the role of DNA evidence in legal cases against their clients, given that DNA evidence is often condemning. Asserts that DNA evidence should not be given as much weight as it has come to be given, but instead should be treated as is any other piece of evidence. Describes the methods of DNA testing and points out the weaknesses in each method, suggesting related defense strategies.

Wecht, Cyril H., and John T. Rago, eds. *Forensic Science and Law: Investigative Applications in Criminal, Civil, and Family Justice*. Boca Raton, Fla.: CRC Press, 2006. Presents an extensive introduction to both forensic science and criminal law, then uses this background to explain the application of forensic investigative techniques and conclusions to legal cases. Uses real case examples to illustrate and clarify abstract legal and scientific concepts and procedures.

Postmortem Identification

Fairgrieve, Scott I. *Forensic Cremation: Recovery and Analysis*. Boca Raton, Fla.: CRC Press, 2008. Explains the processes of combustion and the effects of cremation on the human body. Describes the proper procedures for collecting evidence involving cremation, the analysis of such evidence, and the use of the findings to make positive identifications of decedents.

_______, ed. *Forensic Osteological Analysis: A Book of Case Studies*. Springfield, Ill.: Charles C Thomas, 1999. Collection of case studies addresses the identification of deceased persons based solely on skeletal remains. Shows how experts can derive a great deal of information from an individual's bones, such as height, weight, age, and sex; further, skeletal anomalies and pathologies can be compared against medical records of known individuals.

George, Robert M. *Facial Geometry: Graphic Facial Analysis for Forensic Artists*. Springfield, Ill.: Charles C Thomas, 2007. Brief work provides detailed description of the ways in which a person's facial construction can reveal much about that individual's identity. Topics addressed include facial geography, facial geometry, frontal graphic facial analysis, and lateral graphic facial analysis.

Tibbett, Mark, and David O. Carter, eds. *Soil Analysis in Forensic Taphonomy: Chemical and Biological Effects of Buried Human Remains*. Boca Raton, Fla.: CRC Press, 2008. Collection explains the ways in which soils that come into contact with human remains can affect death investigations. Describes how forensic scientists can examine the interactions of surrounding soils with decomposing bodies to determine such information as cause of death, time of death, and some circumstances relating to death.

Trace Evidence

Blackledge, Robert D., ed. *Forensic Analysis on the Cutting Edge: New Methods for Trace Evidence Analysis*. Hoboken, N.J.: John Wiley & Sons, 2007. Collection of essays by leading experts covers advances in the technologies and techniques that forensic scientists use to examine trace evidence. The types of evidence discussed include fingerprints, bloodstains, ink, fibers, glass, tapes, and residues from automotive air bags.

Houck, Max M., ed. *Mute Witnesses: Trace Evidence Analysis*. San Diego, Calif.: Academic Press, 2001. Collection offers a variety of viewpoints on many of the central concerns among experts related to the handling and interpretation of trace evidence.

_______. *Trace Evidence Analysis: More Cases in Mute Witnesses*. Burlington, Mass.: Elsevier Academic Press, 2004. Anthology presents nine real-life cases in which trace evidence played an important role, providing detailed information on the collection and analysis of the evidence in each case.

Robertson, James, ed. *Forensic Examination of Hair*. Philadelphia: Taylor & Francis, 1999. Collection provides comprehensive coverage of the forensic analysis of hair evidence, beginning with a primer on the physiology and growth of human hair. Contributors address topics such as techniques of hair and follicle examination, tests that can be conducted on human hair (including DNA testing and drug testing), and the value of hair analysis findings as evidence.

Robertson, James, and Michael Grieve, eds. *Forensic Examination of Fibres*. 2d ed. Philadelphia: Taylor & Francis, 1999. Provides extremely detailed information on the collection, preservation, and examination of fiber evidence, with in-depth description of the analytical techniques to which fiber samples are subjected in forensic laboratories.

