BIOLOGICAL ANOMALIES: MAMMALS II

Compiled by:

William R. Corliss

A CATALOG OF BIOLOGICAL ANOMALIES

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PREFACE

After more than twenty-six years of scouring the scientific and semiscientific literature for anomalies, my major observation is that the search has been most fruitful. In fact, I have wondered why the scientific community itself has not been systematically compiling such information. It is surprising that a Catalog of Anomalies does not already exist to guide scientific thinking and research. It is at least as important to recognize what is anomalous as it is to realize what is well-explained in terms of prevailing paradigms. With this outlook and philosophy, here is the sixteenth volume of such a Catalog. It is largely the product of one person's library research. This work has been carried forward entirely through the sale of these Catalog volumes and associated publications.

Under the aegis of the Sourcebook Project, I have already published 32 volumes, totalling roughly 13,000 pages source material on scientific anomalies. (See page iv for a list of titles.) As of this date, these 32 volumes represent only about 40% of my data base. New material is being added at the rate of about 1,200 new items per year, about 700 of which come from the current scientific literature. This acquisition rate could easily be multiplied several-fold just by spending more time in libraries. Even after twenty-six years, only a handful of English-language journals have received my serious attention. The journals in other languages, government reports, conference papers, publications of research facilities, proceedings of state academies of science, and an immense reservoir of pertinent books remain almost untapped. Every library foray uncovers new anomalies; the world's libraries are bulging with them.

Given this rough assessment of the extent of the anomaly literature, one can understand why the Catalog of Anomalies will require at least 30 volumes, many of them larger than the one you now hold. I visualize a shelf of these 30 volumes, or an equivalent CD, accompanied by master indexes, to be the logical initial step in providing scientists with access to what, in my opinion, is not well-explained. The underlining of "my" is significant because anomalousness is often in the eye of the beholder. It depends upon how well one is satisfied with those explanations based on currently accepted paradigms. In the Catalog of Anomalies, the data rule; all theories and hypotheses are considered tentative. The history of science, from the luminiferous ether to the static continents, demonstrates that this is a wise policy.

Will the Catalog of Anomalies impact science significantly? Probably not---at least not right away. Quite often the initial reaction to the volumes already published has been disbelief and even disdain. The data must be in error; the data are too often anecdotal; the data are too old; the purported anomaly was really explained long ago. Germs of truth reside in such complaints. Some science and some observations reported in the Catalog are certainly bad; but this is minimized by a heavy reliance upon respected journals. In addition, the baseline of well-established theories---against which anomalousness in measured---is always shifting. And for every anomaly that can be explained away, a trip to a library will quickly replace it with ten more from impeccable sources. Nature is very anomalous or, equivalently, Nature is not yet well-understood. Much remains to be done in both anomaly research and in the resulting scientific research that will ultimately dispose of these anomalies.

William R. Corliss

P.O. Box 107
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September 1, 1996.

"ROUND ABOUT THE ACCREDITED AND ORDERLY FACTS OF EVERY SCIENCE THERE EVER FLOATS A SORT OF DUST-CLOUD OF EXCEPTIONAL OBSERVATIONS, OF OCCURRENCES MINUTE AND IRREGULAR AND SELDOM MET WITH, WHICH IT ALWAYS PROVES MORE EASY TO IGNORE THAN TO ATTEND TO .... ANYONE WILL RENOVATE HIS SCIENCE WHO WILL STEADILY LOOK AFTER THE IRREGULAR PHENOMENA. AND WHEN THE SCIENCE IS RENEWED, ITS NEW FORMULAS OFTEN HAVE MORE OF THE VOICE OF THE EXCEPTIONS IN THEM THAN OF WHAT WERE SUPPOSED TO BE THE RULES."

William James

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HOW THE CATALOG IS ORGANIZED

Purpose of the Catalog

The Catalog of Anomalies is designed to collect and categorize all phenomena that cannot be explained readily by appealing to prevailing scientific paradigms. Such phenomena are termed "anomalies." Following its definition, each anomaly is rated in terms of: (1) its substantiating data; and (2) the seriousness of the challenge it poses to mainstream paradigms. Next, important examples of the anomaly are recorded, some of the more interesting ones in greater detail. Finally, all the examined references are listed. Thus, the Catalog is a descriptive guide as well as a reservoir of examples of the phenomena along with their supporting references. Science researchers thus have a substantial foundation for beginning further investigations of these intriguing phenomena. In short, the basic purposes of the Catalog are: the collection and organization of the unknown and the poorly explained in order to facilitate future research and explanation.

General Plan of the Catalog

It was tempting to organize this Catalog alphabetically, making it an "encyclopedia of anomalies." But many of the phenomena have obscure names or, even worse, no names at all. Under these circumstances, alphabetical access to the data base would be difficult. Therefore, a system of classification was designed based upon readily recognized aspects of nature, such as lightning or mammal morphology. The universe of anomalies is first divided into nine general classes of scientific endeavor, as illustrated in the diagram on the following page. Few people would have difficulty classifying a phenomenon as biological, astronomical, geological, etc. The second, third, and fourth levels of classification are also based upon generally recognized aspects of nature. The similarity of this sort of classification to that employed in natural-history field guides is quite intentional. Like bird identification, phenomenon classification soon becomes second nature. In fact many of the phenomena described in this Catalog are accessible to anyone with normal senses and, particularly in astronomy, a little optical help.

Most catalogs employ numbering systems, and this one is no exception. Rather than use a purely numerical system, the first three levels of classification are designated by letters. The triplets of letters selected have some mnemonic value. Thus, a BMU anomaly is easily recognized as belonging to the biology class (B); as involving mammals (other than human) (M); and as concerning currently unrecognized mammals (U). The number added to the triplet of letters marks the fourth classification level, so that BMU4 applies to the minhocao, a possible giant armadillo, as indicated in the diagram on the next page. Every type of anomaly has such a unique alphanumeric code. All cross references and indexes are based on this system. Catalog additions and revisions are made easier with this approach.

These codes may seem cumbersome at first, but their mnemonic value to the compiler has been considerable. The codes are simple, yet they are flexible enough to encompass the several thousand types of anomalies in the several diverse scientific disciplines that have so far been investigated.

A glance through this volume will reveal that each entry for an anomaly type bears an X-number, and each reference an R-number. BMU4-X1 therefore specifies the first entry for the purported minhocao. BMU4-R1 is the first reference in this creature's bibliography.

First-order classification	Second-order classification	Third-order classification	Fourth-order classification
A Astronomy	A Arthropods	A Appearance & Morphology	1 MacFarlane's bear
B Biology	B Birds	B Behavior	2 The onza
C Chemistry & Physics	C Biochemistry	**C Chemistry & Physics**	3 De Loys' ape
E Earth Sciences	F Fish	**E Bones & Artifacts**	4 The minhocao
G Geophysics	G Genetics	**F Bodily Functions**	5 The king cheetah
L Logic & Math	H Humans	**G Genetics**	
M Archeology	I Animals without Skeletons	H Health	
P Psychology	L Microorganisms	**I Internal Structure**	Other BMU Entries
X Unclassified	**M Mammals**	**O Organs**	
	P Plants & Fungi	T Talents and Faculties	
	R Reptiles & Amphibians	**U Unrecognized Species**	
	X Life Processes	**X Interactions with Other Life Forms**	
		Z Interactions with Other Entities	12 Cetaceans with two dorsal fins

Bold-face subjects are covered in this volume

CATALOG CODING SCHEME

How Data and Anomalies Are Evaluated

Each anomaly type is rated twice on four-level scales for data "validity" and "anomalousness", as defined below. These evaluations represent only the opinion of the compiler and must be considered only rough guides.

Data Evaluation Scale

1 Many high-quality observations. Almost certainly a real phenomenon.

2 Several good observations or one or two high-quality observations. Probably real.

3 Only a few observations, some of doubtful quality. Phenomenon questionable.

4 Unacceptable, poor-quality data. Such entries are included only for purposes of comparison and amplification.

Anomaly Evaluation Scale

1 Anomaly cannot be explained by modifications of present laws. Revolutionary.

2 Can probably be explained through relatively minor modifications of present scientific laws.

3 Can probably be explained using currently popular theories. Primarily of curiosity value.

4 Well-explained. Included only for purposes of comparison and amplification.

Referring to the evaluation scales above, it should be remarked that anomalies that rate "1" on both scales are very rare. Such anomalies, however, are the most important because of their potential for forcing scientific revolutions.

Anomaly Examples

Examples of anomaly types and the entries discussing them are designated by the letter X in the body of the Catalog. Except in the cases of extremely common phenomena, such as ball lightning, all of the examples discovered so far are entered. If the example is of the "event" type, time and place are recorded if they are available. Such data are the basis of the Time-of-Event and Place-of-Event Indexes, which could in principle lead to the discovery of obscure cause-and-effect relationships. When library research has unearthed a great many examples of a specific anomaly, only the more interesting and instructive are treated in detail. In all examples and entries, direct quotations from eye-witnesses and scientific experts are employed to covey accurately the characteristics and significance of the phenomenon.

The References and Sources

Each anomaly type and the examples of it are buttressed by all references that have been collected and examined. Since some references deal with several examples, each reference includes the X-numbers of the examples mentioned. When a reference covers more than one type of anomaly, it is repeated in each anomaly bibliography. Actually, there is little repetition of this sort in the Catalog.

Perusal of the Source Index will demonstrate that the great majority of the references employed comes from the scientific literature. Heavily represented in this volume of the Catalog are such journals as: Nature, Science, and Journal of Mammalogy. Some less technical publications are also used fairly frequently, such as Science News and the New Scientist. All of the serials just mentioned are generally very reliable, although one must always be wary when dealing with anomalous phenomena. In addition to these often-referenced publications, a wide spectrum of other journals dealing with biology have been found useful here. In contrast to the preceding Catalog volumes, books, both scientific and popular, have played a more important role in biology.

The sources consulted date from the beginning of organized science some 200 years ago. The great bulk of the references, however, comes from the past 80 years. In biology, especially, the explosive growth of the data base in remarkable. Indeed, advances are being made so rapidly in natural history and biology that some things printed in this volume will be outdated before the books leave the bindery.

The Indexes

Most Catalog volumes conclude with five separate indexes. At first glance this may seem to be too much of a good thing, but in the context of a science-wide endcavor each index helps tie the whole together. It is quite apparent, though, that most biological phenomena are not of the "event" type. Therefore, the Time-of-Event and Place-of-Event Indexes are not included in the Series-B volumes.

The Source Index shows immediately the dependence of this Catalog upon the scientific literature rather than newspapers and other popular publications. Its real purpose, though, is the rapid checking of newly acquired references to determine whether they have already been caught in the fishing net of the library-research aspect of the Catalog effort. The Source Index is doubly valuable because many footnotes and bibliographies in the scientific literature omit article titles and, sometimes, even authors! The researcher also comes across vague references to such-and-such an article by so-and-so back in 1950 in Nature. In such cases, the rather ponderous Source and First-Author Indexes can help pin down references lacking in specifics.

The three Indexes use the Catalog codes described above rather than page numbers. The codes are permanent whereas page numbers would change as volumes are revised. The mnemonic value of the Catalog codes is evident here, too, because the approximate nature of each Index entry is readily apparent, while page numbers provide only location.

Supporting Publications of the Sourcebook Project

The Catalog volumes curently being published are actually distillations of huge masses of source material. The Sourcebook Project has already published 32 volumes of such material, as detailed on p. iv. Phase I of the Sourcebook Project resulted in ten loose-leaf notebooks called "Sourcebooks." To meet the demands of libraries, Phase II supplanted the Sourcebooks with a series of six "Handbooks," which are casebound, much larger, and more comprehensive than the Sourcebooks. Phase III, now in progress, is the cataloging phase. This consists of systematizing the data base, which now comprises some 40,000+ articles, and the publication of the "Catalogs."

Catalog Addenda and Revisions

Over 1200 new reports of anomalies are collected each year from current and older scientific journals. New anomaly types and additional examples of types already cataloged are accumulating rapidly. When sufficient new material has been assembled, Catalog volumes will be revised and expanded.

The Sourcebook Project welcomes reports of scientific anomalies not already registered in extant Catalog volumes. Reports from scientific journals are preferred, but everything is grist for the anomaly mill! Credit will be given to submitters in new and revised Catalog volumes. If the reports are from current literature, they may be mentioned in Science Frontiers, the Project's newsletter. Send data to: Sourcebook Project, P.O. Box 107, Glen Arm, MD 21057, USA.

BM INTRODUCTION: Volume II

This is the sixteenth volume in the Catalog of Anomalies. It completes a pair devoted to those 4,400+ mammals other than humans. Three separate volumes of human biological anomalies have already been published. While additional volumes on birds, reptiles, fish, invertebrates, plants, etc. will follow in due course, a cataloging excursion into archeology will follow the forthcoming volume on avian anomalies. It should not be be assumed that this temporary change of direction is due to a paucity of anomalies associated with the other classes and phyla of life. If anything, the opposite is the case!

In content, this second volume on mammalian biological anomalies parallels Humans II and Humans III in its focus on internal anatomy, genetics, the fossil record, unrecognized species, etc. Mammals I, in contrast, deals primarily with the "external atttributes," such as external morphology, behavior, and faculties.

As with the preceding four catalog volumes in biology, catalog entries in the present work range from outrageous heresies to mere curiosities. Of course, the evolutionary paradigm, that great unifier of modern biology, receives most of the scrutiny. It is by far the biggest target for an anomalist. Not far behind is that dictum of the behaviorists that insists that nonhuman mammals are simply unreasoning, instinct-driven automatons. The iconoclastic approach of the Catalog of Anomalies may well offend those used to the reverent attitude adopted by most writers on biology, whether popular or professional. Anomalists are by definition confrontational; they dote on major and minor mysteries; they see problems everywhere. Understandably, this attitude grates on the mainstream scientist.

Biologists should not feel singled out in all this. The preceeding eleven volumes on geophysics, astronomy, and geology treat those disciplines in the same doubting, suspicious way. Indeed, biological anomalies are often closely linked to phenomena from these other disciplines. Geology's fossil record is key to fleshing out the development of life, from its origin(s) through its radiations and extinctions. Astronomy, too, contributes with its inputs to climate changes, the biological devastation of asteroid/comet impacts, and, possibly, the synthesis of prebiotic chemicals, perhaps even life itself, in outer space. The attitude of the anomalist may seem "bad" to a mainstream scientist, but it is eclectic, evenhanded, and ever-inquiring.

BMC CHEMICAL AND PHYSICAL PHENOMENA

Key to Phenomena

BMC0 Introduction

The purpose of this chapter is to collect those mammalian biological phenomena that are basically chemical. By "chemical" we mean, for example, the rare (for mammals) ability to secrete venom and the inability of some mammals to produce ascorbic acid (vitamin C).

For the anomalist, the most significant sections of the chapter are those where the familiar evolutionary scenarios are weakened by protein sequencing and blood typing, particularly those instances where no transitional biochemical forms can be found between major classes of life forms. Finally, as always in the Catalog of Anomalies, one finds many engaging conundrums, such as why mammalian red blood cells should lack nuclei when the cells of birds and reptiles have them.

BMC1 Biochemicals that Challenge Evolution

Description. The presence in some mammals of biochemicals that, in one way or another, seem to defy the usual evolutionary explanations. These challenges to evolution fall into five categories: (1) a high degree of innovation; (2) a high degree of chemical complexity; (3) innovative applications; (4) convergence in animals widely separated taxonomically; and (5) commonly occurring biochemical phenomena that are detrimental in today's environments.

Data Evaluation. Most data come from scientific journals and authoritative works by recognized scientists and naturalists. Rating: 1.

Anomaly Evaluation. Any phenomenon that challenges the concept that animals have evolved through random mutation and natural selection is highly anomalous. However, random mutation plus natural selection can, in principle, explain virtually every biological phenomenon---given enough time. In view of this, most challenges to evolution are not assessed for anomalousness. Rather, we simply register our suspicion that other natural processes may be involved that accelerate and/or shape evolutionary processes.

Possible Explanations. "Adaptive" or "directed" evolution. Convergent evolution may involve the R. Sheldrake's controversial notion of morphic resonance!

Similar and Related Phenomena. See the Subject Indexes in the Series-B catalogs under: Coevolution, Evolution, adaptive; Evolution, convergent; Complexity, Innovation; Morphic resonance.

Entries

X1. Anticoagulants. For those few animals that make a living by consuming the blood of other animals (vampires), the ability to apply an anticoagulant to the prey's wound is an obvious advantage. Some mosquitoes, some leeches, and three species of vampire bats have developed the biological equipment to do this.

All anticoagulants used by vampires seem to be enzymes, but our sources do not reveal whether all vampires use the same enzyme. In any event, it is remarkable that such distantly related species have all found ways to generate anticoagulants and apply them effectively. Either these innovations arose separately three times or more---through random mutations---or anticoagulants and the equipment needed to apply them represent still another example of remarkable biological convergence.

Vampire bats. The anticoagulant in the saliva of vampire bats is usually stated to be an enzyme (R4). Presumably, this enzyme is produced by the salivary glands. In actuality, however, this enzyme is only one component of the vampire bats' armory. Bat saliva also includes additional active ingredients that; (1) keep red blood cells from clumping together; and (2) inhibit the constriction of veins near the wound. (R11)

Together, these three factors are extremely effective. Vampire-bat incisions may bleed for as long as 8 hours. (R7) Humans bitten in their beds awaken to very bloody sheets.

Added to the advantages of vampire-bat saliva is a specialized tongue. The bats do not lap up the blood after the fashion of a cat drinking from a saucer of milk. Rather, they make use of a tongue that is grooved on the bottom and along the sides. These grooves act like capillary tubes and promote blood flow. The top of the tongue remains free of blood. (R7)

It is impossible to determine whether the three biochemical innovations and the cleverly designed tongue coevolved or were added stepwise. Possibly, they all appeared simultaneously, but sudden "perfection" grates against current paradigms, which heavily favor slow cumulative processes.

X2. Poisons. For evolutionists, poisons present some familiar problems of explanation. To be useful in subduing prey or an attacker with poison, an animal has to have a chemical that works quickly upon the nervous system of the victim or attacker as well as a device for delivering the venom through defensive barriers of fur and/or skin. Chemically, poisons are often more complex than anticoagulants (X1) and, therefore, harder to account for by random mutations.

What forces modify an animal's salivary glands to start secreting toxic chemicals in the first place? How are chemically complex venoms sythesized via chains of random mutations, most of which are likely to be ineffective? Has there been enough time for evolution to accomplish these feats?

Additionally, a poison-delivery system must coevolve with the venom. One without the other is useless. Daunting though the evolutionary challenge is, animals from insects to fish to mammals have collectively possess a wide spectrum of poisons and clever delivery systems.

Snakes and bees are well known to be venomous, but most people would be hard put to name a poisonous mammal. Even so, there are several mammalian species whose bites or claspings can induce considerable discomfort in humans.

Shrews in general. In bygone days, say, the 1600s, European shrews were considered by all to be as venomous as vipers. As science developed, though, and germs were recognized, the effects of shrew bites were blamed on bacteria and the poor hygiene of the times. Despite popular opinion, some shrews really are venomous. So far, though, only a few species are "officially" recognized as being poisonous.

Short-tailed shrews. These tiny (15-30 grams) shrews inhabit eastern North America. Short-tailed shrews secrete a poison in their saliva that acts upon the nervous system of any animal it bites. The usual victims are insects, but mice are also immobilized long enough to be eaten. Even humans may be adversely affected. In fact, it was the following century-old event that forced scientists to realize that the old-wives' tales about shrews might be true.