Dwight G. Smith

Glossary

accelerant. Highly flammable chemical used in arson to speed up the burning of property and create maximum destruction from a fire.

acquittal. Decision reached by a judge or jury that a defendant is not guilty of the crime with which he or she has been charged.

actus reus. Act that violates the law; a guilty act.

admissible evidence. Legally adequate evidence that is relevant to proving or disproving a disputed issue in a court of law.

affidavit. Written statement that is taken under an oath and may become part of legal proceedings.

aggravated assault. Purposeful attack on another person that is intended to cause severe bodily harm.

algor mortis. Cooling of the body after death.

alias. Alternative name, often used to conceal the true identity of a person.

alibi. Statement that an individual could not have committed a particular criminal act because he or she was in another location at the time the criminal activity occurred.

alligatoring. Fire pattern in which deep cracking appears on a material surface. Such an indication of prolonged burning in a specific area may help to determine the point of origin of a fire.

alternate light source (ALS) instruments. Light sources employed in crime scene investigations that use filters or special bulbs to emit a narrow range of wavelengths that enable the detection of substances not visible under normal lighting.

amphetamines. Members of a class of drugs that enhance or stimulate the nervous system, increasing energy levels, reducing fatigue, and causing psychological exhilaration.

anabolic steroids. Synthetic chemicals that mimic the action of the hormone testosterone in the body, resulting in muscle growth.

anthropometry. Systematic study of the dimensions of the human body, particularly for purposes of comparison to identify individual persons. See also ***bertillonage***

appeal. Request to retry in a higher court a legal case that has already received a verdict in order to overturn the verdict. An appeal must be based on valid new evidence or novel reconsideration of original evidence.

arch fingerprint. Pattern of fingerprint in which the prominent ridges extend smoothly from one side, rise in the center, and continue through the opposite side of the print.

arrest. Apprehension of a suspected perpetrator of a crime by a law-enforcement officer during or after the commission of the crime.

arson. Illegal, malicious, and deliberate setting of a fire to destroy property.

asphyxia. Sudden or gradual deprivation of the body of a sufficient amount of oxygen to sustain life.

atomic absorption spectrophotometry. Technique used to determine the concentrations of metal elements in a sample based on the absorption of light energy by vaporized atoms.

authentication. Demonstration that an item is genuine.

automated fingerprint identification system. Computerized system that compares images of fingerprints with the images of prints stored in local, state, and federal databases to find potential matches.

autopsy. External and internal medical examination of a dead body to determine cause of death, identify the individual, or study changes caused by disease.

ballistic fingerprint. Distinctive marks etched on a rifle or handgun bullet as it is pushed through the gun's barrel.

ballistics. Field of physics concerned with the physical trajectories and impacts of projectiles (including bullets).

barbiturates. Members of a class of drugs that have sedative or depressing effects on the central nervous system.

bertillonage. System developed in the late nineteenth century by French criminologist Alphonse Bertillon to identify repeat criminal offenders by comparing their anatomical measurements. See also **anthropometry**

biological weapon. Weapon of mass destruction that is based on bacteria, viruses, fungi, and the toxins produced by microorganisms.

biometrics. Science of measuring the physical characteristics of individuals and using them for identification.

bite-mark analysis. Examination and comparison of wounds caused by biting during physical attacks.

blackmail. Attempt to gain money or other reward by the threat of inflicting violence on or exposing some wrongdoing of another; closely related to extortion.

blunt force trauma. Trauma caused to a body part by a blunt instrument or surface through physical impact, injury, or attack.

body farm. Outdoor facility where human remains are allowed to decompose under varying conditions so that forensic anthropologists and other scientists can study the processes that take place.

bribery. Attempt to influence the actions of a person performing a public duty by offering something of value to that person.

burden of proof. Requirement that the prosecution in a court case prove a particular issue for the defendant to be found guilty; in a criminal case, the prosecutor must demonstrate the guilt of the defendant beyond a reasonable doubt.

burglary. Deliberate and illegal entrance into a residence to steal property.

cadaver dog. Dog that is specially trained to find the scents associated with decomposing human remains.

casting. Production of three-dimensional models of impressions left by footwear, tires, or tools at crime scenes.

cause of death. Situation or illness that resulted in the loss of life.

chain of custody. Documentation of the location of physical evidence from the time it is collected until the time it is introduced at trial.

check kiting. Unlawful use of two or more checking accounts to write worthless checks, taking advantage of the time required for checks to clear.

check washing. Use of chemical substances to remove written information from signed checks so that the checks can be altered, enabling the fraudulent collection of funds from bank accounts.

chemical agent. Chemical compound with toxic properties that can be used to cause harm to humans, plants, and animals.

child abuse. Any action by an adult that harms a minor's mental, emotional, or physical state or impairs a minor's normal development.

chromatography. Laboratory technique used to separate chemical mixtures into their individual components and to quantify and identify the isolated components.

circumstantial evidence. Evidence that requires inferences to link it to the material facts of a case; also known as indirect evidence.

cocaine. Powerful drug that stimulates the central nervous system; derived from coca plants. See also **freebase cocaine**

coercion. Intimidation, deception, or physical force used to compel an individual to make a particular choice or take a particular action.

cognitive interview. Interview involving memory recall conducted with an individual who was present at a crime scene; the interviewer asks the subject to relive the event of interest, noting every physical and emotional detail.

cold case. Criminal case that has gone unsolved, often for a long period, and on which active investigation has ceased because the leads or evidence trails have gone cold.

common law. Body of law, going back to early English history, that arises from judicial decisions, rather than from written statutes, and reflects customs, tradition, and precedent.

competency. See **legal competency**

composite drawing. Artistic rendering of the facial features of unknown persons based on eyewitness information for use in narrowing law-enforcement searches.

computed tomography (CT) scanning. Form of radiography in which a three-dimensional image of a scanned object is created by computer from a series of sectional images of the object.

computer crime. Illegal intrusion into computers or computer networks or the use of computers for the perpetration of other crimes.

computer forensics. Examination of computers, computer networks, and communication devices for existing or deleted electronic evidence.

confession. Acknowledgment and admittance of guilt for a crime committed.

consensual crime. Criminal act carried out with the mutual consent of all parties involved.

controlled substance. Drug subject to regulation by law concerning possession and use.

contusion. Injury in which damaged blood vessels leak blood into surrounding tissues; also known as bruise.

conviction. Final determination that a criminal defendant is guilty, made as a result of a trial or a plea bargain.

coroner. Public official who investigates the circumstances of violent or suspicious deaths; a coroner may or may not be a physician. See also **medical examiner**

counterfeiting. Creation of false currency or other items that are intended to be used, sold, or passed off illegally as original or real.

crack cocaine. Form of cocaine that is manufactured through the process of extracting hydrochloride granules through heating; believed to produce a more intense high than powder cocaine.

credit card fraud. Form of identity theft in which a stolen credit card number is used to obtain goods or services fraudulently.

crime laboratories. Public and private facilities at which forensic specialists analyze materials collected from crime scenes for purposes of identification and interpretation.

crime scene. Location where a crime has occurred or where evidence of a crime is collected.

crime scene investigation. Collection and processing of physical evidence at a crime scene by forensic specialists using techniques and procedures designed to protect and preserve all evidence samples for analysis.

crime scene sketch. Representative depiction, annotated and with measurements marked, of the locations and appearances of features and objects found at a crime scene.

criminal investigation. Inquiry into and examination, processing, and evaluation of evidence concerning possible criminal activity based on logic, objectivity, and legal guidelines.

criminal personality profiling. Investigatory technique in which a detailed composite description of an unknown offender is constructed on the basis of crime scene evidence.

criminalistics. Employment of scientific principles in the evaluation of physical evidence to detect, analyze, and solve crimes.

criminology. Scientific study of crime and criminal behavior, including patterns and rates of crime and victimization, etiology of crime, social responses to crime, and crime control.

cross-examination. Attorney's questioning of a witness called by the opposing side in a court proceeding.

cross-projection. Technique used by crime scene investigators to sketch crime scenes in three dimensions.

cryptology. Scientific study of the hiding, disguising, or encryption of messages.

cyanoacrylate fuming. See **superglue fuming**

cybercrime. Crime committed through the use of the Internet and computers.

date rape. Rape committed by a person with whom the victim is voluntarily engaging in a social outing.

***Daubert* standard.** Set of guidelines established by the U.S. Supreme Court concerning the admissibility of expert scientific testimony: Scientific evidence must be based on a testable theory or technique, the theory or technique must be peer-reviewed, the technique must have a known error rate, and the underlying science must be generally accepted by the scientific community.

death certificate. Official document recording the fact of an individual's death.

decomposition. Process by which a cadaver is reduced to a skeleton through the destruction of the body's soft tissue.

defendant. Person accused of having committed a crime in a criminal case.

defense counsel. Attorney who protects the rights and argues the case of the defendant in a legal proceeding.

defensive wound. Injury received by a victim of a physical attack as the result of trying to fend off the attacker.

deoxyribonucleic acid. See **DNA**

direct evidence. Evidence that links directly to material issues in a legal case.

direct examination. Attorney's questioning of a witness called by that attorney to testify in a court proceeding.

DNA. Organic substance found in the chromosomes located in the nucleus of a cell that contains genetic material unique to an individual.

DNA fingerprinting. Procedure in which patterns of sequence variation in DNA samples are analyzed for the purpose of identifying individuals.