> In 1889 Maynard reported the effects produced by a short-tailed shrew that bit him when he was trying to capture it. The skin of his hand was barely punctured in a number of places, yet within 30 seconds a burning sensation was felt, which soon became intensified by shooting pains in the arm. The pain and swelling reached a maximum in about one hour, but considerable discomfort was felt for more than a week afterward. (R1)

Examination of the submaxillary glands of short-tailed shrews revealed an unusual group of granular cells that, according to O.P. Pearson, occur in no other mammals except the European water shrew. Material from these glands injected into mice proved toxic. It is likely that the European water shrew is also poisonous, but this has not been claimed in the literature examined so far. (R1)

It is interesting that in most snakes it is the parotid salivary glands that are modified to produce venom, while in shrews it is the submaxillary salivary glands.

Solenodons. Two species of this shrew-like mammal live in Hispaniola and Cuba. Like the shrews, solenodons are insectovores, but they are much larger (about 1 kilogram). It has been found that the same glands that manufacture the short-tailed shrew's venom are active in the solenodon. (Pearson apparently did not know about the venomous solenodons.) Walker's Mammals of the World elaborates as follows:

> The submaxillary glands of S. paradoxus and presumably those of S. cubanus produce a toxic saliva. The duct of the gland ends at the base of the deeply grooved second lower incisor. S. paradoxus does not seem to be immune to its own venom, as there have been cases of death after fights among cage mates, even though

Solenodons live in Cuba and Hispaniola. Their saliva is toxic like that of some of the much smaller shrews they closely resemble.

the wounds were slight. (R11)

The teeth of the short-tailed shrew apparently do not possess the grooves that aid in venom transfer. In a curious aside, the short-tailed shrews' teeth are black! Is this a warning signal?

Platypuses. As described in BMA50 in Mammals I, the males of this monotreme have poisonous spurs on their hind legs. Even in humans, the poison administered via these spurs can cause extreme pain and partial paralysis. (R6)

X3. Toxic-chemical binders. Here we will find that innovative chemical synthesis need not be beneficial to mammals.

Most, perhaps all, mammalian cells possess a group of proteins that bind to dioxin, polychlorinated biphenyls (PCBs), and many other toxic chemicals, many of which are now classed as dangerous pollutants. Once these toxic chemicals are bound to the protein clump, the clumps journey to cell nuclei where they disrupt normal cell activities, to the detriment of the animals exposed to the toxic chemical. Mammals therefore have a naturally created supersensitivity to exotic chemicals.

Many of the chemicals that can be bound in this manner are man-made and have appeared in nature only since World War II. For years, toxicologists have wondered why mammals should have this "built-in" sensitivity to attack by unnatural chemicals. One explanation that is consistent with the evolution paradigm holds that the receptor that actually binds the toxic substances---the aryl hydrocarbon (Ah) receptor---is present because it also performs useful functions in mammals. The nature of these helpful functions is not yet known, although the Ah receptor does seem to be important in the proper development of young mammals. (R12)

The Ah receptor is so specific to man-made pollutants that a more radical interpretation suggests itself, one that is consistent with the Gaia hypothesis: The Ah receptor acts as a natural brake on the reproductive success of mammals that pollute the environment! In such an extreme interpretation of Gaia, the planet's biosphere acts in ways to protect itself from animals that might damage it. Mainstream biologists of course abhor such thinking.

X4. Pheromones as biological controls. Pheromones are primarily chemical messengers. For example, many female insects, like gypsy moths, release pheromones to attract mates. Among the mammals, pheromones also perform a sexual role. To illustrate, a pregnant mouse may absorb her fetuses when she detects the pheromones in the urine if a strange male. A possible innovative use of pheromones as a behavior control may occur highly social mammals.

Naked mole-rats. These fossorial mammals are eusocial; that is, they have a

Queen naked mole-rats may control their subjects through the emission of pheromones.

caste structure like those in ant and termite colonies. (BMB31-X1 in Mammals I) In a naked mole-rat colony, only the queen breeds, even though all the other females are fertile. Some mammalogists think that the queen suppresses breeding in other females through the pheromones releaed by her urine. (R8, R9) The detailed mechanisms involved in such postulated behavior control are unknown so far. In fact, other scientists maintain that the queen naked mole-rat prevents other females from breeding simply by bullying them. (R10)

X5. High-altitude hemoglobin. When mammals invade high-altitude and underwater niches, where oxygen is in short supply, their bodies usually respond by increasing the supply of red blood cells. One sees this in humans living in the high Andes as well as in the highly aquatic platypus. (R5) In addition, some mammals have enhanced their high-altitude performance in another way.

Llamas, alpacas, guanacos. First of all, all species in the camel group (the Camelidae) are unique in that their red blood cells are oval rather than round. The purpose, if any, behind the unusual shape is elusive. In the Genus Lama (only one "l"), though, which embraces the South American llamas, alpacas, and guanacos, we find red-blood cells carrying a variety of hemoglobin that can transport appreciably more oxygen than other forms of the molecule. (R3, R7)

We know of no other mammals living in high mountains that have been favored with this helpful mutation. In this case, convergent evolution, which seems to have worked so effectively elsewhere, has failed the many other high-altitude species, even though they have been subjected to the same environmental stresses as the South American members of the camel family!

Llamas not only have have oval red blood cells, but their hemoglobin differs markedly from that of other mammals.

References

R1. Pearson, Oliver P.; "On the Cause and Nature of a Poisonous Action Produced by the Bite of a Shrew (Blarina brevicauda)," Journal of Mammalogy, 23:159, 1942. (X2)

R2. Rue, Leonard Lee, III; Pictorial Guide to the Mammals of North America, New York, 1967. (X2)

R3. Perutz, Max; "A New View of Darwinism," New Scientist, p. 36, October 2, 1986. (X5)

R4. Eisenberg, John F., Mammals of the Neotropics, vol. 1, Chicago, 1989. (X1)

R5. Editors of Time-Life; Amazing Animals, Alexandria, 1990. (X5)

R6. Hoffman, Eric; "Paradoxes of the Platypus," Scientific American, 264:18, March 1991. (X2)

R7. Nowak, Ronald M.; Walker's Mammals of the World, Baltimore, 1991. (X1, X2, X5)

R8. Wesson, Robert; Beyond Natural Selection, Cambridge, 1991. (X4)

R9. Honeycutt, Rodney L.; "Naked Mole-Rats," American Scientist, 80:43, 1992. (X4)

R10. Conn, Jeffrey P.; "Naked Mole-Rats," BioScience, 42:86, 1992. (X4)

R11. Fenton, M. Brock; Bats, New York, 1992. (X1)

R12. Ratoff, J.; "Did Evolution Really Anticipate Dioxin?" Science News, 147:277, 1995. (X3)

BMC2 Possible Lunar Effects on Mammalian Biochemistry

Description. The correlation of biochemical phenomena in mammals with lunar cycles.

Data Evaluation. So far, we have found only one report on this phenomenon as related to mammals other than humans. The phenomenon in humans is better documented as cross-referenced below in X1. Rating: 3.

Anomaly Evaluation. Lunar effects on mammalian biochemistry are generally dismissed by mainstream science, often with some disdain. In this context, the phenomenon cataloged here is highly anomalous. Rating: 1.

Possible Explanations. Although they are frequently disputed, many causal links have been reported between lunar position and terrestrial climatic and meteorological phenomena. (See the Series-G catalogs.) These influences could well affect mammalian biochemistry.

Similar and Related Phenomena. Reported lunar effects on mammalian activity (BMB3), behavior (BMB9), and sexual cycles (BMB22), all in Mammals I. See X1 below for cross references to possible lunar effects on human biochemistry.

Entries

X0. Introduction. In a lengthy survey of reported astronomical effects on terrestrial biochemical activity, S.W. Tromp cited a pertinent study involving a nonhuman mammal. (R2)

X1. Possible lunar influences.

Golden hamsters.

> Klinowska (1972) demonstrated lunar rhythms in activity, urinary volume and acidity in the golden hamster. Urinary volume showed a maximum, and activity a minimum, on the same day of the lunar month. pH showed a minimum on almost the same day as the peak in activity and a maximum at about full moon. (R1 as abstracted in R2)

Tromp also referenced about 250 reports from diverse scientific journals relating to astronomical influences on terrestrial biology and geophysics.

Humans: a cross reference. Other volumes in the Catalog of Anomalies describe purported lunar effects on human biochemistry and behavior: disturbed behavior (BMB4 in Humans I) and; in Humans II, bleeding (BHF9), blood-factor variations (BHC11-X3), and menstruation (BHF14).

References

R1. Klinowska, M.; "A Comparison of the Lunar and Solar Activity Rhythms of the Golden Hamster, " Journal of Interdisciplinary Cycle Research, 3:145, 1972. (X1)
R2. Tromp, S.W.; "Studies Suggesting Extra-terrestrial Influences (Apart from Solar Radiation) on Biological Phenomena and Physicochemical Processes on Earth," Cycles, 33:179, 1982. The preceding article was reprinted from: Biometeorological Survey, Volume 1, 1973-1978, Part A, S.W. Tromp and Janneke J. Bouma, eds., London, 1979. (X1)

BMC3 Some Biochemical Curiosities in Mammals

Description. (1) The exceptionally rapid decomposition of corpses; (2) the effect of weather upon the efficiacy of insulin; and (3) the presence of well-formed crystals in mammalian cells.

Data Evaluation. The data come from diverse sources of varying soundness. Only the second and third phenomena derive from acceptable sources. Ratings for the three entries are, respectively: 4, 3, and 1.

Anomaly Evaluation. All three phenomena are rated as mere curiosities. Rating 4.

Possible Explanations. None required.

Similar and Related Phenomena. Relating to the effectiveness of insulin, weather is well-known for its effect upon such human afflictions as arthritis.

Entries

X1. Corruptibility of corpses. In the case of human corpses, most of the interest is in the incorruptibility of corpses, particularly the bodies of saints, where seemingly extravagant claims have been put forth. (See BHC8 in Humans II for more on this supposed phenomenon.) With the other mammals, however, the focus is on exceptionally rapid decay.

Mammals in general. The words that follow were written more than 170 years ago, and we reproduce them for the perspective they provide on the state of science (and writing style!) in the early United States.

> The subject of the moon's influence has engaged but very little of the attention of the philosophical world, and, with the exception of the theory of the tides, has been scarcely noticed. Its influence in promoting, and accelerating, animal decomposition is known only to a certain class of persons, not the most reknowned, indeed, for studying the doctrine of cause and effect, or extending philosophical knowledge, but who, nevertheless, are sufficiently alive in interest; (namely,) persons in the Navy and Company's service. It is a fact well established and authenticated, by numbers of these gentlemen, who have experienced heavy losses thereby, that if an animal fresh killed be exposed to the full effulgence of the moon, at certain seasons, and in certain places, a very few hours only will be sufficient to render the animal so exposed, a mass of corruption; whilst another animal not exposed to such influence, and only a few feet distant, will not be in the slightest manner affected. (R1)

The above quotation was only slightly decommasized!

Shrews in general. Quaint as the foregoing quotation is, some mammal corpses do decay faster than others, as naturalist R.S. Palmer warns specimen collectors:

> A dead Shrew decomposes very rapidly unless kept cool; it may not be salvageable as a specimen if the sun shines directly on it even for a few minutes. (R2)

X2. Weather's effect upon the action of insulin.

Rabbits.

> Insulin lowers the blood-sugar level. Biochemists carrying out routine tests of insulin preparations on animals sometimes observe fairly large large deviations from the normal effects. S. Hansen and H. Brezowsky, of the meteorological-medical station at Bad Toelz, W. Germany, have made studies of the drug on 32 rabbits over a period of a year. They conclude that the variations are related to weather conditions.
>
> .....
>
> The research workers have given no explanation for the facts, but point out certain observations of changes in blood-sugar concentrations in children, apparently connected with meteorological alternations. (R3)

X3. Crystals in mammalian cells. Mammalian cells enclose a wealth of bodies from granules to mitochondria, but sharply geometrical crystals are rare and unexpected.

Big-eared bats (Macrotus californicus). Well-defined crystals appear in virtually all the ova of this species, but apparently never in the ova of even closely related bats. The crystals are sharply four-sided in their central region and seem to taper to three-sided pyramids at both sides. [Such crystal geometry is highly unlikely.] Smallest in primordial follicles they reach dimensions of 6.5 x 20 microns in the more highly developed Graafian follicles. The chemical nature of the crystals is unknown. They are thought to be extruded or reabsorbed eventually. Purpose, if any, is unknown. (R4)

Mammals in general.

Crystalline inclusions have been cited [sic] in a variety of different cells, but their presence in vertebrate ova is rare. Hadek noted that in mammals only the human ovum contains crystalline inclusions, but some mammals (for example the laboratory mouse) display crystalline inclusions following early cleavages of the zygote extending to the blastocyst stage. Thus, *Macrotus* seemingly is unique in that both the ova as well as early embryonic stages of development up to the implanted blastocyst contain crystalline inclusions. (R4)

References

R1. Mill, N.; "Influence of the Moon on Animal and Vegetable Economy," *Journal of the Franklin Institute*, 1:237, 1826. (X1)

R2. Palmer, Ralph S.; *The Mammal Guide*, Garden City, 1954. (X1)

R3. Anonymous; "Can Weather Alter Insulin's Effect?" *New Scientist*, 11: 109, 1961. (X2)

R4. Bleier, WIlliam J.; "Crystalline Structure in the Ova Found in Early Embryological Stages in a Leaf-Nosed Bat, *Macrotus Californicus*," *Journal of Mammalogy*, 56:235, 1975. (X3)

BMC4 The Inability of Some Mammals to Synthesize Ascorbic Acid

Description. The inability of some mammals (including humans) to synthesize ascorbic acid (vitamin C). Only a few, supposedly distantly-related groups of terrestrial species, do not possess this seemingly very useful capability.

Data Evaluation. Because humans readily succumb to scurvy when deprived of vitamin C, we are well aware of this apparent defect in our biological make-up. When other mammals are considered, however, the data are incomplete. We do know that this singular inability seems to have a peculiar distribution among mammalian species, but the phenomenon does not seem to have been studied in depth, at least in the literature surveyed so far. For this reason the observational foundation for this phenomenon is a bit shaky. Rating: 3.

Anomaly Evaluation. The usual explanation of the phenomenon, in view of its spotty distribution among terrestrial vertebrates, is that wild animals almost always consume foods containing sufficient ascorbic acid, so that the loss of the synthesizing capability is not important to their survival. Therefore, the random mutations thought to be responsible for the phenomenon are not selected against ---that is, they are neutral---and the supposed defect could crop up almost anywhere taxonomically. In this Catalog entry, though, the anomaly claimed resides in the apparent taxonomic connections. The peculiar distribution of the phenomenon seems to contradict assumed evolutionary relationships, as in the linkage between the great apes and megabats. These contradictions of accepted evolutionary associations, added to other supporting considerations, challenge prevailing evolutionary family trees. Rating: 1.

Possible Explanations. The strange distribution of this phenomenon, even though supported by other data, is due only to the vagaries of chance mutations. It is all only coincidence!

Similar and Related Phenomena. The human inability to synthesize ascorbic acid (BHC10 in Humans II); the physiological and neurological similarities between primates and megabats (BM16); other biochemical similarities between humans and guinea pigs (BMC6-X1); data supporting the Aquatic Ape hypothesis (see Subject Indexes in the Series-B catalog under: Aquatic Ape hypothesis).

Entries

X0. Cross reference. The phenomenon at hand is treated in some detail, as it relates to humans, in BHC10 in Humans II.

X1. An overview of the phenomenon.

Terrestrial vertebrates in general.

> The ability to synthesize ascorbic acid has been found only in terrestrial vertebrates. The ability is not present in certain passerine birds, in fruit-eating bats, in guinea pigs and in Anthropoidea. We postulate that these species lost this ability by a neutral evolutionary change that occurred sporadically by mutation. The change was adopted in the genetic make-up of a few groups of birds and mammals that are widely scattered in phylogeny. Many herbivorous vertebrate species which consume diets high in ascorbic acid have retained the ability to synthesize it, so that its loss does not appear to be adaptive. (R1)

Of special interest in the above quotation are three linkages: (1) Anthropoidea (humans and the great apes) and fruit-eating bats (the megabats); (2) Anthropoidea and guinea pigs; and by inference (3) Anthropoidea and marine mammals (whales and dolphins).

In the first case, the linkage supports the physiological and neurological evidence suggesting that primates and fruit bats are closely related. In the second, we remark that the biochemistry of guinea pigs is closer to that of humans than to taxonomically nearby rodents. (BMC6-X1) Finally, we have still another close linkage between humans and the marine mammals, which supports of the often-ridiculed Aquatic Ape hypothesis. Although, it must be admitted that the claimed aversion to water of the other Anthropoidea (chimps, gorillas, orangutans) does not fit in here! Nevertheless, in the light of the other observations, one might easily wonder if the phenomenon is entirely a matter of random, "sporadic" mutations!

Reference

R1. Jukes, Thomas H., and King, Jack Lester; "Evolutionary Loss of Ascorbic Acid Synthesizing Ability," Journal of Human Evolution, 4:85, 1975. (X1) Note that this title presumes that the loss was "evolutionary."

BMC5 Anomalies Observed in the Cytochromes - Percent - Sequence - Difference Matrix

Description. Implications from biochemical comparisons of the species that: (1) transitional biochemical forms do not exist between subclasses of lifeforms (mammals, birds, etc.); (2) evolution is circumferential rather than sequential; and (3) biochemical diversity within the subclasses is inconsistent with observed morphological diversity.

Data Evaluation. Biochemistry is a well-developed science, and the many thousands of biochemical comparisons that have been made between the species are on a sound footing. The specific foundation for this Catalog entry is a matrix compiled from this large reservoir of laboratory determinations (reproduced in part below). The data are sound, but the thrust of this Catalog entry is in the implications proffered in a controversial book written by a biochemist. Our rating is based on the data alone and not on interpretations of them. Rating: 1.

Anomaly Evaluation. The claimed absence of transitional biochemicals between major evolutionary subclasses and the claimed circumferential nature of evolution clash head-on with the generally accepted evolutionary paradigm. These implications of the biochemical data are, therefore, highly anomalous. It must be added, though, that the biochemical data are supported by morphological data that are generally ignored by most biologists. Finally, the observation that molecular divergence within subclasses does not always correspond to morphological divergence suggests that small biochemical changes may lead to large morphological changes and vice versa. This undermines common expectation that all morphology is determined at a molecular level. Overall rating: 1.

Possible Explanations. The evolution paradigm as presently formulated is incorrect and requires a major overhaul. Biochemistry (including DNA) does not completely determine morphology; some part of heredity may be "epigenetic."

Similar and Related Phenomena. The relationship between genetics (DNA) and morphology (BMG); mammalian parallelisms (BMA1 in Mammals I); the cytochrome-C enigma (BHG19 in Humans III). The dearth of predicted transitional forms in the fossil record (BME1).

Entries

X0. Introduction. The classical technique for constructing an evolutionary family tree is to classify animals according to the differences and similarities in their morphology, including both their external appearances and internal structures. When accurate biochemical and genetic analyses were made available in recent years, it became obvious that here were two additional ways to classify animals, since both proteins and DNA differed from one species to another. Even better, protein and DNA differences can be quantified in terms of the percentages by which these molecules' sequences of amino acids differ. Such quantitative comparisons are widely believed to be more objective and reliable than trying to evaluate differences in physical morphology, such as skull shape. Happily, both protein and DNA measurements tend to confirm most, but not all, of the taxonomy laboriously established over the decades through conventional morphological assessment.

Here and in the remainder of this

chapter, we will look at the apparent anomalies evolving from biochemical measurements, including blood-typing. Genetic (DNA) anomalies, though similar to biochemical anomalies, are covered in Chapter BMG in this volume.

X1. <u>The cytochromes-percent-sequence-difference matrix</u>. In his book <u>Evolution: A Theory in Crisis</u>, M. Denton devotes a long chapter to the observations one can make on <u>the</u> "matrix." The entries in this matrix represent the percentage differences of 33 different cytochromes (types of proteins) taken from species ranging from humans to bacteria. A portion of this matrix is reproduced here as it relates to fish, reptiles, birds, mammals---the presumed sequence of biological evolution. The source of Denton's matrix is the 1972 edition of M.D. Dayhoff's <u>Dayhoff Atlas of Protein Structure and Function</u>.

The salient feature of that portion of the matrix reproduced here---and indeed the entire matrix from humans to bacteria---is that the numbers (percentage differences) in each subclass (mammals, birds, etc.) are pretty much the same. Each subclass is isolated and distinct as far as the numbers go, except for birds and reptiles, which seem to be about equally distant from the mammals. In other words, biochemically speaking, mammals as a subclass are much more closely related to each other than to the birds and fish. No surprise here! This grouping conforms to the conventional taxonomic tree that shows mammals on a different branch than the birds and fish. As for the closeness of birds and reptiles, this also agrees with current thinking.

The farther one moves across or down the matrix, the bigger the numbers. Insects, for example, range from 19-31% distant from mammals, birds, reptiles, and fish. At the far edges of the matrix, bacteria are 64-72% from <u>all</u> other forms of life. Yet, each subclass remains isolated and distinct.

Thousands of such biochemical comparisons have been measured, and the results are always the same. In fact, the same relationships are found when

MAMMALS, BIRDS, REPTILES
TELEOSTS, CYCLOSTOMES

	HORSE	DOG	KANGAROO	PENQUIN	DUCK	Pigeon	TURTLE	TUNA	BONITO	CARP	LAMPREY
HORSE	0	6	7	12	10	11	11	18	17	13	15
DOG	6	0	7	10	8	9	9	17	16	11	13
KANGAROO	7	7	0	10	10	11	11	17	17	13	16
PENQUIN	12	10	10	0	3	4	8	17	17	14	18
DUCK	10	8	10	3	0	3	7	16	16	13	17
Pigeon	11	9	11	4	3	0	8	17	17	14	18
TURTLE	11	9	11	8	7	8	0	17	16	13	18
TUNA	18	17	17	17	16	17	17	0	2	8	18
BONITO	17	16	17	17	16	17	16	2	0	7	18
CARP	13	11	13	14	13	14	13	8	7	0	12
LAMPREY	15	13	16	18	17	18	18	18	18	12	0

A portion of the cytochromes-percent-sequence-difference matrix. (After R1) other proteins and DNA are compared among the species making up the full spectrum of life. (See BMG.)

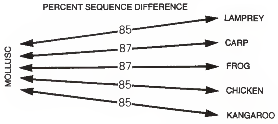
X2. Observations drawn from the matrix. The observations are several and profound. Actually, each is profound enough to warrant a separate section in this chapter. But to unify the discussion and reduce redundancy, we combine three of the observations here.

Observation #1: No transitional biochemical forms eixst between subclasses. Denton comments as follows on this:

> Every [amino-acid] sequence can be unambiguously assigned to a particular subclass. No sequence or group of sequences can be designated as intermediate with respect to other groups. All the sequences of each subclass are equally isolated from the members of another group. Transitional or intermediate classes are completely absent from the matrix. (R1)

This observation is consistent with the fossil record as constructed after more than two centuries of geological exploration. There are few if any convincing transitional fossils linking mammals to reptiles or between any of the major groups of life forms. (This is, of course, denied by many scientists!) If evolution has proceeded by small steps, as generally proclaimed, some transitional forms would be expected on both the morphological and biochemical levels. The standard explanation given by evolutionists is that both morphological and biochemical transitional forms are very rare and have not yet been found. Thus, evolution-by-small-steps, particularly between major taxonomic groupings, does not appear to be supported by either morphology or biochemical analysis. This situation has led to the hypothesis of punctuated equlibrium, in which major biological transformations occur without observable intermediate forms, just as in quantum mechanics where an atom jumps from one state to another without producing observable transitional forms. Physicists are not at all concerned over the lack of transitional forms! (Should they be?)

Observation #2. Life forms seem to be organized circumferentially rather than sequentially. Biology professors and the science media habitually portray evolution as having progressed from primitive to advanced forms sequentially: from the lowly jawless lamphreys to carp; from fish to amphibians; and so on up the ladder. Unfortunately for this idea, no biochemical ladder has been found. When the biochemical distances are measured from molluscs to carp and then from molluscs to the supposedly more primitive lamphrey, the numbers



The biochemical distances between a gastropod mollusc and a wide spectrum of other animals is roughly the same. This illustrates what Denton calls circumferential organization. (After R1)

come out the same. The distance from molluscs to kangaroos also turns out to be the same. A kangaroo by this measure is no more advanced than the jawless lamphrey. Primitiveness has lost its meaning.

Of course, the lamphrey, carp, and kangaroo do differ from each other biochemically, but they remain equidistant from the molluscs in biochemical measure. Denton summarizes this phenomenon by stating that life forms are related circumferentially rather than sequentially ---assumimg biochemical measures are indicative. In the sketch, this means the radii are all about equal, but life forms are separated around the circumference.

These biochemical facts deny that one species is more advanced than another, and that some favorite examples that biologists use in illustrating the progress of evolution are not what they have been proclaimed to be. In fact, this situation is also supported by other evidence, as Denton asserts:

> The fact that lungfish, monotremes and all the other favourite links of evolutionary biology give no hint of their supposed transitional status at a molecular level is perfectly in keeping with the fact that there are many morphological features of their biology which have never been easy to reconcile with their supposed transitional status and which have always suggested that they represent unique and isolated types. (R1)

Continuing in this vein, so-called "living fossils" would not be fossils at all. For example, when hemoglobins are compared, the opossums, which have prospered essentially unchanged for almost 100 million years, are not primitive in terms of their hemoglobin. If anything, they are slightly farther away from the supposed common ancestor of mammals and marsupials than are the placental mammals. In terms of hemoglobin evolution, then, opossums are less primitive; that is more evolved; than humans! (R1)

Observation #3: Molecular divergence may not correspond to morphological divergence. The cytochromes-difference matrix shows that the classical evolutionary arrangement of subclasses based upon morphology is, with minor exceptions, identical to the arrangement constructed from biochemical evidence. All mammals are grouped together and rather sharply isolated in terms of percentage differences. So are birds, fish, etc. alone in their own subclasses. But within the isolated subclasses, biochemical diversity is not always consistent with morphological diversity. To illustrate, the molecular divergence among frogs is about the same as it is between the mammals. Yet, frogs are morphologically pretty much the same; but mammalian diversity, from bats to whales, is very great. Again, conifers are just as divergent molecularly as the flowering plants, but the latter are wildly divergent at the morphological level. Denton admits that this lack of correspondence is anomalous. (R1)

The implication is that within the mammals, for example, the amount of molecular change is not always consistent with the amount of morphological change. Mammals that are close molecularly speaking may look very different morphologically and vice versa. This same situation prevails in genetics (BMG).

X3. A profound conclusion. Based upon considerable biochemical evidence, such as the matrix reproduced in part earlier, Denton has little confidence in the basic evolutionary paradigm now dominant:

> This new era of comparative biology illustrates just how erroneous is the assumption that advances in biological knowledge are continually confirming the traditional evolutionary story. There is no avoiding the serious nature of the challenge to the whole evolutionary framework implicit in these findings. (R1)

Reference

R1. Denton, Michael; Evolution: A Theory in Crisis, London, 1985. (X1-X3)

BMC6 Miscellaneous Blood and Biochemical Differences among Mammals

Description. Curious and unexpected differences between the biochemistry and blood characteristics of species generally thought to be closely related.

Data Evaluation. Except for the unnucleated mammalian erythrocytes (red blood cells), which are a matter of common knowledge among biologists, the other observations recorded below represent, so far, the work of single research teams and need to be confirmed by others. Rating: 2.

Anomaly Evaluation. Three of the four entries below (X1-X3) run counter to current thinking about some fine points on mammalian taxonomy. They are, therefore, moderately anomalous. The exception, again, is the unnucleated mammalian erythrocyte, which contrasts sharply with the nucleated erythrocytes of the reptiles and birds. However, since mammals are widely separated taxonomically from birds and reptiles, this contrast is easy to accept; but the loss of the erythrocyte nuclei remains puzzling. Rating: 2.

Possible Explanations. Morphology is sometimes a poor guide in deciding taxonomic relationships.

Similar and Related Phenomena. Biochemical curiosities in mammals (BMC3); human blood chemistry variability (BHC11); human blood polymorphisms (BHC12); variability of human hemoglobin (BHC13). The last three phenomena are described in Humans II (BHC).

Entries

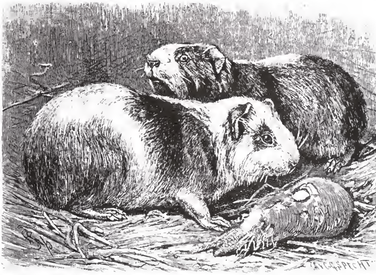
X1. General mammalian biochemistry.

Guinea pigs. Guinea pigs certainly look like rodents superficially, and indeed they have long been classified as such. But the advent of modern biochemistry, with its capability of determining the sequences of amino acids in proteins, has cast doubt on this taxonomic assignment. In the lab, the proteins of guinea pigs are found to differ substantially from not only rodents but also many other mammals. W-H. Li, a geneticist at the University of Texas, has said of the guinea pig: "...its insulin is very strange." (R4) In fact, Li and his colleagues have discovered that many other guinea-pig proteins are also strange in the context of mammalian biochemistry.

> Li and his colleagues found that of the 51 amino acids that make up insulin, humans and mice had all but 4 in precisely the same sequence. Guinea pigs, however, had insulin that differed from mice and humans by 18 amino acids. In addition, they differed from cows by 19 amino acids and from the opossum---a marsupial ---by 20 amino acids. This pattern was repeated in a number of other proteins as well. (R4)

What do these amino-acid differences imply? In their 1991 report in Nature, Li's University of Texas group wrote:

> Our phylogenetic analysis of amino-acid sequence data, however, imply that the guinea pig diverged before the separation of the primates and the artiodactyls from the myomorph rodents (rats and mice). If true, then the myomorphs and the caviomorphs [guinea pigs] do not constititute a natural clade, and the Caviomorpha (or the Histricomorpha) should be elevated in taxonomic rank and regarded as a separate mammalian order distinct from the Rodentia. (R3)



Despite their rodent-like appearance, guinea-pig biochemistry differs strongly from that of the Rodentia.

The guinea pigs also differ from the rodents in some morphological details, but these were not evidently persuasive when biologists placed them in the same taxonomic bin as the rodents.

X2. Blood proteins.

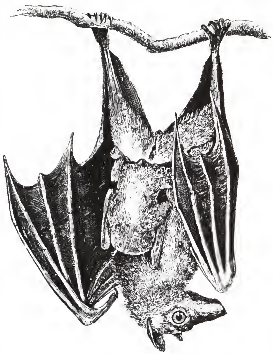
Megabats. Even though the megabats (large fruit-eaters) look superficially a lot like the microbats (small, echo-locating, mostly insect-eaters), they differ rather profoundly internally. In particular, the megabats possess a primate-like neurological connection between their eyes and mid-brain. This contrasts sharply with the more "primitive" connection of the microbats (BM16) In biochemistry, too, the differences are great:

> Arnd Schreiber, Doris Erker and Klausdieter Bauer of the University of Heidelberg have looked at the proteins in the blood serum of megabats and primates and found enough in common to suggest a close taxonomic relationship between the two groups. (Biological Journal of the Linnaean Society, vol. 51, p. 359) (R6)

In other words, bats and mammalian flight may have evolved twice, with both distantly related animals eventually hitting upon the same innovations of membraneous wings stretched between the fingers and upside-down "perching."

X3. Blood types. Before biochemists were able to reliably sequence the amino acids in proteins, scientists tried to use blood groups (types) to chart not only human evolution but also the rest of the animal kingdom. But, alas, the results were often confusing and their implications cloudy. Over 35 years ago, E. Shute summarized the situation:

> It is abundantly clear that the blood groups have now shown such marked and often theoretically unexplainable variations among the races of man that it is asking too much to utilize their distribution in sera and tissues to provide evolutionary clues below the human level. Such attempts either prove too much, such as our



The blood serum of megabats (fruit bats) suggests a close taxonomic relationship with the primates!

similarity to rodents and whales, or that humans differ more from one another than from chimpanzees, or that gorillas are much more distant from us than chimpanzees and orangs, or that we share blood groups with plants, or that the most topsy-turvy relationships exist throughout the world of mammals and birds. Since serology cannot be used to explain the relationships of human races, since that would integrate widely different and disparate nations, they can scarcely tell us more reliably of our relations to other animals, even primates. (R1)

Despite this powerful caveat, blood groups are still used in evolutionary comparisons.

Bonobos (pygmy chimpanzees). In an article in Science 83 (now defunct), P. Raeburn related the many ways in which bonobos are more like humans in their behavior than the common chimpanzee. It is also known that the DNAs of humans and common chimps differ by only about 1%, but we have not yet found how much human and bonobo DNAs differ. In view of this lack of data (temporary, we hope), perhaps blood types will cast more light on the closeness of humans to the two species of chimpanzees. Raeburn wrote:

> Blood analyses show that pygmy chimps all have the same blood type, which is indistinguishable from the human type A. On the other hand, common chimps have much greater diversity in blood groups, and in that regard the common chimps are more humanlike. (R2)

Blood types therefore contradict the current thinking that bonobos are the more humanlike species, at least in terms of behavior and social interactions.

But, going back to the quoted warning from Shute, are blood groups really useful in fixing evolutionary relationships? For that matter, will some future Shute express the same doubts about DNA analysis, which is now ascendant in taxonomy?

X4. Erythrocytes.

Mammals in general. The erythrocytes (red blood cells) of mammals lack nuclei, but those of reptiles and birds do not. (R5) This fact certainly cleanly separates mammals from the birds and reptiles, but what is its import? Repairing to a biology textbook (R7), we find that mammalian erythrocytes are actually created with nuclei but that these are extruded (along with mitochondria and other cell structures) as the blood cell matures. This leaves the mammalian erythrocytes almost fully packed with hemoglobin. Where and why in the evolution of mammals did this strange development take place?

Camels, llamas, etc.. Strangely, as mentioned in BMC1-X5, the erythrocytes (red blood cells) of all members of the camel family are oval in shape, as they are in the birds, reptiles, fish, and amphibians. In all other mammals, they are round. The evolutionary significance of this shape anomaly, if any, is unknown. (R8)

References

R1. Shute, Evan; Flaws in the Theory of Evolution, Philadelphia, 1961. (X3)
R2. Raeburn, Paul; "An Uncommon Chimp," Science 83, 4:40, June 1983. (X3)
R3. Graur, Dan, et al; "Is the Guinea Pig a Rodent?" Nature, 351:649, 1991. (X1)
R4. Oliwenstein, Lori; "Of Mice and Men and Guinea Pigs," Discover, 13:63, January 1992. (X1)
R5. Proctor, Noble S., and Lynch, Patrick J.; Manual of Ornithology, New Haven, 1993. (X4)
R6. Timson, John; "Did Bats Evolve Twice in History?" New Scientist, p. 16, June 4, 1994.
R7. Curtis, Helena; Biology, New York, 1979. (X4)
R8. Nowak, Ronald M.; Walker's Mammals of the World, Baltimore, 1991. (X4)

BMD DISTRIBUTION OF MAMMALS IN SPACE AND TIME

Key to Phenomena

BMD0 Introduction

On our turbulent planet we cannot expect to find a homogeneous distribution of mammals in space and time; that is, geographically or in the fossil record. Geological events (volcanic eruptions, drifting continents, etc.) and astronomical catastrophism (asteroid impacts) have decimated animal populations throughout geological time and, apparently, also triggered sudden radiations of life forms afterwards. These biological extinctions and explosions have been spotty geographically and temporally. Obviously, such random events can explain many of the observed biogeographical phenomena. Pandemics and interspecies competition also stir the mix and lead to population inhomogeneities.

But there are some distribution phenomena that cannot be so easily explained; and there are still others that we simply classify as being of the "believe-it-or-not" variety. Our objective in this chapter is the collection of these distribution puzzles and curiosities. Broadly speaking, distribution phenomena do not exert significant pressures upon existing paradigms. While not especially anomalous, they are nevertheless engaging.

BMD1 Remarkable Congregations and Concentrations of Mammals

Description. The existence of very large numbers of mammals, generally a million or more of the same species, in a limited geographical area. Such asssemblages are usually only temporary, as during breeding seasons or when food is particularly abundant.

Data Evaluation. Large numbers of active mammals are very difficult to count accurately. Although the numbers quoted below come from reliable sources, they are only approximate. In addition, the figures often vary markedly from year to year. There is no question, however, that our arbitrary figure of one million is often approached and sometimes exceeded. Rating: 1.

Anomaly Evaluation. There is nothing anomalous about mammals congregating in large numbers for such purposes as breeding, eating, or protection. This phenomenon is cataloged for its curiosity value only. Rating: 4.

Possible Explanations. See X1 below.

Similar and Related Phenomena. Mass migrations (irruptions) of mammals, notably lemmings and gray squirrels (BMB28 in Mammals 1); large concentrations of birds (BBD), fish (BFD), insects (BAD), and so on for other animals.

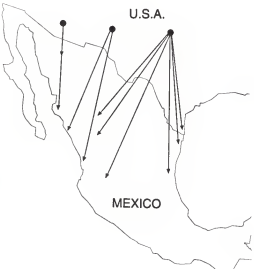
Entries

X1. Congregations. Mammals may gather in immense numbers for several reasons: (1) Food is abundant; (2) There may be safety in large numbers; (3) Certain environments offer protection against predators or weather; (4) Major predators are absent; and (5) Some species are very sociable and just like to be in crowds.

There is nothing particularly mysterious about huge assemblies of mammals, but in some cases the sheer numbers involved cry out for cataloging!

Mexican free-tailed bats (Tadarida brasiliensis). It is frequently asserted that these bats hold the record for the largest congregations of mammals, but some prairie-dog towns (below) may have actually surpassed bat caves in total population although not in population density.

The Mexican free-tailed bat ranges from the southern United States to Argentina and the West Indies. The huge congregations of this species, however, are to be found in the American Southwest. Here, some particular caves seem---for reasons not apparent to humans---highly attractive; and the bats assemble there by the tens of millions. Mainly, these congregations are maternity colonies and consist mostly of females. During the 1960s, it was estimated that 100 million Mexican free-tailed bats were living in 13 Texan caves, but numbers have dwindled sharply in recent years. (R4) Some specific population figures follow.



Migration routes of Mexican free-tailed bats from U.S. caves to Mexico. (R6)

Bracken Cave, Texas. About 20 million bats, rising to 40 million after the females give birth. (R4, R7) No dates specified.

Frio Cave, Texas. 13 million in the 1950s. (R6)

Eagle Creek Cave, Arizona. 25-50 million in the 1960s, but only 600,000 in 1970. (R4)

Carlsbad Caverns, New Mexico. 8.7 million in 1936 (R2, R4), but reduced to only 200,000 in 1973. (R4)

Mice (species not given). During a population explosion in Australia in 1916, 544 tons of mice, representing 32 million individuals, were caught. (R1) Area of infestation not given.

Black-tailed prairie dogs. Prairie dogs live in colonies called "towns," and some of these were immense in bygone days.

> A town in western Texas many years ago is said to have had an area of about 64,000 sq km and to have contained 400 million prairie dogs. (R4)

Northern fur seals. The larger mammals do not gather in numbers as great as the bats and rodents mentioned above. Even so, some seals and sea lions converge to form huge breeding assemblages. For example, in 1983, the breeding herd of northern fur seals in the Pribilof Islands, located in the eastern Bering Sea, was reported to be about 870,000. (R8)

Common dolphins. Schools of up to 300,000 have been seen in the Black Sea in areas where large concentrations of fish occur. (R4)

X2. Concentrations. Concentration or population density is measured in terms of numbers per unit area. We catalog this parameter separately, because high population densities seem to produce psychological changes in some mammals, whereas sheer numbers do not. One manifestation of abnormally high population density may be "irruptions" or large-scale migrations, as evidenced by the occasional mass movements of some species of lemmings and the eastern gray squirrel. (BMB28 in Mammals I)

Meadow mice (species not given). In 1958, 5,000-6,000 meadow mice per acre were counted in a 20-acre pasture in the Pacific Northwest. (R1)

Rice rats (Oryzomys longicaudatus). During a population explosion of this species in central Chile, "...incredible densities of 1,710 to 1,802 individuals per hectare were recorded." (R5) Note: 1 hectare = 2.47 acres.