DNA profiling. Process of statistically analyzing the output of DNA typing results to determine the probability that another nonrelated individual in the general population might share the same exact DNA fingerprint as the one obtained in an evidence sample.

document examiner. Expert in the examination of questioned documents to establish their authenticity or origin through the analysis and comparison of handwriting, papers, inks, writing instruments, and other elements.

drug abuse. Illegal or improper use of substances that alter normal bodily function.

drug addiction. Physical dependence on a substance characterized by tolerance (need for greater amounts of the substance to achieve the same effect) and withdrawal symptoms accompanying the cessation of use.

drug paraphernalia. Products that have been created, modified, or adopted from their intended uses for the purposes of making, using, or concealing illegal drugs.

drunk driving. Operating or controlling a motor vehicle while under the influence of intoxicants; also known as driving under the influence, or DUI.

electrophoresis. Analytical technique that uses electrical fields to separate and analyze charged molecules.

embezzlement. Unlawful appropriation of money or property held in trust by one person for another.

energy-dispersive spectroscopy. Analytical technique used to construct an elemental profile of a sample of interest.

ethics. Principles of conduct, moral duty, and obligation that guide individuals in their decisions and actions.

evidence. Any form of proof pertaining to an aspect of a legal accusation that can be presented during trial for review by the jury and the judge.

exclusionary rule. Legal principle applied in U.S. courts that holds that evidence obtained in a manner that violates a defendant's constitutional rights is inadmissible in the defendant's prosecution.

exculpatory evidence. Evidence that is favorable for the defendant in a criminal trial; such evidence may clear the defendant or tend to show that the defendant is not guilty.

exhumation. Removal of a body from a grave or tomb, often for further study.

expert witness. Person who possesses specialized knowledge, training, or experience and testifies regarding that expertise in legal proceedings, with the purpose of assisting jurors in understanding an area with which they are unfamiliar.

explosive taggants. Tiny particles or chemicals that are added to explosives by manufacturers to enable authorities to identify the sources of the explosives if they are used in criminal activities.

extortion. Use of illegal threats by one party to obtain money or property from another; closely related to blackmail.

eyewitness testimony. Account given by a person who directly observed the commission of a crime or an action related to a crime.

facial reconstruction. See **forensic sculpture**

Federal Rules of Evidence. Rules governing the admission in U.S. federal courts of the facts that attorneys may use to prove their cases.

felony. Serious crime, usually punishable by a prison sentence (as opposed to a jail sentence) or death.

forensic. Adjective derived from the Latin word for "public," used to describe matters suitable for public discussion and debate, especially in public courts.

forensic accounting. Profession in which accounting, auditing, and investigative skills are applied to assist in legal investigations.

forensic anthropology. Study of human skeletal remains for the purpose of gathering evidence to be used in legal investigations and court proceedings.

forensic archaeology. Profession in which standard archaeological field methods are applied to the recovery of evidence from forensic scenes and archaeological theory and experimental research findings are applied in the interpretation of such scenes.

forensic entomology. Study of insects and their by-products for the purpose of gathering evidence to be used in legal investigations and court proceedings.

forensic geoscience. Scientific field that applies geological information and earth science techniques to investigations related to criminal or other legal proceedings.

forensic nursing. Application of forensic science techniques and nursing practice in proceedings that interface with the law.

forensic odontology. Study of teeth and dentition patterns for the purposes of identifying individuals, living or dead, and gathering evidence to be used in legal investigations and court proceedings.

forensic palynology. Study of pollens and spores for the purpose of gathering evidence to be used in legal investigations and court proceedings.

forensic pathology. Field of medicine in which a variety of techniques are applied to the examination of human remains with the aim of establishing the causes of unnatural deaths.

forensic photography. Photography used to document crime and accident scenes and to provide visual exhibits for legal proceedings.

forensic psychiatry. Field of medical practice that involves the application of medical expertise and research findings concerning mental health in legal contexts.

forensic psychology. Field of psychological practice concerned with assessment, consultation, psychotherapy, and the study of human behavior and thinking within judicial systems.

forensic science. Application of scientific knowledge and techniques to legal matters, particularly to criminal investigations.

forensic sculpture. Process in which sciences such as anthropology, osteology, and anatomy are combined with artistry to approximate, from human remains, parts of individuals in three-dimensional form for purposes of identification.

forensic toxicology. Application of the knowledge of poisons to the identification of cases of homicide, suicide, accidents, and drug abuse for legal purposes.

forgery. Manufacture or alteration of printed or electronic documents, literary works, or works of art with the intention to deceive and defraud.

fraud. Intentional misrepresentation or distortion of facts for some form of gain.

freebase cocaine. Purest form of cocaine, created through the extraction of hydrochloride from powder cocaine.

***Frye* standard.** Legal test that requires the trial court to determine whether a scientific theory or scientific method used to generate evidence is generally accepted as reliable in the scientific community.

gas chromatography. Separation technique used in the qualitative and quantitative analysis of evidence samples.

geographic information system. Computer-based mapping system that can store, retrieve, and analyze relationships among geographically referenced or geospatial data; used by law-enforcement agencies to map crime and carry out strategic planning.

geographic profiling. Use of information about geographic locations and their connections to draw conclusions about the probable characteristics and identity of unknown criminal offenders.

grid search. Search of a crime scene in which investigators methodically follow a grid pattern to maximize the likelihood of finding evidence while minimizing the likelihood that they will fail to discover evidence.

guilty but mentally ill. Legal plea or verdict in which the defendant admits committing the crime but claims to have been mentally incompetent at the time.

gunshot residue. Burned, partially burned, and unburned powder and primer that are released as a firearm is discharged.

habeas corpus. Court order to bring a person being detained before a court or judge to determine whether the person's imprisonment is lawful.

hallucinogen. Synthetic or natural chemical substance that causes alterations of perception, including but not limited to changing what users see, hear, feel, taste, smell, and experience about themselves and their relationship to the world and others.

handwriting analysis. Examination of samples of handwriting, usually to establish validity, fraud, or forgery.

hate crime. Criminal act targeted specifically toward a member of a particular group (whether based on race, ethnicity, sexual orientation, age, gender, or some other characteristic) because of the person's membership in that group.

heroin. Highly addictive opiate drug that is chemically converted from morphine to a solid crystalline form.

hesitation wound. Tentative, superficial injury caused by uncertain movement or pausing in the use of a sharp-edged weapon in an attack or suicide.

high-performance liquid chromatography. Technique used in the separation, detection, and identification of the pure compounds that are present in a mixture.

hit-and-run incident. Situation in which the operator of a motor vehicle causes damage to other persons or property with the vehicle and flees the scene before law-enforcement authorities arrive.

homicide. Death of a human being caused by the act of another. See also **involuntary manslaughter**; **murder**; **voluntary manslaughter**

hypothesis. Tentative assumption that can be tested for validity.

identity theft. Illegal appropriation of another person's personal data for the purpose of gain or profit.

immunity from prosecution. Exemption from being tried in a criminal case in exchange for providing testimony or information that is valuable to the state's prosecution of another.

impression evidence. Evidence that takes the form of an alteration of a surface resulting from contact with a body part or object; includes bite marks, fingerprints, footprints, knife cuts, tire tracks, and tool marks.

inculpatory evidence. Evidence that tends to establish the guilt of a defendant.

indictment. Document that officially charges one or more persons with a criminal offense.

informant. Person who provides information to law-enforcement authorities concerning the parties involved in crimes, often in exchange for some kind of consideration, such as money or immunity from prosecution.

inhalant. Product containing chemicals that emit fumes that, when inhaled, can cause altered mental status.

insanity defense. Legal defense tactic used in the hope of reducing the culpability of criminal defendants by asserting that when they committed their crimes they were incapable of distinguishing between right and wrong, they were unable to resist their impulses, or their criminal actions were products of mental defects or diseases. See also **guilty but mentally ill**

interrogation. Questioning of suspects by law-enforcement personnel to determine their possible involvement in criminal activity under investigation.

involuntary manslaughter. Unintentional killing that results from failure to perform a legal duty to safeguard human life, from the commission of an unlawful act not amounting to a felony, or from the commission of a lawful act involving a risk of injury or death that is done in an unlawful, reckless, or grossly negligent manner.

iodine fuming. Technique used to make latent fingerprints visible.

iris recognition system. Computer-assisted system that identifies individuals based on comparisons of patterns in the irises of the eyes.

judge. Appointed or elected public official who is charged with authoritatively and impartially resolving disputes presented in a court of law.

jurisdiction. Authority of a law-enforcement agency to investigate or a court to decide a given case; also refers to the geographic area within which an agency or court has authority.

jury. Group of persons selected at random who are sworn to consider the facts and evidence in a legal case to arrive at a verdict.

kidnapping. Unlawful detention of a person by force against the person's will.

laceration. Wound with torn or ragged edges.