Laboratory mice. The psychological effects of high population density were demonstrated experimentally by a biologist at the National Institutes of Mental Health.

> The scientist released four pairs of mice into mouse heaven: a room containing all the nesting material, food, and drink the mice could ever need. Absent were any natural predators or pressures of daily life; all the fortunate mice had to do was enjoy themselves. They immediately devoted themselves solely to sex and eating. Five hundred sixty days later there were 2,200 mice in the room, the peak population of this little love nest. Four years later, all the mice were dead. They had lost their will to live. Their sex drives had disappeared, along with normal behavior patterns of the wild that delineate the sexes. The declining days of the rodent hedonists were spent grooming their bodies, eating, and sleeping. (R2)

References

R1. Anonymous; "Mouse Invasion!" National Wildlife, 26:24, June/July 1988. (X1, X2)

R2. Eisenberg, John F.; Mammals of the Neotropics, vol. 1, Chicago, 1989. (X1)

R3. Thomas, Warren D., and Kaufman, Daniel; Dolphin Conferences, Elephant Midwives, and Other Astonishing Facts about Animals, Los Angeles, 1990. (X2)

R4. Nowak, Ronald M.; Walker's Mammals of the World, Baltimore, 1991. (X1)

R5. Redford, Kent H., and Eisenberg, John F.; Mammals of the Neotropics, vol. 2, Chicago, 1992. (X2)

R6. Fenton, M. Brock; Bats, New York, 1992. (X1)

R7. Ezzell, Carol; "Cave Creatures," Science News, 141:88, 1992. (X1)

R8. Reeves, Randall R., et al; Seals and Sirenians, San Francisco, 1992. (X1)

BMD2 Apparent Dearths and Absences of Mammals

Description. The apparent dearth or complete disappearance of specific mammals from certain geographical areas where one would normally expect them to be. Such population changes may be seasonal, episodic, or persist over recent geological time.

Data Evaluation. Obviously, it is much easier to count extant populations of mammals than to confirm dearths or absences of particular species. "Living fossils" and animals recently labeled "extinct" are always turning up. There are so many remote areas and places of concealment that accurate counting is next to impossible. Rating: 3.

Anomaly Evaluation. Apparent seasonal and episodic dearths and disappearances of mammals (X2 and X3 below) are probably all explicable as the consequence of incomplete counting and reconnaissance of mammal populations. The small number of large carnivores in, for example, Australia relative to other continental areas (X1) is more puzzling. However, there is no theory that insists that any specific geographical area must have specific quotas of certain animal types. One can easily substitute climatic conditions, diseases, and other such factors to account for large carnivores that seem to be missing from nature's "balance pans." Rating: 3.

Possible Explanations. Incomplete counting and reconnaissance.

Similar and Related Phenomena. General reduction of biodiversity as seen in the fossil record and extant populations (BME4); biological explosions and extinctions in the fossil record (ESB1 and ESB2 in Anomalies in Geology).

Entries

X1. The dearth of some mammal types. The Order Carnivora comprises the placental dogs, bears, raccoons, weasels, mongooses, hyenas, and cats. These animals are well-distributed world-wide except for Australia, New Zealand, Madagascar, and many oceanic islands. (R4) Focussing on Australia, the only large member of the Order found there today is the dingo, which was evidently brought to the continent recently by the first settlers from Asia. The placental dingo has, in effect, replaced the extinct (or nearly extinct) thylacine or Tasmanian tiger/wolf---the only recent, large marsupial carnivore. (See BMD12.) (Note that an animal can be carnivorous and still not be member of the Order Carnivora!) Other carnivorous marsupials, such as the Tasmania devil and quoll, weigh only 5 kilograms or less.

The puzzle at hand is: Why didn't more large carnivores evolve in Australia? Wallabies and kangaroos are abundant there, creating an ideal niche for large carnivores. Looking back in the fossil record doesn't solve the problem. The only large marsupial carnivores found there are the extinct marsupial lion and, possibly, a giant, meat-eating kangaroo. Statistically speaking, the continent of Australia has only one-fifth as many large carnivores as East Africa, the continent of North America, and Southeast Asia. Why, when marsupials converged---via evolution---on so many other placental forms, were the large carnivores omitted---especially when a rich, wide-open niche beckoned? (R3) (See also BMA1 in Mammals I.)

One reason may be that Australia has an excess of large carnivorous reptiles, such as pythons and crocodiles. However, these do not heavily impact the kangaroos and wallabies, which are the marsupial analogs of the placental deer and rabbits. Except for the predations of the dingos, these animals go almost unchecked.

X2. Apparent seasonal disappearances. Long ago, people surmised that when winter approached the vanished swallows had not really left but were simply hibernating in the mud of local ponds and lakes! Now, everyone knows they all fly south. But what about the bats that also seem to vanish when cold weather approaches?

Bats in general.

> Bats are found during winter months hibernating in caves, abandoned mines, and old houses, but never in large enough numbers to account for the summer bat population. In addition, the hibernating bats are mostly males. Females, particularly, seem to disappear. Where do they go?
>
> Hoping to find the answer, James Beer and Fred Greeley, graduate students in zoology, have been capturing and banding bats in Wisconsin iron and coal mines, caves, and houses. Since July, 1947, more than 6,000 bats have been marked with an identifying government band fastened to a wing. About 4,300 have been banded in an iron mine near Hurley in northern Wisconsin.
>
> With the exception of the Hurley mine, which houses an estimated 65,000 bats, seldom are more than 100 bats found in the state in a single winter colony. Greeley said the number found hibernating could not account for the quantity present in the area during summer. (R1)

Apparently, local hibernation is not the answer. It was logical, then, to look farther south for hibernating bats that migrated from the north.

To this end, D.R. Griffin banded summering bats in New England and then searched for them among hibernating bats in New York and Pennsylvania---all to no avail. (R1) Where did the bats from the northern states go?

Perhaps pertinent is the fact that the bats wintering in the north are mostly males, whereas the summer roosts are mainly female. This reminds one that the same situation prevails in the American Southwest, where the immense summer populations of Mexican free-tailed bats are predominantly females. In the winter, males are more common. (BMD1-X1) It is obvious that many millions of female Mexican free-tailed bats must winter somewhere else. Given such huge populations to study, banders have found that some of the bats summering in the Southwestern caves really do migrate farther south. They have been found wintering in Mexican caves up to 1,800 kilometers farther south. Some also remain behind to hibernate. (R5)

It is, therefore, quite likely that the "missing" female bats in the northern states also migrate south for the winter. The naturalists just have not found them yet, either because they have such small populations to deal with or they have not looked far enough to the south. There does not seem to be anything mysterious here.

X3. Episodic dearths. Some large mammals seem to disappear for years, even for a century or more, be duly classified as extinct, and then reappear. Such long disappearances are a bit perplexing to zoologists.

Gorillas (species not given).

> The massive gorilla is a good example. The ancient Greeks and Romans probably knew about gorillas, because their stories describe them. But then gorillas seemed to have dropped from the sight of civilized man, and were not rediscovered until 1847. (R2)

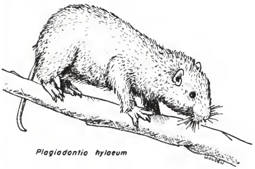
Golden hamsters.

> The golden hamster, reported in Syria in 1839, was not seen there again until 1930. (R2)

Hispaniolan hutias (Plagiodontia aedium).

> A case nearer home is the rodent, Plagiodontia aedium, of San Domingo. It was recorded on the island in 1836 and did not turn up again until 1948. (R2)

Six other species of hutias are known; only one of the six still lives,



One of the seven species of Hispaniolan huitas. These rodents weigh about one kilogram. Most are known only from recent fossils; some seem to appear and then disappear for long periods.

the others have left very recent fossils. (R4)

Obviously, observers cannot be everywhere at all times. Given the rarity of some mammals, it should not be surprising that gaps in the records appear. The many recent reports of the thylacine may signal the resurrection of this large marsupial. (BMD12)

X4. Cross reference: Species-impoverished modern groups of mammals. Looking back in time via the mammalian fossil record, one usually sees not the progressive flowering of new species on the evolution's Tree of Life, but instead the opposite: shrinking biodiversity. In this Catalog, this phenomenon is deemed a phenomenon of the fossil record and is treated more fully in BME4 and BME5. We merely cross reference the phenomenon here and provide a typical example for background purposes.

Primates in general. These animals, including our own evolutionary predecessors, exemplify this shrinking biodiversity.

> Today there are only three genera and four species of great apes, and these are confined to fast-vanishing tropical rainforest or woodland habitats. But there are about a dozen genera and even more species of larger-bodied hominoids known from the Miocene. This means that anthropologists are confronted with many ancient apes with no known living counterparts. Adding to the confusion are more smaller-bodied genera and species from the Miocene that appear to be related to monkeys, lesser apes, or have no apparent living relatives. (R6)

Unfortunately, this sharp decline in biodiversity is also found among the amphibians, birds, and other animals.

References

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R3. Diamond, Jared M.; " A Case of Missing Marsupials," Nature, 353:17, 1991. (X1)

R4, Nowak, Ronald M.; Walker's Mammals of the World, Baltimore, 1991. (X1)

R5. Fenton, M. Brock; Bats, New York, 1992. (X2)

R6. Shipman, Pat; "Where Have All the Primates Gone?" New Scientist, p. 16, June 13, 1992. (X4)

BMD3 Cycles in Mammal Populations

Description. Periodicities in mammal populations that challenge the classical predatory-prey-cycle model. The common and widely accepted explanation of periodical fluctuations in mammal populations excludes such factors as multiple predators, multiple prey species, and external influences such as solar activity. Yet, there is evidence these are involved and the "standard model" thereby faulty.

Data Evaluation. Although rough periodicity is readily observed in the populations of some mammals, especially in the far north, it is very difficult to collect precise data on numbers of predators and prey. The areas involved are just too large; and the number of investigators, too small. The classical fur-trade data are not always accurate. The scientific literature on the subject is actually substantial, but it is compromised by the factors just mentioned. Rating: 3.

Anomaly Evaluation. The reality of mammal population cycles is readily accepted by mainstream science. The challenges here are directed at the simplistic predator-prey model and involve such complicating factors as: (1) the existence of chaos in the data; (2) extraterrestrial influences (sunspot cycle); and (3) the involvement of multiple predators and prey species. Since only the simplicity of the model is in question, the anomaly rating is understandably low. Rating: 3.

Possible Explanations. The customary predator-prey model is simplistic.

Similar and Related Phenomena. Concentrations and dearths of mammals (BMD1 and BMD2, respectively). Lemming and gray squirrel irruptions (BMB28-X1 in Mammals 1).

Entries

X0. Introduction. The populations of some mammals rise and fall periodically. The 9- to 11-year cycle of North America's snowshoe hare is probably the best known. These natural periodicities vary considerably for several reasons: (1) They may be affected by weather and climatic change; (2) Food supplies vary; (3) Predator populations change; (4) Diseases come and go; etc. Two major cycles are recognized: a short cycle of 3-5 years and a longer one of 9-11 years. Although many animals may be entrained in each of these major cycles, it is customary to indentify a single species as the "key indicator" of the periodicity. The snowshoe hare is assigned this role in the 9-11 year cycle; lemmings to the 3-5 year cycle.

The simplest model for such population cycles has the populations of the key animals (lemmings or snowshoe hare) expanding in times of abundant food and few predators. Lagging these key populations are those of the predators. Of course, as populations continue to increase, the food supplies for the lemmings and snowshoe hares are pushed to the limit. With overpopulation come disease and the urge (with lemmings in particular) to emigrate en masse. (See BMB28-X1 in Mammals 1.) The predator-population crash lags that of the key prey animals. In fact, the predators often turn in desperation to other prey and thereby entrain them in the cycle.

The question always arises as to why certain cycle periods are favored; i.e., 3-5 and 9-11 years. Biological systems, like physical systems, say, pendulums, have natural frequencies. The frequency of a simple pendulum is controlled by its length, that of a biological population cycle by such factors as the number of offspring produced per unit of time by both prey and predator. Of course, there are additional factors, such as the prey's food supply, but this is the basic idea.

There is nothing anomalous in the

basic mechanism just described, but some curious and controversial aspects remain.

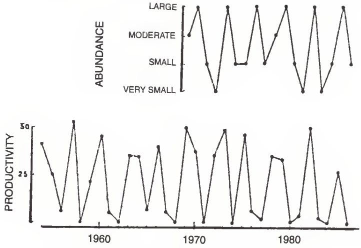
X1. Chaos in mammalian population cycles. If chaos is present in any system---biological or physical---the onset and duration of the next cycle cannot be predicted with certainty. It is difficult for many reductionist-minded scientists to admit that much in nature may be chaotic, since one goal of science is prediction of the future. Chaos theory is rather new to science, and some of the thoughts introduced below are not universally accepted by biologists and are, therefore, mildly anomalous.

Lemmings. Like the snowshoe hares, lemmings are inhabitants of the far north. A major predator is the arctic fox. When the lemming population falls precipitously, due to mass emigration and disease, the foxes are left without a major source of food. They then turn to other prey, especially ground-nesting birds, such as geese and swans. The eggs and nestlings of these species are easy prey. Even adult birds are taken. The result is that the breeding success of the birds (called "productivity") is entrained in the lemming cycle. Geese, such as the brent geese, have high productivity about every 3 years, when the arctic foxes are gorging on lemmings. Weather, too, is a factor in these far-northern climes. The complex, fascinating system of lemmings, geese, foxes, and weather is poorly understood. The existence of chaos within this system is admitted by J.J.D. Greenwood, when he says:

> ...there is no doubt that the breeding output of the geese does, indeed, follow a three-year cycle, though with sufficient variation that it is difficult to predict output in advance. (R3)

Voles. Like lemmings, voles inhabit far northern Europe. Rather than the arctic fox, a species of weasel is usually the major predator. Weather, again, comes into the picture. This biological system is also said to be chaotic, at least in the far north:

> A model of predator-prey interaction, modulated by seasonality, simulates with some accuracy the observed three-to-five year population cycles of northern voles. Put another way, the field data can also be broken down by nonlinear analysis to reveal their underlying chaotic components. Rodent population dynamics, whether predicted or observed, are chaotic,



Variation in the abundance of lemmings (top) and the productivity of dark-bellied brent geese (bottom) on the Taimyr peninsula. (R3) but with a strong periodic component imposed by the density-dependent appetites of their mustelid [weasel] tormentors. Interestingly, chaos is absent in vole populations further south, where climate is more clement and the predators more varied. (R6)

X2. Possible influence of the sunspot cycle. Sunspots have been blamed for everything from the belligerence of nations to the weather. It is the latter variable that might influence the periodicity of terrestrial biological systems. Despite much study and argument, there is no scientific consensus that sunspots have any appreciable effect on either terrestrial biological systems or the weather. Any evidence to the contrary would be anomalous.

Snowshoe hares. The classical predator-prey cycle of 9-11 years involves the snowshoe hare and lynx in the forests of northern Canada. The hare-lynx tale is a textbook staple. When the snowshoe-hare population crashes, the story goes, the lynx population follows in due course. A natural periodicity of about 10 years ensues. This venerable phenomenon was based historically upon the hare-fur-purchase records of the Hudson's Bay Company that go back into the 1700s.

C.S. Elton pointed out a possible sunspot connection in his famous 1924 paper in the British Journal of Experimental Biology (2:119, 1924). Elton's correlation was not generally accepted. For example, in 1936, D.A. MacLulich analyzed the fur-trade data and concluded:

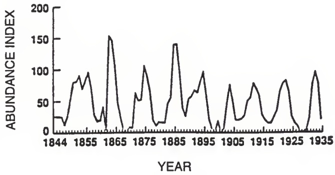
> The fluctuations in the numbers of neither lynx (Lynx canadensis) nor varying hare (Lepus americanus) are correlated with sunspots; but they are strongly correlated with each other. (R1)

[Note: varying hare = snowshoe hare. It is classified as a hare and not a rabbit!]

Even so, the sunspot connection simmered away on the back burner. One reason for not completely rejecting the idea lies in the fact that the snowshoe hare is hunted by different predators in different parts of Canada. The lynx, the coyote, and the great horned owl all have a taste for this mammal. One would expect that different primary predators would result in different predator-prey cycle lengths. This is not the case. The snowshoe hare population cycle is about 10 years long everywhere. One implication is that there exists an external driving force with a period of about 10 years. Perhaps the sunspot cycle is in control after all!

A.R.E. Sinclair et al reported in 1993 on a different scheme for investigating the influence of the solar cycle. We quote from the abstract of their paper in American Naturalist:

> Dark marks in the rings of white spruce less than 50 yr old in Yukon, Canada, are correlated with the num-



Abundance of snowshoe hares in northern Canada. (R2) ber of stems browsed by snowshore hares. The frequency of these marks is positively correlated with the density of hares in the same region. The frequency of marks in trees germinating between 1751 and 1983 is positively correlated with the hare fur records of the Hudson Bay Company. Both tree marks and hare numbers are correlated with sunspot numbers, and there is a 10-yr periodicity in the correlograms. (R5)

The more popular science publications immediately embraced the solar cycle-climate-hare-tree mark linkage. (R7, R8) Apparently mainstream science was unconvinced.

A 1995 paper in Science, which was signed by many of the authors of the 1993 American Naturalist paper, did not even mention the sunspot connection. Instead, it described controlled experiments on 1-square-kilometer areas in the Yukon, where food and mammalian predator abundance were manipulated. (R9, R10) The study's conclusion:

> These results support the view that population cycles in snowshoe hares in the boreal forest are a result of the interaction between food supplies and predation. They do not support either the plant-herbivore model or the predator-prey model for cycles, but suggest that hare cycles result from a three-trophic-level interaction. (R9)

In other words, both food supplies (plants) and predators act together to create the 10-year snowshoe-hare cycle. Neither food supplies nor predators are sufficient by themselves; and the solar cycle does not seem to be involved at all. This is certainly not the final study of this long-debated phenomenon.

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R2. Dewey, Edward R.; Cycles, New York, 1971. (X1, X2)
R3. Greenwood, J.J.D.; "Three-Year Cycles of Lemmings and Arctic Geese Explained," Nature, 328, 1987. (X1)
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R9. Krebs, Charles J., et al; "Impact of Food and Predation on the Snowshoe Hare Cycle," Science, 269:1112, 1995. (X2)
R10. Stenseth, Nils Christian; "Snowshoe Hare Populations: Squeezed from Below and Above," Science, 269: 1061, 1995. (X2)

BMD4 Exotic Mammals

Description. Scientifically recognized types of mammals observed living successfully and permanently in the wild far from their native lands but whose presence is emphatically denied by zoologists. This definition is unusually complex in order to exclude those mammals accidentally or deliberately introduced, such as the rabbits in Australia and the Norway rat almost everywhere, as well as mammals that have temporarily escaped from captivity.

Data Evaluation. The observations come mainly from newspapers, folklore, and Fortean publications. Almost all of the data are anecdotal and reported by persons with little experience in field observation. Although the quantity of the data is great---many hundreds of references---the quality and sources are generally unacceptable to science. Rating 3½.

Anomaly Evaluation. Even if cougars are really permanent residents in England and kangaroos thrive in North America, no important biological laws would be shaken. Mammals are very adaptable. Cougars could survive easily in England. Even if the existences of these exotic animals could be verified, it would only prove that current scientific skepticism is unwarranted. Such would hardly be very anomalous, but we are obliged to catalog such phenomena for the record. Rating: 3.