lands and grooves. Raised and indented characteristics of the rifling in the barrel of a firearm; the marks made by lands and grooves on bullets fired are distinctive to individual weapons.

latent fingerprint. Fingerprint impression that cannot be seen under normal conditions.

legal competency. Individual's capacity to understand the nature and purposes of his or her legal rights and obligations.

less-lethal weapons. Weapons designed to force compliance with the wielders' orders, but not to maim or to kill.

lineup. Law-enforcement investigative tool in which a crime suspect and other people who look similar to the suspect (typically six persons in all) are placed side by side in a room where they can be viewed by an eyewitness for identification purposes.

livor mortis. Discoloration that occurs in the skin of a corpse shortly after death as a result of the gravitational settling of pooled blood; also known as lividity.

Locard's exchange principle. Dictum that holds that whenever two objects come into contact, each leaves some trace or residue on the other that can be detected through careful examination.

loop fingerprint. Pattern of fingerprint in which the ridges enter from either side of the print, recurve, and tend to pass out on the same side where they entered.

luminol. Chemical substance widely used in presumptive or nonspecific tests for blood during crime scene examinations.

M'Naghten rule. First formal test of legal insanity, developed in Great Britain in 1843; focused on whether the defendant's insanity prevented him or her from knowing what he or she was doing or knowing the difference between right and wrong when the crime was committed.

manner of death. Way in which a death was caused, determined by a coroner or medical examiner as falling into one of five classifications: natural, accidental, homicide, suicide, or undetermined.

manslaughter. See **involuntary manslaughter**; **voluntary manslaughter**

marijuana. Drug derived from the dried leaves and flowering tops of cannabis plants; when smoked or eaten, marijuana alters an individual's mental state.

mass spectrometry. Analytical technique in which ions of a sample are formed and subsequently separated according to their mass-to-charge ratio.

measurement marker. Easily recognizable object of known size that a forensic photographer places next to an item of evidence for comparison purposes before taking a crime scene photograph.

medical examiner. Physician or forensic pathologist responsible for investigating the circumstances of suspicious or violent deaths. See also **coroner**

mens rea. Criminal intent.

methamphetamine. Powerful neurological stimulant drug that influences heart rate, body temperature, blood pressure, appetite, alertness, and mood.

Miranda warnings. Information about certain constitutional rights that law-enforcement personnel in the United States must provide to persons in custody before questioning them; so-called Miranda rights include the right to remain silent and the right to legal counsel.

misdemeanor. Minor crime punishable by a fine or imprisonment for a relatively brief period (less than one year in most U.S. jurisdictions).

Model Penal Code. Code of criminal provisions developed by the American Law Institute and intended to standardize criminal law among the various states.

modus operandi. Method by which a crime is carried out.

morphine. Opiate drug, used medically for pain relief, derived from the principal alkaloid of opium through boiling and filtration techniques.

motive. Reason a person commits a crime.

murder. Intentional unlawful killing of a human being by another.

narcotic. Drug that causes a stuporous effect, used medically in low doses to relieve pain.

narcotic tolerance. Physical need for increasing quantities of a narcotic drug to achieve a given level of effects.

National Crime Information Center. Central U.S. database for crime-related information, maintained by the Federal Bureau of Investigation and available electronically to local, state, and federal law-enforcement agencies.

neighborhood check. Systematic survey conducted by law-enforcement personnel near a crime scene in the search for investigative leads.

neutron activation analysis. Method of determining the presence and composition of trace elements in a substance by bombarding the sample with neutron particles.

oblique lighting analysis. Examination technique that involves lighting an object from different angles to enhance the visibility of its surface features.

offender. Perpetrator of a crime.

opiate. Compound derived from the opium poppy; opiate drugs include codeine, morphine, and opium.

oral autopsy. Examination of the mouth and teeth of a deceased person, usually for the purpose of establishing identity.

organized crime. Criminal activities of highly organized, disciplined associations engaged primarily in illegal operations for monetary gain.

paraffin test. Method formerly used to determine whether a person had recently fired a firearm; the hands were coated with melted paraffin, and then the cooled paraffin casts were examined for the presence nitrates from gunpowder.

paranoia. Mental disorder characterized by fixed delusions, typically involving persecution.

parole. Release of a prisoner, generally subject to conditions, before the individual's sentence has been completed.

partial fingerprint. Fingerprint consisting of only a portion of a pattern area.

PCP. See **phencyclidine**

pedophilia. Sexual attraction to children.

perjury. Deliberate false statement made under oath.

phencyclidine. Powerful synthetic hallucinogen originally developed as an anesthetic.

physical evidence. Any item of a tangible nature that may be of importance during an investigation or may be used to prove facts in a judicial proceeding.

pistol. Handgun that operates on the inertia or blowback principle: When a pistol is fired, the force of the discharge ejects the fired casing, loading and cocking the weapon for the next firing.

plea bargaining. Legal practice in which an agreement is reached between a prosecutor and a defendant that disposes of a criminal matter; generally, the defendant agrees to plead guilty in exchange for a reduction of charges.

police. Officers of municipal law-enforcement agencies whose primary mission is to protect their communities from crime and other threats.

police artist. See **composite drawing**

police detective. Police officer who specializes in criminal investigations.

police lineup. See **lineup**

pollen rain. Release of vast amounts of pollen by male flowering plants within a given ecological landscape.

polygraph. Instrument designed to detect deception on the part of a person being interviewed through the measurement of physiological changes in that individual's body in response to questioning.

pornography. Material depicting erotic behavior that is intended to arouse sexual excitement.

postmortem interval. Length of time since death.

precipitin test. Method used to determine whether a blood sample is of animal or human origin.

predatory criminal. Type of offender who commits crimes that involve confrontation and the selection or stalking of vulnerable victims.

preliminary hearing. Judicial examination of the arrest and charges brought against a person accused of a crime.

preliminary report. First formal report by a law-enforcement investigator concerning a criminal offense, used as the foundation for all subsequent reports.

premeditation. Degree of planning and forethought sufficient to indicate the intention to commit a crime.

presumptive test. Screening test, usually using a chemical reagent, that provides tentative identification of an unidentified substance at a crime scene or in the laboratory.

priority assignment. Method of organization used by law-enforcement agencies in which personnel are assigned to investigations based on the cases' perceived importance.

Privacy Act of 1974. Federal law designed to protect individuals' rights to privacy; prohibits government agencies from reviewing or releasing information on individuals unless certain conditions are met.

private investigator. Non-law-enforcement investigator who is paid by private citizens or organizations to gather information on private matters, generally of a civil rather than criminal nature; also known as a private detective or private eye.

privileged communication. Communication between two individuals whose confidentiality the law protects (such as attorney and client or physician and patient) that takes place in circumstances in which the parties intend for the communication to remain secret. Such communication cannot be admitted into evidence in a judicial proceeding without the permission of the parties involved.

probable cause. Reasonable belief, based on available information, that a person is connected to a crime; the standard of probable cause must be met for police to make an arrest, conduct a search of a person or the person's property, or obtain an arrest warrant.

probation. Conditional sentence that allows a convicted offender to avoid imprisonment as long as the offender abides by the requirements of the court.

profiling. See **criminal personality profiling**

progress report. Report created during a law-enforcement investigation to document formally the progress of investigative efforts.

prosecutor. Attorney who acts on behalf of the government during a criminal proceeding.

psychological profiling. See **criminal personality profiling**

psychopath. Individual with a psychological disorder characterized by egotistical, self-centered, impulsive, and exploitative behaviors, lack of remorse, and emotional callousness.

putrefaction. Stage in the decomposition of animal proteins in which flesh and tissue are broken down by the action of anaerobic microorganisms.

pyromaniac. Individual with a mental illness characterized by a compulsive need to set fires.

racial profiling. Police practice of using race or ethnicity as a primary reason for stopping, questioning, searching, or arresting potential suspects.

radial fracture line. Fracture in a glass surface that results from the bending of the surface toward a striking force, causing jagged lines from the point of impact outward.

rape. Criminal act of engaging in sexual intercourse with a person against that person's will.

rape kit. Package of examination materials used by a doctor or nurse (examiner) for gathering evidence from a victim following a sexual assault.

reagent. Substance that brings about a chemical reaction when added to another particular substance.

reasonable doubt. Absence of moral certainty of a defendant's guilt.

recidivism. Relapse into criminal behavior by persons who have previously been arrested or imprisoned for criminal activity.

rectangular-coordinate method. Crime scene sketching technique in which two right angles are drawn from an evidence item to the nearest permanent object.

response time. Amount of time that elapses between a law-enforcement agency's receipt of a complaint or call for service concerning a crime and the arrival of officers at the crime scene.

revolver. Handgun in which a revolving multi-chambered cylinder aligns with the barrel prior to discharge.

rigor mortis. Temporary stiffening of the cardiac and skeletal muscles that takes place shortly after death as a result of chemical changes within the muscular tissue.