Possible Explanations. Most observations of exotic animals are misidentifications. The cases of phantom or spectral animals are either fraudulent or have psychopathological origins. Most verifiable exotic animals are most easily explained as feral domestic animals or escapees from zoos.

Similar and Related Phenomena. Scientifically unrecognized mammals (BMU).

Entries

X0. Background. In the present volume, two classes of "mystery" mammals are recognized: (1) Those potential new species that we term "unrecognized" mammals; and (2) Those animals that are well-established in the mammal guides but turn up in unexpected places---spots where they are not native and not established after introduction from other continents. These latter animals---the "exotic" or "erratic" mammals---are the subject of this section. We have essentially a "distribution" phenomenon. The "unrecognized" mammals, which are the grist of the cryptozoologists, are cataloged in BMU.

We should emphasize the cautionary statements made above under Data Evaluation. The "mystery" mammals of this section lie firmly in the province of sensational newspaper stories, folklore, and, a bit more seriously, Forteana. Forteans have been compiling accounts of mystery animals for decades, but science takes little notice of their bulging files. Recently, however, the tales of large, exotic cat-like animals have been bolstered by photography and some physical evidence. They, therefore, have become more believable; so much so that we must accord this kind of mystery animal some attention. Exotic mammals may not be particularly anomalous but they do have high curiosity value.

X1. Cat-like animals. By far the most common of the exotic mammals is the cougar (or puma, or panther, or mountain lion, etc.). In the Americas, these big cats are not rare in the Western United States, but they are very secretive. Small confirmed populations are also found in Florida and the far Northeast. More are scattered through Mexico, Central America, and down through South America as far as northern Chile and Argentina. Cougars are so wide-ranging that sightings anywhere in the New World cannot be deemed anomalous.

Cougars observed on other continents are more interesting to the anomalist, for these mammals cannot be indigenous. A few reports of animals that seem to be cougars emanate from continental Europe, but the hotbed of activity is Britain, where thousands of sightings have accumulated in recent years. G.M. Eberhart, in his 1983 survey of monsters worldwide, lists over 200 references mentioning British cougars. [The names "puma" and "panther" seem to be preferred in Britain.] He wrote:

> In 1963-64 British newspapers were saturated with reports of panthers that were seen in the commons, fields, and gardens of southern England. A far cry from housecats that have returned to the wild, these animals, dubbed "Surrey pumas" by the press, left huge tracks in snow and mud, mauled livestock, and terrorized farmers, motorists, and even policemen with surprise appearances and unearthly screams. All witnesses described what they had seen as a big cat, although they identified it variously as a tiger, a lion, a puma, a lynx, or a cheetah. (R5)

A few escaped cougars may have established themselves in Britain, giving rise to some of the "cat" stories.

It is not only in Surrey that cougar-like animals have seized the attention of residents. P. Sieveking, in a survey of sightings in Britain in 1994, found that reports emanated from thirty English counties as well as Wales, Scotland, and Northern Ireland. The scientific literature was, as always, mute on the subject, so Sieveking pulled his data from over a hundred newspapers. (R6)

Surrey seems to be the focus of cougar activity. To illustrate, the Day Book of the Godalming police station, Surrey, recorded 362 puma sightings between September 1962 and August 1964. (R2, R6)

An anecdote typical of the Surrey sightings is taken from the Bords' book Alien Animals:

> On July 4 [1966] a group of police, Post Office engineers and villagers watched through field glasses as a puma stalked a rabbit and ate it. Motor-cycle patrol officer Constable Robin Young said: 'It was ginger coloured and had a long tail with a white tip and a cat like face. It was just walking casually round the meadow. I had a good look at it through binoculars from 60 yards away.' (R2)

The hundreds, possibly thousands, of similar anecdotal reports make little impression on zoologists. More recently, though, the cougar data have been becoming a bit more substantial:

> The evidence is not merely anecdotal. The last 12 months have seen many fuzzy photographs and several enormous paw prints. The remains of sheep and calves, stripped clean to the bone, found in Cornwall and northeast Scotland in particular, are said not to be the work of dogs or foxes. Some of the Cornish cadavers show claw marks on the neck, flank and belly, half an inch apart with a spread of three or four inches. (R6)

Some mainstream experts are being swayed by this harder data. For example, the "Beast of Bodmin Moor" certainly has the form and behavior of a cougar, and we have a film that shows this. R. Rhodes made a video of this beast as it stalked this lonely moor of gorse and bogs some 250 miles southwest of London.

Douglas Richardson, curator of mam-

> mals at London Zoo, said he had seen Ms. Rhodes' videotape and confirms that the animal is a black panther. Wild cats are extremely rare in Britain, though pumas are adaptable to various climates. (R7)

As Richardson suggests above, cougars could easily survive in Britain if they were accidentally or intentionally introduced.

Despite the mountain of anecdotal evidence, still photos, and the video, puzzles remain: (1) Given all the reported activity, why have no cougar bones, skins, or corpses been found? (R3) (2) Many anecdotes identify "black" panthers, yet none has ever been killed anywhere. (R2) Could some of the black panther reports be akin to the "black-dog" reports below? (X3) There may be parapsychological factors in some British cougar sightings, just as with UFOs and ghosts. Even with such trepidations, the British cougars are becoming more "real."

Kangaroos are so unique in form that they are hard to misidentify. Even so, many U.S. sightings have been reported in the newspapers over the years, but none appears in the science journals we have surveyed!

X2. Kangaroos. Kangaroos are so distinctive that misidentifications seem unlikely. These marsupials are not native to North America, but Americans keep seeing them anyway. Perhaps some kangaroos do escape from zoos and wildlife parks, but never enough to account for all of the observations.

The tales one hears are wonderful for newspaper headlines. Other sightings turn up in Fortean publications. Take, for example, the experience of two Chicago policemen early on the morning of October 18, 1974:

> ...as they faced the five-foot marsupial at the end of the dark alley, they changed their minds---the creature was showing absolutely no interest in being captured. Ciagi and Byrne didn't like the way the thing was looking at them and it obviously didn't like the way they were trying to handcuff it.
>
> In fact, the moment they attempted to approach, it "started to scream and get vicious," Byrne would tell a reporter later. "My partner got kicked pretty bad in the legs. He (the kangaroo) smacks pretty good but we got a few punches to the head and he must have felt it."
>
> ...the pair retreated and sadly watched the kangaroo bounce away as other squad cars arrived on the scene. The kangaroo stepped over a fence and was last seen tearing down the street at about 20 miles an hour." (R5)

As is usually the case with mystery animals, there were no photographs, no specimens, living or dead, for zoologists to inspect. No kangaroos were reported missing by zoos. Many similar accounts are found in the Fortean literature. (R3, R4) One has to admit that these stories sound quite far-fetched.

X3. Dog-like animals. Large, black, fierce dog-like animals are venerable fixtures of European folklore and Forteana. For example, G.M. Eberhart (R5) and the Bords (R2) each list well well over one hundred references in their bibliographies relating to these purported animals. Virtually all of their citations, however, are from publications dwelling well outside of the scientific realm.

This lack of scientific concern is understandable because so many of the observations of these canines tell of glowing eyes, dripping jaws, etc.---literally hounds of the Baskervilles. Some are actually ghostly or "spectral" for they appear and disappear like ghosts. They have a habit of accompanying people wandering in lonely places, only to disappear just as mysteriously as they appeared. Sheep with their throats torn out are often blamed on these supposed animals. Almost invariably colored black, the spectral dogs should probably be classified with those "men in black" and the "black helicopters" of ufology. Here, with the "black dogs," we have obviously strayed far from objective zoology and must turn to other mammalian phenomena.

References

R1. Michell, John, and Rickard, Robert J.M.; Phenomena: A Book of Wonders, New York, 1977. (X1)
R2. Bord, Janet, and Bord, Colin; Alien Animals, New York, 1980. (X1)
R3. Cohen, Daniel; The Encyclopedia of Monsters, New York, 1982. (X1)
R4. Coleman, Loren; "Kangaroos across America," Fortean Times, no. 37, p. 25, Spring 1982. (X1)
R5. Eberhart, George M.; Monsters, New York, 1983. (X1)
R6. Sieveking, Paul; "Beasts in Our Midst," Fortean Times, no. 80, p. 37, April-May 1995. (X1)
R7. Anonymous; "Authorities Hunt Cat-like 'Beast" on British Moor," Baltimore Sun, January 20, 1995. (X1)

BMD5 Geographically Separated Populations of Flightless Mammals

Description. The existence of populations of flightless mammals that are very closely related taxonomically but geographically separated by wide water or land barriers. The question is, of course, how did these populations come to be separarated by such great distances.

Data Evaluation. The geographical distributions of most of the mammals discussed below are well known. Here we rely mainly upon standard mammal guides, along with several articles from scientific journals and science magazines. Rating: 1.

Anomaly Evaluation. Since most mammals, even if they cannot fly, are highly mobile on both land and water, most terrestrial and marine barriers can be surmounted by walking or swimming. When such easy natural explanations seem strained, one can invoke rafting on logs or clumps of floating debris. Temporary land bridges, which appear during waning sea levels, can perform the same transportation service. If any difficult cases remain, naturalists can point to the "relict" explanation. In this, a population is initially widespread under favorable climatic and geological conditions. Then, changes, such as sea-level changes and desertification, can concentrate and isolate pockets of the species in limited areas, as on islands and the tops of plateaus. Even ancient humans have been enlisted to account for recent population anomalies. With so many reasonable explanations at hand, it is impossible to accord this phenomenon more than a low anomaly rating. Rating: 3.

Possible Explanations. See above discussion.

Similar and Related phenomena. Global trends in the distribution of mammals (BMD6).

Entries

X1. Marine species observed far inland. Some dolphins, such as the susus, have become inured to fresh water and are now pemanent residents of rivers like the Ganges and Indus. (BMA24 in Mammals I) An occasional whale will swim up large rivers and estuaries where brackish water prevails, but they eventually return to the marine environment. It is the seals that provide us with the most puzzles. Some of them are great wanderers in and out of water. Some are seen far up rivers and in lakes with difficult-to-traverse aqueous links to the ocean. In some of these cases, we must ask whether the seals are simply far-travelers or members of relict populations; that is, animals that were stranded far inland after higher sea levels subsided long ago.

We begin with the wanderers and move next to the potential relict populations.

Northern fur seals. One member of this species was observed in the Sacramento River 144 kilometers from the Pacific. (R6) The same species is also known to make overland winter migrations from Herendeen Bay on the north side of the Alaskan Peninsula to Balboa Bay on the Pacific. The distance is about 13 kilometers. For part of the distance, small streams aid these eminently marine animals, but they do have to "walk" a lot! (R2)

Crabeater seals. For reasons unknown, these seals sometimes wander far into Antarctica's forbidding interior, where they ultimately perish and become mummified. They have been found 113 kilometers from open water. Some carcasses are at altitudes of 1,300 meters. Live seals have also been captured while engaged in their suicidal treks. (See details in BMB34 in Mammals I.)

Harbor seals. Vagrants will sometimes enter Loch Ness, perhaps adding to reports of the famous monster of these waters. (R7) Furthermore:

> Small local populations inhabit some rivers and lakes of western Hudson Bay, moving as far as 240 km inland. A small population lives in the Seal Lakes (Lacs des Loups Marins) at the headwaters of the Nastapoka River in northern Quebec. (R7)

Ringed seals. This seal is abundant in the Arctic and Subarctic. It also has a propensity to wander up rivers and into lakes. The most interesting populations of ringed seals, however, are well inland and probably relict. Reeves et al write:

> Two relict lake populations exist in the Baltic region, one in Lake Saimaa in eastern Finland and one in Lake Ladoga near Leningrad. Both lakes are connected to the Neva River. However, neither of these freshwater seal populations appears to mix with the marine population. (R7)

The two freshwater populations were apparently cut off from the members of their species in the White and Barents seas in postglacial times, perhaps 9,000-9,500 years ago when water levels receded.

Caspian seals. Closely resembling the ringed seals, the Caspian seals are isolated in the 1,250-kilometer-long lake called the Caspian Sea, which is situated between Russia and Iran. These seals are also considered to be relict populations. (R7)

Baikal seals. Lake Baikal, in Siberia, is 636 kilometers long and over 1,000 kilometers from the nearest ocean. Yet, here are found tens of thousands of seals well-adapted to the lake's near-pristine fresh waters.

The Baikal seals are obviously closely related to the ringed and Caspian seals. Their fore flippers are somewhat longer and stronger, and they do not have the spots of their cousins.

Lake Baikal's great distance from any ocean assures us that these seals are relict. But more than any other seals they cause zoologists to ponder how they got there and became isolated. R.R. Reeves et al have something to contribute here:

> Two main hypotheses concerning the origins of the Baikal seal have been discussed. One is that it (or its precursor) was pushed southward from the Arctic Ocean by Pleistocene glaciers, eventually moving up the Yenisey River and reaching Lake Baikal about 100,000 years ago. The other is that they evolved along with the ringed and Caspian seals from a common ancestor in the Paratethyan Basin of southeastern Europe, moving northward through glacially formed lakes and rivers and finally becoming established in Lake Baikal. Most Soviet experts accept the first of these hypotheses, that Baikal seals were isolated from ringed seal ancestors of the Arctic Ocean, and evidence from their internal and external parasites supports this view. (R7)

Seals (species not given). M. Meurger (R4) has noted that seals may have been seen in the Great Lakes in recent times. For example, the Evening Review (Niagra Falls, New York) of June 2, 1938, mentioned that a black seal 8 feet long was observed at Wasaga Beach on Lake Huron in 1938. Since the Great Lakes are connected to Hudson Bay through the Albany River, such a sighting is not out of reason. Particularly since harbor seals are already known in some lakes in the Hudson Bay area. Of course, there is always the possibility that the seal was an escapee from an aquarium.

X2. Flightless, terrestrial mammals geographically far-separated. When flightless species that are closely related are separated by oceans and other water barriers, the question of distribution can be answered in several ways:

(1) The animals are excellent swimmers (like the elephants that have voluntarily swum to islands almost 300 kilometers from the mainland). (See BMT6 in Mammals I.)

(2) The species drifted across water barriers on logs or rafts of debris.

(3) A species population was united in the past but some members colonized new lands via temporary land bridges, such as the one that supposedly sometimes spanned the Bering Strait, or via a southern route across Antarctica before it, Africa, and South America drifted apart.

(4) A species population was united in the past but climatic or geological changes destroyed connecting routes leaving relict groups on islands, mountain tops, etc.

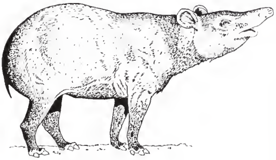
(5) Early humans transported the animals across the barriers, as was evidentally the case with the dingo in Australia.

In most cases such explanations are eminently reasonable and sufficient. A few minor problems do remain.

Falkland wolves. Extinct since about 1876, the Falkland wolves were the only terrestrial mammals found on the Falklands according to the earliest historical records. These mammals consumed geese, penguins, and an occasional seal. But how did they cross the 400 kilometers of Atlantic Ocean separating the Falkland Islands from Argentina?

One suggestion has prehistoric humans domesticating the wolves and transporting them across the water. This is not unreasonable, for the early explorers of the Islands found these wolves to be unusually sociable and unafraid of humans. A second surmise is that the lower sealevels during the Pleistocene exposed enough terra firma to make colonization much easier via a land bridge. One must then ask why other terrestrial mammals did not also take advantage of this opportunity. The Falkland wolf remains "something of a mystery." (R6)

Tapirs. Tropical Central and South America boast three species of tapirs; a single additional species lives in the tropical forests of Southeast Asia. Although the latter is placed in a different subgenus, all tapirs are very closely related even though separated by the entire width of the Pacific. The fossil record shows that tapirs originated in the Northern Hemisphere and were once widely distributed in both Asia and Central and South America. Current thinking asserts that the species were formerly united by the Bering Land Bridge when sealevels were lower and the climate warmer. (R6) For this explanation to be reasonable, the northern climes would likely have had to have been drastically warmer than they are now to induce these eminently tropical animals to make the crossing!



New World tapirs (3 species) are uniformly dark, whereas the Malayan tapir displays a striking black-and-white pattern that makes it virtually invisible in the jungle.

Raccoons. Some 18 species of raccoon-like animals inhabit the New World. They are geographically separated from the single Asian raccoon---the lesser panda. (R1 and BMA1-X7 in Mammals 1) Zoologists consider the lesser panda to be a relict species. Like the tapir, it may have been connected to the New World species by the Bering Land Bridge.

Mammals in general. The presence of flightless mammals on the Galapagos, located about 1,000 kilometers from South America, is explained best by the rafting theory says J.M. Diamond in a 1987 issue of Nature. The flightless mammals there are all very small and more adaptable to long sea voyages than larger mammals. In fact, Diamond observes, the farther islands are from the nearest mainland, the more likely the mammals living there are apt to be very small. On Luzon, 19 of the 20 endemic mammals are small rodents. So are all those on the Galapagos. Except for the dingo (presumably brought by early humans), the few placental mammals endemic to Australia are also very small physically. In contrast, those islands closer to land masses have higher proportions of larger mammals. These presumably made the trip by swimming or, in northern regions, by crossing on ice during winters. (R3)

Rafting and swimming, supplemented by ephemeral land bridges can, in principle, account for most of the features of mammalian distribution. In this context, the reservations expressed above concerning the Falkland wolf and the tapirs do not seem to be pressing.

X3. Terrestrial species separated by impassable terrain. In many parts of the world's continents, naturalists find pockets of mammals that are isolated from their close relatives by forbidding terrain, such as burning deserts and precipitous cliffs. Such situations are too many to catalog. One example will suffice.

Pikas. Throughout the western United States are hundreds of isolated populations of pikas separated by as much as 100 miles. These isolates are usually explained by invoking the Ice Ages, a time period when changing climates made the distances that now separate the pika's mountain refuges passable. (R5)

References

R1. Shute, Evan; Flaws in the Theory of Evolution, Philadelphia, 1961. (X2)

R2. Jones, Robert D., Jr.; "An Overland Migration of Fur Seals," Journal of Mammalogy, 44:122, 1963. (X1)

R3. Diamond, Jared M.; "How Do Flightless Mammals Colonize Oceanic Islands?" Nature, 327:374, 1987. (X2)
R4. Meurger, Michel; Lake Monster Traditions, London, 1988. (X1)
R5. Udall, James R.; "The Pika Hunter," Audubon, 93:60, March 1991. (X3)
R6. Nowak, Ronald M.; Walker's Mammals of the World, Baltimore, 1991. (X1)
R7. Reeves, Randall R., et al; Seals and Sirenians, San Francisco, 1992. (X1)

BMD6 Sharp Zoogeographical Divisions Despite Minimal Barriers to Movement

Description. The existence of separate, sharply demarcated, diverse faunas in the presence of easy-to-surmount land and/or water barriers.

Data Evaluation. Zoogeography is a well-developed science with a large literature. Here, we use only A.R. Wallace's original writing as complemented by a modern encyclopedia article. Rating: 1.

Anomaly Evaluation. When two distinct faunas are separated by only a narrow geographical barrier, it is at least curious when the two faunas have not mixed. But the phenomena cannot be considered profound if mixing has been discouraged until recently by geological changes, as may be the case with Wallace's Line in the South Pacific. Assuming this is so, the phenomenon is not of great import. Rating: 3.

Possible Explanations. See X2 below.

Similar and Related Phenomena. Geographically separated populations of flightless mammals (BMD5); variation of biodiversity with latitude (BMD7).

Entries

X0. Background. In BMD5, we see how sea and land barriers can sometimes isolate mammalian populations. There are also instances where radically different faunas exist very close to each other, with virtually no barriers in between, but yet have not intermixed to any great extent. The most outstanding of these faunal divisions occurs in the East Indian Archipelago. The first person to describe this division was A.R. Wallace. Appropriately, his dividing line was named Wallace's Line.