rip attack. Method of safe burglary in which the exterior metal sheets of the safe are peeled from a weakened corner location.

robbery. Taking of property from a person in the person's presence by the use of force or threat of force.

sadism. Sexual perversion in which pleasure is gained from the infliction of pain on a living thing.

sanity hearing. Judicial procedure in which one or more psychiatric experts testify regarding their evaluations of the defendant's mental status.

search warrant. Court order that authorizes police to search a specific location for certain articles and to seize and produce those articles before the court.

sector search. Search of a crime scene in which investigators divide the location into equal areas to maximize the likelihood of finding evidence while minimizing the likelihood that they will fail to discover evidence.

self-incrimination. Statements or actions of a person that tend to suggest that the individual committed a crime.

semen. Male reproductive fluid; normally contains spermatozoa, reproductive cells carrying male genetic material.

serial offending. Commission by one offender of three or more separate but related crimes with "cooling off" periods between the acts.

sobriety testing. Measures taken by law-enforcement officials to determine whether persons are intoxicated in situations in which being intoxicated is dangerous or unlawful.

spectrophotometer. Instrument used to identify substances through the measurement of light absorption.

spiral search. Search of a crime scene in which investigators move through the scene in an ever-expanding circular fashion from the center to the outer perimeter to maximize the likelihood of finding evidence while minimizing the likelihood that they will fail to discover evidence.

statute. Law enacted by the legislative branch of a government.

statutory rape. Sexual intercourse with an individual under a legally specified age of consent; this act is illegal even if the underage person willingly consents to participate.

sting operation. Law-enforcement tactic in which officers simulate criminal operations in order to catch offenders as they carry out criminal acts.

strip search. Search of a crime scene in which investigators divide the scene into long, narrow sections that are then searched from one end to the other; often multiple searchers walk shoulder to shoulder in a line that moves simultaneously across an area. Also known as a linear search.

subpoena. Writ commanding a person to attend a judicial proceeding.

substance-detection dog. Dog trained to work with a handler to discover, through scent, contraband items and hazardous materials associated with criminal activities or security threats.

suicide. Act of intentionally killing oneself through one's own effort or with the assistance of another.

summons. Judicial instrument used to initiate a legal proceeding or to command the appearance of a person before a court or other body.

superglue fuming. Use of the fumes of cyanoacrylate esters to develop and preserve fingerprints.

surveillance camera. Video or still camera, often mounted on an elevated location in a public area such as a highway or parking lot, used to monitor activity and record criminal acts for possible use as evidence in prosecutions.

suspect. Person under investigation for possible criminal activity who has not yet been charged.

terrorism. Coercive use of violence or threat of violence to terrorize a community or society to achieve political, economic, or social goals.

testimony. Statement made in a legal proceeding by a witness under oath.

tests of suitability. Three standards used to establish if an item has importance in a legal case: The evidence must be competent, relevant, and material.

tool mark. Impression left on a surface as the result of forceful contact between a tool and the surface.

toxicology. See **forensic toxicology**

trace evidence. Evidence present in very small amounts, requiring careful attention, and often special techniques, to detect.

trajectory. Flight path of a projectile, such as a bullet.

transfer evidence. Evidence that has moved from one person or object to another (such as from an offender to a crime victim) through contact or near contact.

triangulation. Method used in crime scene documentation in which measurements are taken from two fixed points to an item of evidence, forming a triangular frame of location.

ultraviolet light. Radiation in wavelengths beyond the violet, visible end of the light spectrum.

verdict. Formal decision reached by a jury or judge on matters of fact submitted for deliberation and determination in legal proceedings.

vigilantism. Illegal assumption of law-enforcement responsibilities by private citizens.

voiceprint. Visual representation of an individual's voice based on biometric measurements.

voluntary manslaughter. Unintentional killing that results from an intentional act done without malice or premeditation and while in the heat of passion or on sudden provocation.

war crimes. Crimes against humanity committed during armed conflicts that go beyond the acts normally considered permissible in wartime.

white-collar crime. Nonviolent criminal offenses committed by workers of the salaried class.

whorl fingerprint. Pattern of fingerprint in which the ridges encircle a central plain.

withdrawal symptoms. Mental and physical effects produced by the sudden cessation of the ingestion of addictive drugs.

witness. Person who offers testimony in a legal proceeding; also used to refer to a person who was present when a crime took place.

witness interviewing. Questioning of persons who were present when a crime took place (including victims) by law-enforcement personnel to gain information to further the investigation of the crime.

Dwight G. Smith

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