The Wallace of Wallace's Line was the same scientist who framed the theory of evolution independently of Darwin. A.R. Wallace spent many years naturalizing in South America and, especially, in Southeast Asia and Australasia. It was in the latter areas that he drew his famous line separating Southeast Asian fauna from that of Australasia. More precisely, Wallace's Line runs between Bali and Lomboc (or Lombock), in Indonesia) and between Borneo and the Celebes. Between Bali and Lomboc, the two faunal regions are separated by only about 15 miles of water---the Strait of Lomboc. Many mammals can easily negotiate such a narrow water barrier. It is an easy flight for birds. So, we would expect a copious flow of species in both directions. But this has not happened to the degree one would expect, even for the birds. As anomalists, we must ask why there has not been a greater admixture of species.

Wallace formally drew his line in 1860. (R1) It was widely accepted for many years, but as more evidence accumulated it became somewhat blurred. In the early 1900s, Weber drew a different line farther to the east. Weber's Line was based upon better data as well as oceanographic information. Some zoologists reject the idea of a sharp line, preferring instead a broad band separating the two zoogeographical regions. This is not unreasonable because different species have different motilities---obviously birds travel across water barriers more readily than kangaroos! Regardless of whether it is one line or another, or a band, a profound difference does exist between the mammals on either side of an easily surmountable geographical barrier.

Wallace's Line sharply separates two distinctly different faunas: that of Southeast Asia from that of Australasia.

X1. Wallace's Line. We now excerpt directly from Wallace's 1860 paper, but one must remember that his "Line" has blurred a bit as additional zoological discoveries have been made.

> The Australian and Indian regions of Zoology are very strongly contrasted. In one, the Marsupial order constitutes the great mass of the Mammalia in the other not a solitary marsupial animal exists. Marsupials of at least two genera (Cuscus and Belideus) are found all over the Moluccas and in Celebes; but none has been detected in the adjacent islands of Java and Borneo. Of all the varied forms of Quadrumana, Carnivora, Insectivora and Ruminantia which abound in the western half of the Archipelago, the only genera found in the Moluccas are Paradoxurus and Cervus. The Sciuridae, so numerous in the western islands, are represented in Celebes by only two or three species, while not one is found further east. Birds furnish equally remarkable illustrations.
>
> .....

To define exactly the limits of the two regions where they are (geographically) most intimately connected, I may mention that during a few days' stay in the island of Bali I found birds of the genera Copsychus, Megalaima, Tiga, Ploceus, and Sturnopastor, all characteristic of the Indian region and abundant in Malacca, Java, and Borneo; while on crossing over to Lombock, during three months collecting there, not one of them was ever seen; neither have they occurred in Celebes nor in any of the more eastern islands I have visited. Taking this in connexion with the fact of Cacatua, Tropidorhynchus, and Megapodius having their western limit in Lombock, we may consider it established that the Strait of Lombock (only 15 miles wide) marks the limits and abruptly separates two of the great Zoological regions of the globe.

.....

Leaving the Philippines out of the question for the present, the western and eastern islands of the Archipelago, as here divided, belong to regions more distinct and contrasted than any other of the great zoological divisions of the globe. South America and Africa, separated by the Atlantic, do not differ so widely as Asia and Australia; Asia with its abundance and variety of large Mammals and no Marsupials, and Australia with scarcely anything but Marsupials. (R1)

X2. Accounting for the faunal differences. As with the relict populations described in BMD5, the phenomenon remarked above by Wallace may be the consequence of geological changes.

> Much of the area east of Wallace's Line underwent great disturbance in the Tertiary period, and some of the islands did not emerge until the Pleistocene. Thus the western islands represent essentially a continental fauna and the eastern islands an insular one. (R3)

One might, then, visualize the water barrier as being much more formidable until relatively recently. Possibly there has not yet been enough time for a zoological equilibrium to be established across the lowered geographical barrier. This, however, must remain surmise because we cannot reconstruct exactly what happened.

References

R1. Wallace, Alfred R.; On the Zoological Geography of the Malay Archipelago, vol. 4 of the Journal of the Proceedings of the Linnean Society, London, 1860. (X1) As reprinted in R2.

R2. Anonymous; "Wallace's Line," Science News Letter, 24:42, 1933. (X1)

R3. Goodnight, Clarence J.; "Zoogeography," Encyclopedia Americana, 29:296, New York, 1966. (X0-X2)

BMD7 Decrease in Biodiversity with Latitude

Description. The decrease in biodiversity with increasing latitude. This statement applies to all life forms.

Data Evaluation. A well-referenced survey article in a scientific journal is the only source used here. The article, though, seems to ignore marine mammals, so the relevance of the phenomenon to mammals in general is questionable. Rating: 3.

Anomaly Evaluation. The phenomenon cataloged here conforms to both popular and scientific expectations. Despite this "reasonableness" of the phenomenon, it is difficult to explain it in terms of such contributing factors as niche width, predation, competition, habitat richness, mutualism, etc. A minor mystery therefore remains. Rating: 3.

Possible Explanations. Abiotic factors (weather, etc.) in the polar regions and biotic factors (competition and predation) in the tropics combine to produce the phenomenon. See fuller discussion below.

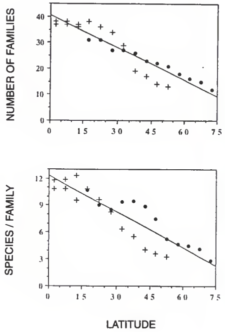
Similar and Related Phenomena. Wallace's Line (BMD6).

Entries

X1. General observations. It is widely recognized by scientists and laypersons alike that tropical reefs and rainforests exhibit exceptionally high biodiversity. That there are far fewer species in the polar regions is also taken as a truism. The frigid weather of the high latitudes and the warm sun and abundant rainfall of the tropics would seem to make this Catalog entry obviously nonanomalous. But perhaps this general impression is incorrect. Some biologists are not so assuming. In 1995, D.M. Kaufman wrote:

> A question of great interest to biogeographers, and those concerned with biodiversity, is "Why are there so many species?" and, in particular, "Why are there so many species in the tropics?" It may be useful, conversely, to think of this question as "Why are there so few species in the temperate to polar regions?" It is necessary to explain not only why there is a peak in species richness near the equator, but also why diversity decreases from the tropics toward the poles. (R1)

It must be injected here that the polar regions actually teem with life.



The number of families present declines at higher latitudes. So does the number of species per family.

Marine life, but not land life, is abundant: seals, whales, fish, krill, etc., all thrive and multiply, thanks to nutrient-rich waters that upwell in these regions. Nevertheless, general biodiversity is low---there are multitudes of individuals in the oceans but few species when compared to tropical reefs---at least when all phyla are considered. But with nutrients abundant, why has there not been more speciation in the polar seas?

Kaufman has crafted a theory to explain the huge difference in biodiversity, and it more or less conforms to the popular expectations of polar and tropical life:

(1) In the polar regions, primary biological productivity is low due to lack of sunlight. Physical conditions are extreme, and animals must divert much energy to survival.

(2) In the tropics, such abiotic forces lessen; life is easier (?) and species can devote more resources to interacting with other species, as in competition and predation. Here, the biotic forces are dominant. In Kaufman's own words:

> I suggest that the general explanation for latitudinal gradients may be as follows: abiotic conditions limit diversity by setting higher latitude boundaries of ranges and allow only a few species to exist near the poles; biotic interactions become limiting (where abiotic conditions are more favorable) to set the lower latitude boundaries of ranges and allow many species to exist in the tropics. Ultimately, these phenomena produce the latitudinal gradient in species richness. (R1)

Compiler's comments. The gist of this seems to be that in the tropics that are more niches to fill and more interfaces with other lifeforms. These stimuli and unshacklings allow more speciation. Whereas, in the polar climes, life is harsh and speciation is thereby repressed.

One pictures the random mutations that might lead to speciation as occurring at the same rate at all latitudes. One is lured into thinking that in the nutrient-rich marine environments of the polar regions that there, too, species would proliferate, but this has not happened, although there do seem to be more species of marine mammals in the polar seas than tropical waters! We have seen no statistics on this.

A careful reading of Kaufman's paper reveals that she has apparently restricted her analysis and discussion land mammals only. With this narrowing of the scope of discussion, her theory seems reasonable. But does it really apply to the mammals of the polar seas?

We wonder if the latitude-biodiversity phenomenon is completely explained when one considers both terrestrial and marine mammals.

Reference

R1. Kaufman, Dawn M.; "Diversity of New World Mammals: Universality of the Latitudinal Gradients of Species and Bauplans," Journal of Mammalogy, 76:322, 1995. (X1)

BMD8 Preference for Certain Geological Formations

Description. The concentration of the activities of certain mammals in terrain associated with certain geological formations.

Data Evaluation. We have only a single report involving only one species (African elephants) by a professional geologist. The observation is very general, more like an impression, and not backed up be careful study. No supporting data have been found elsewhere. Rating: 3.

Anomaly Evaluation. The African elephants' curious behavior relative to rock types has not been explained formally, but two possibilities come to mind: (1) The underlying rock affects the palatability of the vegetation; and/or (2) The rock transfers desired minerals in the vegetation. Based upon the reasonableness of such possibilities, a low anomaly rating is in order. Rating: 3.

Possible Explanations. See above.

Similar and Related Phenomena. Elephant "mining" activities (BMT12-X4 in Mammals I).

Entries

X1. General observations.

Elephants.

> During two and a half decades of African bush geology, an observation has forced itself upon me which may perhaps have been noticed by others, namely, that elephants appear to show preference for certain geological horizons. This is at times so well pronounced that the boundary line between two formations can be deduced from native information as to how far elephants circulate in the district. I Have noticed it particularly in regions where crystalline rocks, mainly granite masses, come into contact with sandstone, and it is the latter which the elephants prefer.
>
> .....
>
> In some cases, as to a certain extent within the Forest of Sibiti, where the decomposition of sandstone gives rise to dense vegetation, the question explains itself. Otherwise, however, the country was either tree savanna or light bush, and in such cases the reason is difficult to explain. It might be a question of food, chemical composition of water or nature of the weathering soil. (R1)

Elephants and, indeed, many mammals, strive to find and consume minerals or vegetation containing minerals lacking in their diets.

References

R1. Hyde, Herbert P.T.; "African Elephants as Geological Indicators," Nature, 165:326, 1950. (X1)
R2. Anonymous; "Elephant Story from Africa: Elephants Know Their Rocks," Science News Letter, 57:184, 1950. (X1)

BMD9 Entombed Mammals

Description. The discovery of living mammals apparently confined in completely enclosed cavities, though the confines need not be airtight.

Data Evaluation. A single, very old (1849) report in Scientific American. First, it must be stated that editors 150 or so years ago were not as skeptical about anecdotes like the one used to support this claim. It is very probable that we have here a case of mistaken observation. There is no scientific experience supporting the phenomenon. The major reason for cataloging the phenomenon is that it is a part of a suite of Fortean lore involving entombed toads, insects, and other creatures, which are supported by hundreds of accounts similar to the one cataloged below. Rating: 4.

Anomaly Evaluation. If mammals can be proven to have been entombed for periods of years, it would contradict all that we know about mammalian metabolism. Rating: 1.

Possible Explanations. The mammal involved in our only observation is a bat. Bats are well known to roost and, in some species, hibernate, in tree cavities. In the case at hand and, indeed, in general for entombed animals, it is likely that a small entrance to the "tomb" was overlooked in the confusion of the discovery.

Similar and Related Phenomena. Mammal hibernation (BMF6 and BMF7); entombed toads and frogs (ESB8 in Anomalies in Geology), snakes, and other reptiles (BRD), insects (BAD), etc.

Entries

X1. General observations.

Bats.

> A curious fact of Natural History occurred a short time ago in the woods of Blair Adam, Scotland. A silver fir tree had been felled, which, as is very usual with that species, had separated into two stems, (about twelve feet from the ground) but they afterwards grew together again, and the tree grew in a single stem for 18 or 20 feet above the junction, which appeared to be about four feet in length, and twelve inches in diameter. When the tree was cross cut about four feet below where the junction was supposed to have commenced, a small hollow was dicovered in the heart of the tree, and something was observed to flutter within it. A boy put his hand in and pulled out a large bat, one of the ears of which was cut off by the saw; but the animal was in such a lively state, that, when thrown on the ground, it flew away over the tops of the adjacent trees. Robert Wishart, the woodman, an experienced and steady man, said that the aperture from which the bat was taken was about seven inches long, and barely three inches in diameter; and that the animal, when found, was with its head down towards the foot of the tree; that he examined the tree very carefully, but could find no communication with the external air. He thought the parts of the tree must have been growing together for six or eight years. (R1)

Reference

R1. Anonymous; "Curious Imprisonment of a Bat," Scientific American, 4:246, 1849. (X1)

BMD10 Late Survival of Mammoths and Mastodons

Description. The survival of the mammoth and/or the mastodon into at least historical times (2,000 B.C. and later), perhaps even to within the last 1,000 years.

Data Evaluation. The data suggestive of late survival are divided into four categories:

(1) Sighting of live animals. The several claims within the last thousand years invariably come from old, suspect sources.
(2) Physical traces. Excepting the deep-frozen mammoths of the north polar regions, there are no convincing remains dated at less than 4,000 years.
(3) Myth and tradition. Although many native traditions tell of elephantine animals, the tales are vague and undatable. Knowledge of the elephantine form could have been passed down through many generations from the time when humans and mammoths did coexist. The knowledge could also have arrived through the diffusion of knowledge from elsewhere---even from Asia where elephants exist today.
(4) Art and sculpture. Some recent petroglyphs, carvings, and effigy mounds suggest that New World humans could represent the elephant form accurately. But such knowledge, like that found in some traditions, could have filtered down through many generations or even have arrived through diffusion from Asia, although this latter possibility is strongly disputed.

In general, the data supporting the survival of mammoths and/or mastodons later than 4,000 years ago are very weak. Rating: 3.

Anomaly Evaluation. Even if the mammoths or mastodons are eventually proved to have survived later than 4,000 years, or even into the present, no important biological paradigms are threatened. Animals believed to have been extinct for millions of years are occasionally found; viz., the coelacanth. Our planet still has many areas unfrequently by humans. A living mammoth would obviously be a great curiosity and would negate the experts' assertions that the species met its demise 9,500 or so years ago, but it would hardly be biologically anomalous. Rating: 3.

Possible Explanations. Mammoths were certainly known to the early inhabitants of North America, say, 4,000 years ago and earlier. This could account for many of the suggestive traditions and artistic representations. Knowledge of the elephant form could also have come through diffusion from Asia.

Similar and Related Phenomena. Late survival of ground sloths (BMD11), thylacines (BMD12), Steller's sea cow (BMD13), and other mammals (BMD14).

Entries

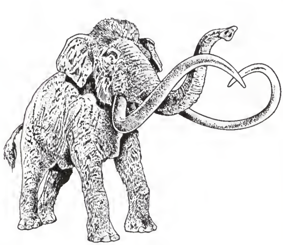
X0. Introduction. The mammoth no longer plods the shores of the Arctic Ocean, and the last thylacine expired in a Hobart zoo in 1936. Gone, too, is South America's giant sloth, along with the American camel and Steller's sea cow. At least this is what all the naturalists tell us. But is there a tiny chance that they are wrong and that some officially recognized, but now supposedly extinct, mammals still survive in remote, utterly wild corners of the planet? Perhaps all the mammoths did not all freeze to death 9,000 years ago in Siberia and Alaska and, instead, lived on into the 1700s and even later. And thylacines may still prowl the remoter forests of Tasmania. (BMD12)

We approach this phenomenon of late survival of the mammoth by breaking our accumulated data down into four parts according to the type of observation: (1) visual observations of live animals; (2) very fresh physical remains; (3) legend and tradition; and (4) representations of the mammoth or mastodon in art and sculpture.

Note that mastodons as well as mammoths are included in this entry.

X1. Actual sightings of live animals. Direct visual observations of supposedly extinct mammals are rare, necessarily anecdotal, and almost always made by persons inexperienced in the natural history of the creatures in question. Such data are almost never accepted by the scientific community. Still, the fleeting, often suspect, glimpses assembled below and in the remainder of this chapter hint that a few officially extinct mammals may have to be put back into the field guides.

No one seriously claims that the mammoth still roams the Siberia taiga. Of course, there are those immense accumulations of mammoth bones and even a few amazingly fresh carcasses frozen in the deep Siberian and Alaskan muck.



The imperial mammoth. Did this species and/or other elephantine species survive into historical times in North America?

But, these are the vestiges of animals probably entombed 9,500 or more years ago, perhaps by a precipitous change in the climate or some other natural catastrophe. (See ESB4 in Anomalies in Geology for more on this.) Any historical observations later than than, say, 8,000 years ago, would contradict the entire accepted mammoth-extinction scenario and, therefore, would be anomalous in the sense the word is used in this Catalog.

In fact, there are records of mammoth and mastodon sightings occurring well into historical times. We will now present some of the more interesting of these visual data.

The David Ingram observations. In the period 1568-1570, an English sailor, a David Ingram, along with two companions, made a most remarkable journey on foot from the Gulf of Mexico all the way to Cape Breton in Canada. Ingram's account of their adventures appeared in C.J. Weston's Documents Connected with the History of South Carolina, published in London in 1856. We quote now from an excerpt that appeared in the American Antiquarian in 1887. Original spelling has been preserved. (R8) A modernized and more complete treatment can be found in (R21).

> The animals seen by Davyd Ingram, who was a sailor and travelled with two companions only, were (p. 14): "buffes, beares, horses, kyne, wolves, foxes, deare, goates, sheepe, hares and conyes;" and the following will give a further idea of his marvelous sights and discoveries (p. 15):
>
> "This Expedition did alsoe see in those Countryes a Monstruous Beaste as bigge as a Horse and in every proportyon like unto a horse bothe in mayne, hoofe, heare (hair) and neighinge, savinge yt was small towardes the hinder partse like a greyhounde; these Bestes haue twoe teethe or hornes of a foote longe growinge streight furthe of there nostrelles; they are natural Enimyes to the horse. He did alsoe see in that Countrye both Eliphantes and Uunces." [Ounces; i.e., pumas?] (R8)

Which is the supposed mammoth, the "Monstruous Beaste" or the "Eliphante"? Very weak data, indeed, but still suggestive and intriguing.

Tale of a Russian convict. The following account passed through several hands and caution is advised. Our account comes from the Zoologist, a rather iconoclastic scientific journal of the Nineteenth Century. E. Newman, the editor of the Zoologist, obtained his information from the New York World---hardly an auspicious source.

It seems that one of the New York World's correspondents had (supposedly) interviewed Cheriton Batchmatchnik, a Russian convict who had escaped from the mines of Nartchinsk, in Siberia. In his long trek to freedom, Batchmatchnik claimed that he had chanced upon a warm, fertile valley 50 miles wide and 150 long. It teemed with animals. Seeking a safe shelter, the convict entered a huge cave which proved to be filled with large beasts. He stealthily penetrated farther into the cave.

> One turn, then another, he heard a heavy startling snort, and there in the half light of the cave, standing before him, alive, chewing the cud, and waving its proboscis to and fro with a gentle, majestic motion, he saw---a mammoth!...During his stay in the valley he was close to five of them, all of which were nearly of a size, being about twelve feet high, eighteen feet long, with tusks projecting about four feet, and being eight to ten feet counting the curve. (R2)

Batchmatchnik gave voluminous details, saying there were fifteen to twenty of the monsters in the valley. They were nocturnal feeders, spending the days in the cave. Very peaceful and sluggish, they never bothered him. (R2, R3)

The convict's story has the earmarks of journalistic fabrication. Even the Russian names sound "made-up". As a matter of miscellaneous interest, Batchmatchnik's travels resemble somewhat those found in S. Rawicz's 1984 book The Longest Walk, in which another prisoner, Rawicz, made his escape from Siberia. He then made his way to India and, on the way, spied a band of Yeti! (See BHU7 in Humans III.)

The Russian hunter's tale. In 1920, the French charge d'affaires at the Consulate in Vladivostok had lunch with a Russian hunter, who had just returned from four years in the taiga. This hunter recounted an incident from 1918 during which he followed huge oval tracks (2 feet wide) through the mud and snow. Curious about the makers of the tracks, he followed them for days, gaining steadily on his quarry.

> One afternoon [he went on] it was clear enough from the tracks that the animals weren't far off. The wind was in my face, which was good for approaching them without them knowing I was there. All of a sudden I saw one of the animals quite clearly, and now I must admit I really was afraid. It had stopped among some young saplings. It was a huge elephant with big white tusks, very curved; it was a dark chestnut color as far as I could see. It had fairly long hair on the hindquarters, but it seemed shorter on the front. I must say I had no idea that there were such big elephants. It had huge legs and moved very slowly. (R17)

The above quotation comes from B. Heuvelmans' On the Track of Unknown Animals. The cited reference is a book by the French charge d'affaires. Gallon: Mammouths, Paris, 1946. Heuvelmans describes the hunter's story as "more circumstantial" than most.

A highly suspect datum. The datum now at hand (and it really is highly questionable) comes from the The National Tombstone Epitaph, hardly part of the scientific literature! But, at the very least, it is amusing. The article develops the theme that intrepid Chinese explorers landed in North America several millennia ago. The basis for such paradigm-shattering speculation is an ancient Chinese work called the Shun-Hai Ching, which is reputed to be about 3500 years old. In it, the aforesaid Chinese explorers mentioned encounters with several strange animals in this newly found land far to the east. One creature can be easily identified as the collared peccary, a mammal known only in the New World, thus supposedly establishing the reality of the trans-Pacific contact. Now, here is the piece de resistance from the Chinese explorers' account:

> Here we met a creature as tall as

> three men and so great that the earth trembled as he walked. He had a voice as loud as thunder. He was red like fire. From his mouth he spat spears of pearl, and he had but one long arm. He was wont to take up men in his hand and dash their brains out against rocks.

Could this creature have been anything but a mammoth? Incidentally, the frozen Siberian mammoths are also reported to have been covered in part with reddish hair. (R23)

Two even-less-reliable accounts! In 1887, it was rumored about the Pacific Northwest that some Indians who had journeyed far up the Yukon River, in Canada, had come upon some gigantic circular tracks. Following this trail, they overtook huge, hairy beasts that they identified as mammoths! (R10)

A very similar tale was published in the English Mechanic in 1873. In this instance, Indians belonging to the Stickeen Tribe, again following immense round tracks, caught up with elephant-like animals. One of these hunters described the animals as: "...being large as a post trader's store, with great, shining, yellowish-white tusks and a mouth large enough to swallow a man in a single gulp." (R11)

X2. Recent physical remains. Here, we attend to those carcasses, skins, tracks, and bones that can be scientifically shown to be considerably more recent than the accepted date of their owner's extinction.

If the mammoth truly became extinct some 9,500 years ago, one would surely not expect to find fresh remains, but rather only fleshless, somewhat weathered skeletons. Excepted, of course, are those long-frozen cadavers found in the polar regions of Siberia and Alaska. (ESB4 in Anomalies in Geology) For the most part, all mammoth remains dug up in temperate climes have met the above expectations. In fact, we have found only two items that might be considered anomalous. As before, mastodons are included along with mammoths.

Marrow-filled bones. J. Collett, the State Geologist of Indiana, in his 1880 report, mentioned:

> ...some new facts that seem to indicate that the mastodon existed in our country at a more recent date than is commonly supposed. In nearly all the specimens that have been found, generally in places where the animal has been mired, the skeletons are in a greater or less state of decay. In a skeleton discovered a few years ago, in Fountain County, the marrow of the larger bones was used by the workmen to grease their boots, and the place of the kidney-fat was occupied by lumps of adipocere. (R5, R6)

The point here is that one would expect that all organic matter would have disappeared in 9,500 years---the official time span since mammoth extinction.

Unweathered bones. In 1924, J.W. Russell, from the University of Western Ontario, presented the following information at a meeting of the British Association for the Advancement of Science.

> Most mastodon remains have been recovered from bogs containing peaty material which acted as a preservative; so that it has been impossible to tell how long since these big elephants lived. Prof. Russell told of finding a mastodon skeleton which had no preservative, and showed the bones and described the rapid weathering and dissolving which would have occurred had they been long exposed. The bones show that the mastodon must have died quite recently, he concluded. (R13)

In geological parlance, "quite recently" could be 100,000 years! Actually, of course, no one knows.

Late survival of dwarf mammoths. In 1993, S.L. Vartanyan et al announced in Nature the discovery of numerous teeth belonging to dwarf mammoths on Wrangel Island, in the Arctic Ocean. These teeth were dated between 4,000 and 7,000 years---several thousand years younger than the most recent remains of their larger cousins. (R25, R26)

D. Palmer has remarked that this fossil find means that the dwarf mammoths at least survived until the pyramid-building days of the ancient Egyptians. (R27) But why did the larger species of mammoth not also survive? The species are closely related and inhabited roughly the same territory.

Wrangel Island is thought to have separated from the North American mainland about 12,000 years ago, but this geographical separation would not have protected the dwarf mammoths from the catastrophic climate changes that many think caused the demise of the larger mammoths.

Regardless of the reason, some mammoths did live a couple thousand years beyond the official date of the demise of the mammoths. Thus, it is not beyond possibility that we will eventually find that the normal-size mammoths did, too.

X3. Myth, legend, tradition. Folk tales sometimes provide science with useful hints about natural history, such as the existence of new species. But, where the question is one of the possible recent survival of supposedly extinct species, myth and tradition are almost useless. The problems are several: (1) The animal descriptions may be embellished or grossly distorted; (2) The animals of folklore are often difficult to relate to known species; (3) The data of myth may be "contaminated" by information introduced from distant places by travellers; and (4) The dates of any late survivals suggested by myth and tradition are very hard to pin down. For these reasons, we cannot rely on on myth and tradition with confidence for help with the phenomenon at hand.

The natives of northeast Asia, China, and northern North America all tell fanciful tales of contacts with huge creatures possessing tusks and "arms" used for grasping and carrying. No one denies that ancient humans in these northern lands were once contemporaneous with the mammoth and the mastodon, perhaps for thousands of years. In fact, it has been amply demonstrated that post-Pleistocene humans hunted and consumed mammoths whenever they could. Because of this, the existence of substantial accumulations of myths and traditions involving mammoths and mastodons is not at all surprising.

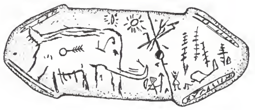
Interesting though all these stories may be, they really shed little light on the possible late survival of mammoths. For example, some traditions speak of the "stiff-legged bear." Could this have been a mammoth? It could have been, since humans certainly preyed upon the mammoth. But who can say for certain, and what are the dates involved? We simply cannot accept such data in assessing late survival. Too much "interpretation" and reading between the lines is required. We will now abandon this type of evidence. Anyone who is interested in reading more about mammoth myths and traditions is referred to R9 and R16.

X4. Art and sculpture. Although myth and tradition cannot be dated, artifacts often can. Therefore, if a demonstrably recent artifact portrays an extinct mammal so accurately and realistically that the artist or sculptor probably had personal knowledge of the animal, we have evidence of late survival that we should at least consider.

The elephantine shape is so distinctive, with the large body, post-like legs, trunk, and tusks that an artist would have to either see the animal in the flesh or perhaps a good representation of it in order to etch or sculpt a realistic rendition of the unique form. Some possible mammoth "artwork" relevant to the question of recent survival follows.

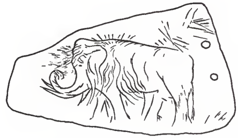
A warning is always in order when trafficking in controversial artifacts: Frauds and hoaxes are very common in archeology.

The Lenape Stone. The appended sketch shows one side of the famous Lenape Stone. This object was supposedly found by a boy plowing a field near Doylestown, Pennsylvania, in 1872. The



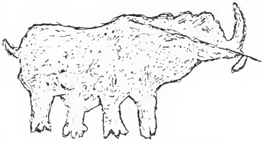
Plowed up in 1872 in a Pennsylvania field, the Lenape Stone seems to record an Indian encounter with a mammoth.

scene engraved seems to depict an Indian encounter with a mammoth. Is this stone proof that recent American Indians knew and perhaps hunted the mammoth? Hardly, in the eyes of mainstream archeologists! The Lenape Stone was not discovered by a professional archeologist under controlled conditions. It has always been a controversial artifact, and the charge of fraud is prominent here. (R19)



The Holly Oak pendant was carved on a whelk shell. Today, it is widely considered fraudulent.

The Moab petroglyph. Etched into a rock wall in the canyon of the Colorado, near Moab, Utah, is a crude elephantine figure. About 2 feet long, it seems to depict the trunk, one tusk, and toes of a pachyderm. The artist seems to have had a clear conception of elephant anatomy. Of course, the date



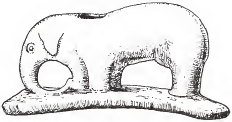
This Moab (Utah) petroglyph "could" be a crude representation of a mammoth.

of the petroglyph is unknown, and we cannot ascertain whether it represents a mammoth or mastodon. It could even be an Asian elephant, information about which might have come from Central America. (R15)

Another elephantine rock drawing has been found in Hava Supai Canyon, in Arizona. (R18)

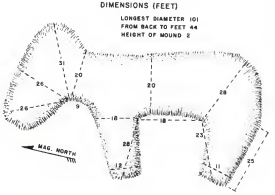
The Holly Oak pendant. In 1864, an inscribed fossil whelk shell illustrating a mammoth was allegedly found in a peat deposit near the Holly Oak railway station, in northern New Jersey. J.C. Kraft and R.A. Thomas claimed in Science that the pendant proves that early humans in America had close contact with mammoths only several thousand years ago. (R22) The Holly Oak pendant has always been controversial, and recent laboratory measurements date the shell itself at 885 AD. The date of the etching is obviously later. If the pendant is genuine, it would imply that mammoths might have survived until perhaps a thousand years ago. This date is far more recent than most scientists are willing to accept. In fact, a recent study of historical records associated with the discovery of the pendant suggest fraud. (R24)

Elephant pipes. The artist who carved the sandstone pipe here illustrated was certainly familiar with the elephantine form, even though no tusks are shown. Found in Louisa County, Iowa, in 1872 or 1873, by a farmer, this artifact is readily attributable to the Adena culture ascendant in the area about 1,000 BC. (R4, R20) Additional elephant pipes have been unearthed in Iowa. (R18) Fraud has not been suggested here to our knowledge. If any art or sculpture can be taken as "proof" of the late survival of the mammoth, these pipes are good candidates.



There can be no mistaking the elephant form in this Indian pipe found in an Iowa mound.

Elephant effigy mounds. Near Prairie du Chien, Wisconsin, aviators can see large mounds below that have obviously been heaped up to represent various animals. These are typical "effigy"



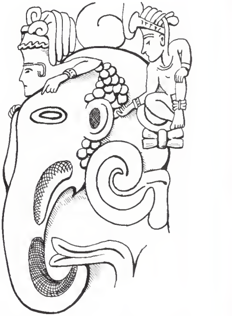
This Wisconsin effigy mound seems to be a crude representation of an elephant.

mounds. In this particular group are found two mounds that some claim must be effigies of elephants. The more convincing of these is reproduced here. To us, the outline of the mound only vaguely suggests an elephant; some imagination is definitely required! (R7)

Central American elephant motifs. At several archeological sites in Central America, one finds rather convincing carvings of what seem to be elephant heads, such as the one shown here, which comes fom Copan, a Mayan site in Honduras. (R12) It is possible that a toucan or some other creature is depicted, but the carving certainly looks elephantine. Mammoth remains are not common as far south as Honduras, so we may have here instead a case of the Precolumbian, trans-Pacific diffusion of a common Asian motif.

Another remarkable representation of an elephantine animal was found in 1930 by J.P. Fox at Arroyo Sonso, 25 kilometers southeast of Puerto Mexico. The statue is almost a meter high and is carved out of very hard dark-gray basalt. The trunk, ears, and other features are eminently elephantine. The artist must have had accurate knowledge of either modern elephants or the mammoth. (R14)

Although the diffusion of motifs from Asia is vigorously denied by most archeologists, there exist many other Asian "affinities" in Central and South America. Precolumbian contact with the New World by Asians is implied by many of these artifacts, and they could account for the existence of the elephant motif in this region. (R20) (See also the Series-M catalogs.) Such early Asian contacts would actually be more anomalous than the late survival of the mammoth! This being so, the only other explanation is that the natives of Central America knew the mammoth 1,000-2,000 years ago!



This elephant-like head (with "rider"?) is located at the Mayan site at Copan, Honduras. Mainstream archeologists insist that it is a macaw!

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BMD11 Current or Very Recent Survival of Giant Ground Sloths

Description. Sightings, recent physical traces, and other evidence that animals resembling large, officially extinct ground sloths have survived into historical times and, possibly, even until the present, in South America.

Data Evaluation. The evidence that large ground sloths were contemporaneous with early humans 8,000-10,000 years ago in South America is convincing. As for very recent survival---within historical times---the data are much less impressive, being mostly traveller's tales and vague reports from remote areas by inexperienced persons. Our rating is based on the recent data. Rating: 3.

Anomaly Evaluation. The coexistence of ancient humans and large ground sloths several thousand years ago is not anomalous, for early humans preyed upon many large Pleistocene mammals that are now extinct. However, current scientific opinion holds that all large ground sloths became extinct no less than 8,000 years ago. While proof that ground sloths still survive would be a bit embarrassing, only opinions and not paradigms are involved. Animals thought to be long extinct, even large ones, are still being found alive. Living ground sloths should be rated as curiosities only. Rating: 3.

Possible Explanations. Misidentifications of recognized, extant South American animals.

Similar and Related Phenomena. Late survival of mammoths (BMD10); present survival of thylacines (BMD12); late survival of North American camels, horses, etc. (BMD13); unrecognized mammals (BMU), especially the minhocao (BMU4) .

Entries

X0. Introduction. Central and South America are today home to five species of sloths. All five are arboreal and tip the scales at under 20 pounds. The fossil record reveals that our present-day sloths are midgets when compared to several huge ground sloths that apparently became extinct several thousand years ago. The largest of these ground sloths bears the name Megatherium. When standing on its hind legs, it was 15 feet tall. Smaller ground sloths, the Mylodons, were (or are) probably about the size of oxen. Apparently all of these ground sloths were (or are) herbivorous and well content to remain on the ground.

Megatherium could hardly be overlooked if it still survives, although it must be recognized that many remote parts of South America remain incompletely explored, there remain vast areas where giant animals could potentially still lurk undiscovered. So far, though, no one has claimed that Megatherium still lives.

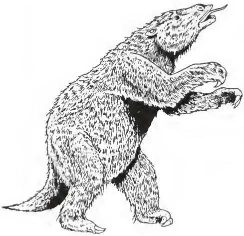
Be this as it may, there is tantalizing evidence that the smaller ground sloths were not only contemporaneous with early humans but may actually have been captured, confined, and eaten by our predecessors. Even more interesting are some sightings of Mylodons within historical times. In fact, some of today's naturalists are eager to invade those poorly explored areas of Patagonia and Amazonia to search for late-surviving Mylodons or, as the Amazon natives call them, Mapinguaris.

As with the mammoths, we examine the possible recent sightings first.

X1. Sightings of living ground sloths.

The Lista sighting. Historically, the most significant observation of a large ground sloth in historical times was made by R. Lista in the late 1800s. F. Ameghino, a famous Argentine zoologist of the period, wrote the following about the ground sloth and his friend Lista's brief glimpse of this putative creature:

> Many times I have heard allusions to a mysterious quadruped which is said to exist in the interior of the territory of Santa Cruz [the southernmost province of Argentina], living in burrows hollowed out of the soil, and usually only coming out at night. According to the reports of the Indians, it is a strange creature, with long claws and a terrifying appearance, impossible to kill because it has a body impenetrable to firearms and missiles.
>
> It is several years since the late Ramon Lista, a traveller and geographer well known to the world of science, told both myself and my brother Charles, and several other persons---and had, I believe, even printed the statement in one of his works---that he had seen the mysterious quadruped in question. He came across it one day during one of his journeys in the interior of the territory of Santa Cruz, but in spite of all his efforts he was unable to capture it. Several shots failed to stop the animal, which soon disappeared in the brushwood; all search for its recovery being useless.
>
> Lista retained a perfect recollection of the impression this encounter made upon him. According to him the animal was a pangolin (Manis), almost the same as the Indian one, both in size and general aspect, except that in the place of scales, it showed the body to be covered with reddish grey hair. He was sure that if it were not a pangolin, it was certainly an edentate nearly allied to it.
>
> In spite of the authority of Lista, who, besides being a learned traveller, was also a skilled observer, I have always considered that he was mistaken, the victim of an illusion. Still, although I have several times tried to find out what animal might have given him the illusion of the pangolin, I was never able to guess.
>
> It was not an illusion. Although extremely rare and almost extinct, the mysterious animal exists, with the sole difference, that instead of being a pangolin, it is the last representative of a group which was believed to be quite extinct, a gravigrade edentate related to Mylodon and Pseudolestodon. (R1; R5)



The Megatherium or giant ground sloth reached a height of about 15 feet and was a vegetarian.

As we shall see, a key point in Lista's story is the apparent imperviousness of the Mylodon's skin to weaponry. It should also be remarked that pangolins (scaly anteaters) are native to Asia and Africa, not South America. Living pangolins are also much smaller than the Mylodon.

Vague modern reports. For many years, rumors have been filtering out of Brazil's trackless western Amazonia telling of a 6-foot, 500-pound giant sloth clothed in reddish hair. The rubber gatherers of this region report that this fearsome creature emits a hideous odor and transfixes one with a paralyzing stare! As mentioned above, it seems armored against spears and shotgun pellets. Modern cryptozoologists consider this animal to be the legendary Mapinguari, better known to science as a Mylodon, one of the large ground sloths, and officially extinct for millennia.

D.C. Oren, and American biologist working with the Goeldi Natural History Museum in Belem, Brazil, has been tracking these stories. Recently, gold miners are said to have killed one of these ground sloths; but, as is so often the case, all we have is a vague unverifiable report. As with the North American Bigfoot, hard data are elusive, particularly actual physical remains. (R9, R10)

Oren also claims that three ground sloths have actually been caught, but that the captors could not stand the stench of the animals and abandoned them. The overwhelming odor is thought to emanate from a gland on the sloth's belly. (R6)

Oren, however, is optimistic. He sees his hunt for the late-surviving ground sloth to be more than just one more useless monster hunt.

> If South America'a largest terrestrial mammal has been hidden to science until 1994, what else does the Amazon have in terms of biodiversity that's new to us. (R9)

X2. Physical traces.

Bones and skins. Fossil skeletons of several species of ground sloths are found in South America. But bones alone are not particularly helpful in demonstrating very recent or current survival. Skins, however, usually deteriorate faster than bones. Therefore, a soft, flexible skin from a ground sloth would be a sign of the recent survival of its wearer.

The skin of some ground sloths, Mylodons in particular, is very unusual. Sloths belong to the Order Xenarthra, which also includes the armadillos and South American anteaters. Like the armadillos, the Mylodons were armored, but not with external plates. Instead, their skin contained bony ossicles about the size of coffee beans. These ossicles would have made these ground sloths highly resistant to attacks by arrows and even shotgun pellets. This explains why both legend and reports of modern encounters with ground sloths tell of their imperviousness to projectiles. (See X1.) Thus, the unique nature of ground-sloth skin not only explains the puzzling inability of hunters to kill the animal but also the ease with which scientists can identify scraps of Mylodon skin should they come across them. But do such samples of skin still survive?

Again we quote F. Ameghino, for he first announced to the scientific world that a Mylodon skin had been discovered. In 1898, he wrote:

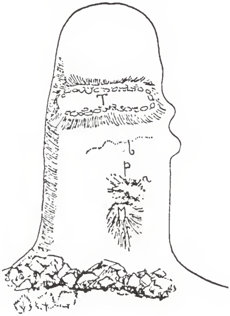
> Lately, several little ossicles have been brought to me from Southern Patagonia, and I have been asked to what animal they could belong. What was my surprise on seeing in my hand these ossicles in a fresh state, and, not withstanding that, absolutely similar to the fossil dermal ossicles of the genus Mylodon, except only that they are of a smaller size, varying from 9 to 13 or 14 mm. across. I have carefully studied these little bones from every point of view without being able to discern any essential difference from those found in the fossil state.
>
> These ossicles were taken from a skin which was unfortunately incomplete, and without any trace of the extremities. The skin, which was found on the surface of the ground, and showed signs of being exposed for several months to the action of the air, is in part discoloured. It has a thickness of about 2 centimeters, and is so tough that it is necessary to employ an ax or a saw in order to cut it. (R1)

Could so tough a piece of skin, obviously belonging to a Mylodon, be taken as evidence of recent survival?

The source of the skin announced by Ameghino was soon revealed. The find had been made in a cave in the far south of Argentina near the Strait of Magellan. Named after the owner of the nearby ranch, the cave was called Cueva Eberhardt. Eventually, pieces of the skin were made available to a rather amazed scientific world. (R5)

The Cueva Eberhardt skin had been found in April of 1888, and scientists of that period struggled with the exciting possibility that the skin was recent. It was impossible to say for sure until radiocarbon dating was possible. With radiocarbon dating, it was possible to show that the Cueva Eberhardt skin was far from recent: it dated from 13,500 BP (Before Present). Furthermore, other Mylodon skins have turned up since 1888. They are a bit younger: about 8,600 BP. So, we can say with confidence that the ground sloth skins now available to science do not prove recent survival. Of course, this does not mean that younger skins or even living specimens do not exist.

Next, an interesting facet to the Cueva Eberhardt story.



Plan of Cueva Eberhardt. Rolled-up Mylodon skins were found at (a) and (b). At (T) was a raised platform, and at (p) there was chopped hay. (Adapted from R5)

X3. Ground sloth domestication. Once the Cueva Eberhardt was recognized as the source of the Mylodon skin, several expeditions thoroughly excavated the cave. One group was led by R. Hauthal. They published their findings in Revista del Musco de la Plata, 9:409, 1899. This report was summarized the same year by A.S. Woodward in Natural Science. We quote now from Woodward's paper.

> It now appears that the remains of so-called Neomylodon are not found at the exposed entrance of the cavern, which is of very large proportions (30 metres high), but occur only in an inner chamber which has every appearance of having been artificially constructed by cross-barriers. At a short distance from the entrance there is a rude wall of tumbled blocks extending the whole way across, except a narrow gangway left at one side. On passing through this the great chamber just mentioned is reached, and another wall-like barrier 50 metres further inwards extends completely across the cave from side to side, preventing any ingress except by scrambling. In the middle of the chamber there is an artificial mound. The floor proved to be covered with a layer of dust and stones, varying from 30 centimetres to a metre in thickness. In it at one spot were found numerous shells of mussels mingled with the broken bones of guanaco and deer---evidently the remains of food of man. Beneath the surface layer near the inner barrier was discovered a great mass of excrement of a herbivorous animal, in some places more than a metre in depth. Most of the material was in the form of impalpable dust, which almost choked the workmen, but a few large lumps were in a good state of preservation, and rivalled the droppings of the elephant in size. Part of the heap showed clear indications of having been burned. Nearer the middle of the chamber was dug up a considerable accumulation of dry cut hay in a good state of preservation. In the lower layer---in the excrement, the hay, and the surrounding rubbish---were found numerous broken bones of the so-called Neomylodon, belonging to several individuals, both old and young, with another well-preserved piece of skin. (R2)

Apparently, early humans were not only contemporaneous with the ground sloths but also captured them for use as a food source. (R4)

Of course, all this close association with early humans does not mean that the Mylodons survived until our time, because humans certainly occupied Patagonia thousands of years ago---perhaps 8,000-10,000 years ago. Actually, some recent, very controversial archeological work at Pedra Furada, in Brazil, may push the settlement of South America back to 50,000 BP. (R8)

Summarizing: Although we have ample physical traces of large ground sloths in Patagonia, they are probably no younger than 8,000 or so years. So far, there is no physical evidence of ground sloth survival into historical times.

X4. Legends and traditions. The Tehuelche Indians of Patagonia have a tradition of a large nocturnal animal that might be a large ground sloth. B. Heuvelmans elaborated as follows:

> It is a large heavy beast, as big as an ox but with shorter legs and covered with thick short coarse hair. Its appearance is very frightening. It is armed with enormous hooked claws, just like an anteater's, with which it digs a huge burrow, where it sleeps all day; that is why it is hardly ever seen. According to some versions its habits are amphibious. There is some doubt whether it is savage or not, but all agree that it cannot be harmed by arrows or bullets, and oddly enough, this last fabulous-looking characteristic is the best evidence that the monster is not a fable. (R5)

Heuvelmans means that the seeming imperviousness of the animal accords well with the armored nature of the known ground sloths. (See X2.) It is also worth pointing out that the "amphibious" character is not out of line either since today's sloths, though primarily arboreal, have been observed swimming in South American rivers. However, one would certainly expect that Indian tradition would mention the overpowering stench mentioned in connection with the modern Brazilian contacts. To our knowledge, they do not!

It is possible that the Brazilian and Patagonian animals are not the same species, seeing these regions are separated by close to 4,000 kilometers. We obviously have much to learn here.

References

R1. Ameghino, Florentino; "An Existing Ground-Sloth in Patagonia," Natural Science, 13:324, 1898. (X1, X2)

R2. Woodward, A. Smith; "The Supposed Existing Ground-Sloth of Patagonia," Natural Science, 15:351, 1899. (X3)

R3. Anonymous; "The Jemisch, or Great Ground Sloth," English Mechanic, 72:118, 1900. (X2, X3)

R4. Anonymous; "The Remains of an Extinct Ground Sloth," Scientific American, 113:39, 1915. (X3)

R5. Heuvelmans, Bernard; On the Track of Unknown Animals, New York, 1958. (X1-X4)

R6. Anonymous; "Hunt for the Monster of the Amazon," New Scientist, p. 9, January 22, 1994. (X1)

R7. Nowak, Ronald M.; Walker's Mammals of the World, Baltimore, 1991. (X2)

R8. Bahn, Paul G.; "50,000-Year-Old Americans of Pedra Furada," Nature, 362:114, 1993. (X3)

R9. Stolzenburg, William; "Bigfoot of the Amazon," Nature Conservancy, p. 7, July/August, 1994. (X1)

R10. Anonymous; "The Mother of All Sloths," Fortean Times, no. 77, p. 17, October/November 1994. (X1)

BMD12 Current Survival of the Thylacine

Description. Sightings, photographs, physical traces, and other evidence that the thylacine (or Tasmanian tiger) still survives.

Data Evaluation. Although sightings of the thylacine are abundant (accompanied by some photos) and recent tracks seem legitimate, such positive evidence is counterbalanced by the absence of specimens, living or recently expired. Only when an actual specimen appears will the thylacine be crossed off the extinction lists. Rating: 2.

Anomaly Evaluation. Proof that the thylacine survives; i.e., a specimen; would not overturn any cherished paradigms. It would only demonstrate that science has been too conservative in their evaluation of the continuing stream of new reports. A low anomaly rating is in order. Rating 3.

Possible Explanations. None required.

Similar and Related Phenomena. The purported survival of a large ground sloth (BMD11) and other supposedly extinct mammals (BMD13, BMD14); the possible existence of mammals not officially recognized by science (BMU); unrecognized hominids (BHU in Humans III).

Entries

X0. Background. The thylacine (also known as the Tasmanian wolf or Tasmanian tiger) is or was the marsupial analog of the placental dog and wolf. In fact, the similarities are sometimes so astonishing that some scientists wonder what biological "influence" makes such distantly related animals so much alike!

The largest, recognized marsupial carnivore to survive into historical times, the thylacine measured about 5 feet in length, including its peculiar stick-like tail. Striped on the back and hindquarters, it did look vaguely tigerish. The thylacine, however, should not be confused with the hypothetical Queensland tiger, which is claimed to be a large cat-like marsupial. The thylacine is so distinctive that it is hard to mistake it if it is seen clearly. Even its tracks are easy to recognize---five toes in front, four in back. If it lives today in numbers large enough to maintain a breeding population, it should be seen and readily recognized---at least occasionally.

Although the last captive thylacine died in a Hobart, Tasmania, zoo in 1936, hundreds of Tasmanian sightings have been reported since that date. Even so, scientifically convincing evidence of its continued existence on that island has not surfaced. Biologists really must have a specimen, dead or alive, to cross the thylacine off the "extinct" list.

Still roaming the forests of Tasmania? Though classifed as extinct, reports of thylacine sightings keep coming in. Note the distinctive stripes and large gape. The tail is stiff and stick-like.

On the Australian mainland, where the thylacine has been considered extinct for several thousand years, the situation is about the same: many sightings and tracks but no acceptable corpses or captive animals.

X1. Sightings. This class of evidence is always suspect. We select here only those we deem the best out of a large file of visual observations.

Tasmania. The thylacine was well known to the early settlers of this island state of Australia. In fact, these marsupial carnivores were so destructive to Tasmanian ranchers that bounties were paid. Thousands of thylacines were killed right up through the early Twentieth Century. Then, about 1930, the thylacine population crashed. Official extinction was declared in 1936.

Despite the official pronouncement, occasional thylacines are still reported. Typical of the hundreds of observations accumulated since 1936 is the following:

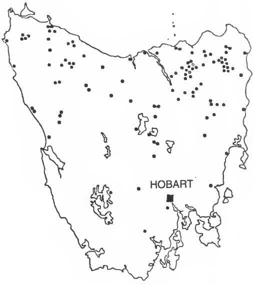
> In 1970, six respected citizens of a farming community in the northeast were traveling home together on a road between Scottsdale and Launceston. Shortly after midnight, they saw an animal "about the size of a sheep dog" cross the road in front of their car "half trotting and half walking." The animal was striped across the hindquarters and the tail "was very thick at the base and carried straight off the body, unlike the tail of any other animals." Everyone in the car was quite familiar with Tasmanian fauna and there was no doubt in anyone's mind that the creature that had crossed their path was a thylacine. (R4)

One of the best recent thylacine reports came from an experienced naturalist in 1982.

> In March 1982, a park ranger in northwestern Tasmania awoke in the dead of night. From force of habit, he scanned the woods, his spotlight punching through black walls of rain. And there in the beam was one of the strangest creatures he had even seen. About the size and shape of a dog, it was covered with stripes that ran from its shoulders across its back to its thick, rigid tail.
>
> The animal stood still as the startled ranger counted the stripes, then it nonchalantly gave an enormous jaw-stretching yawn. But when the ranger reached for his camera, the creature faded into the undergrowth, leaving nothing but a rank smell. It also left a trail of excitement, for the bizarre beast looked exactly like a Tasmanian tiger---also called a thylacine or Tasmanian wolf---an animal thought to have been extinct nearly 50 years ago. (R6; R5)

Computers have been harnessed in an attempt to add credence to the many thylacine sightings piling up in Tasmania. A short article appearing in New Scientist in 1990 began with:

> A computer analysis has left little doubt that the supposedly extinct Tasmanian tiger or wolf still exists in remote areas of Australia's island state.



A surprising number of thylacine sightings were reported in Tasmania between 1970 and April 1980.

We now summarize the remainder of the article.

H. Nix, of the Australian National

University's Centre for Resource and Environmental Studies, has a computer program based upon detailed descriptions of climatic, topographic, and environmental factors that identifies areas where a particular animal or plant could flourish. Nix gathered the environmental requirements of the thylacine from records of where they had been shot and trapped in the past. This plus the computer program allowed Nix to identify prime thylacine territory. Comparing this information with the best sightings over the past 60 years, Nix found perfect agreement. In other words, post-extinction reports of thylacines come from just those areas where one would expect them to! (R9)

Mainland sightings. The number and persistence of thylacine sightings on mainland Australia are surprising, because the animal has been considered extinct there for several millennia. Fossils dated as thousands of years old have been found, but the idea of current survival has been authoritatively dismissed. Scientific pronouncements, however, have not suppressed many recent observations of the thylacine in southeastern Australia and in the state of Western Australia---two regions separated by a couple thousand miles!

M. Smith in his review of thylacine observations obviously considered the following event from 1977 very significant:

> Recently, a group of eight Thylacines, including a female with pouch young, were reported near the New South Wales-Victorian border. The location was not disclosed, but a number of photographs have become available, one of which was published in the daily press. The picture is clear and convincing, and if genuine its importance cannot be overestimated. (R2)

X2. Other photographic evidence. In addition to the above-mentioned photographs, there exist many fuzzy, inconclusive pictures of animals that might be thylacines. Much controversy surrounds many of these. Photographic fakery is easy and common with modern technology, so we cannot give these photos much weight.

For example, in 1981, a series of thylacine photos were presented to the world by K. Cameron purporting to show a thylacine digging at the foot of a tree in Western Australia. Some of the photos may have been staged or faked, but A.M. Douglas, a retired officer from a museum in Perth, believes that one is genuine. (R7) Douglas bases his confidence upon Cameron's description of the alleged thylacine's behavior---it was too accurate to have been fabricated! (R8)

X3. Organized searches. If the thylacine survives in any numbers, well-financed expeditions should surely come up with enough evidence to satisfy the scientific community. Unfortunately, they have not.

On Tasmania, in addition to simply combing the island's heavily wooded mountains, there have been several systematic deployments of snares, baited traps, and automatic cameras. The latter were designed to be triggered when animals broke beams of infrared light. Many species were caught or photographed, especially the Tasmanian devil, but the thylacine was not. (R1, R4, R5)

Negative evidence cannot prove extinction, but it weighs heavily in the thinking of scientists.

X4. Suspected thylacine tracks. As pointed out in X0, thylacine tracks differ from those of dogs (dingos) and the other large marsupials. In addition to the five toes on front paws and four on rear paws, the hind pads of the feet are more prominent than those of dog prints, because thylacines put their weight there rather than on their toes, as dogs do. (Actually, the fifth toes on the front paws often do not show up well.)

M. Smith considers the so-called Old Davey Track (a Tasmanian trail) tracks to be perhaps the best proof that the thylacine still survives.

> In January, 1958, a small party discovered tracks in the deep mud of the Old Davey Track between Pt.

The footprints of the thylacine (top) differ markedly from those of the domestic dog (bottom).

> Davey and Muydena. They were bigger than a [Tasmanian] Devil's with all four toes pointing forward, the claws almost level with one another, and the hind pads much longer than a Dog's. Guiler identified them from a photo as belonging to a Thylacine. (R2)

Of course, many other thylacine track reports have been recorded.

X5. Evidence of thylacine predation. Thylacines killed prey by clamping their jaws about the throat and dragging them down. Usually, the neck was broken, and there were signs of a considerable struggle. Typically, the thylacine then consumed the blood and ate just the head, some organs, and soft parts, eschewing the flesh altogether. Thylacines rarely, if ever, returned to their kills, especially if humans had been on the scene. Kills showing such characteristics could be the work of thylacines, but the thylacine doubters can also say that dingos or Tasmanian devils were the culprits, even though they usually leave different signs. Kills also constitute rather weak evidence. (R2, R8)

X6. Thylacine corpses. The probability that the thylacine survives is greatest on Tasmania, but no recent thylacine remains have shown up there, according to the literature at hand. On the mainland, however, where extinction is supposed to have occurred thousands of years ago, two suspect thylacine remains have been reported.

In 1970, M. Archer found a thylacine leg bone on the remote Kimberley Plateau in northwestern Australia. Archer suspected that it might be only decades old. (R6) The fact is, though, that "youthful-appearing" bones carry no weight in the recent-survival arguments. Radiocarbon dating is essential.

In 1966, also on the mainland, a thylacine carcass was recovered by a party from the Western Australian Museum. The source was a cave on Mundrabilla Station, near the border of West Australia.

> The carcass was fully covered with hair, had a musty odor, and looked like a recent dried-out carcass after the maggots had left but before the hide- and fur-eating invertebrates had begun their attack. It was not a dehydrated carcass, with dried intestines and flesh. (R8)

This carcass was carbon-dated at the University of Sydney as being 4,500 years old. Nevertheless, in two articles, A.M. Douglas defends the recency of the remains. His argument is based upon the still-remaining odor of decay plus the "fresh" appearance of the carcass as compared, say, with the remains of a dingo known to be only about 20 years old. As for the radiocarbon dates, he notes that the cave had obviously been flooded in the past. The incoming water could have soaked the carcass and introduced extraneous carbon via soluble carbonates, which could have skewed the radiocarbon dating. (R7, R8)

X7. Mainstream opinions. When confronted with the mass of thylacine sightings, tracks, photos, etc., the professional biologists and naturalists are still loath to accept the thylacine's continued survival, especially on the Australian mainland. They have their reasons, as expressed by P. Aitken, of the South Australian Museum, speaking of the mainland only.

> Surely, had they existed here all this time, it would have had to be in large numbers to survive disease, poor seasons and settlement. And had there been such numbers they would have been sighted, shot or trapped at least once. (R1)

Other mainstream biologists see here a psychological phenomenon:

> Even today there are still many skeptics, scientists and laymen alike, who think that the problem is a social phenomenon that feeds upon itself, and has no actual basis in fact. Some talk of it as the local version of the Loch Ness Monster, always there but never proven, as if Nessie is the prototype of "things" that don't really exist. (R5)

References

R1. Anonymous; "Hold That Tiger!" Walkabout, 34:28, June 1968. Cr, M.J. Shields. (X1, X4, X8)

R2. Smith, Malcolm; "Review of the Thylacine (Marsupialia Thylacinidae)," in Carnivorous Marsupials, Michael Archer, ed., p. 237, Mosman, 1982. Cr. M.J. Shields. (X1, X3, X5, X6)

R3. Rounsevell, D.E., and Smith, S.J.; "Recent Alleged Sightings of the Thylacine (Marsupialia Thylacinidae) in Tasmania," in Carnivorous Marsupials, Michael Archer, ed., p. 233, Mosman, 1982. Cr. M.J. Shields. (X1)

R4. Park, Andy; "Is This Toothy Relic Still on the Prowl in Tasmania's Wilds?" Smithsonian Magazine, 16:117, August 1985. Cr. M.J. Shields. (X1, X4)

R5. Anonymous; "Thylacine Reports Persist after 50 Years," ISC Newsletter, 4:1, Winter 1985. (X1, X2, X4, X8) ISC = International Society for Cryptozoology.

R6. Bunk, Steve; "Just How Extinct Is Tasmania's Tiger?" International Wildlife, 15:37, July-August 1985. Cr. M.J. Shields. (X1, X2, X7)

R7. Douglas, Athol M.; "Tigers in Western Australia?" New Scientist, p. 44, April 24, 1986. (X1, X3, X7)

R8. Douglas, Athol M.; "The Thylacine: A Case for Current Existence on Mainland Australia," Cryptozoology, 9:13, 1990. (X1, X3, X6, X7)

R9. Anonymous; "Computers Help to Hunt the Tasmanian Tiger," New Scientist, p. 24, March 10, 1990. (X1)

BMD13 Current or Very Recent Survival of Steller's Sea Cow

Description. Recent sightings and washed-up corpses of large marine animals resembling the supposedly extinct Steller's sea cow.

Data Evaluation. The last Steller's sea cow is thought to have been slaughtered in 1768. Since that date a very few sightings and carcasses have made their ways into the literature---mostly popular books and science magazines. Some of the accounts are based on difficult-to-find Russian journals and newspapers. No experienced scientist has, to our knowledge, ever observed a live animal or a corpse since G.W. Steller discovered Steller's sea cow in 1741. All later sightings came from nonprofessionals, such as whalers and hunters. Although the accounts presented below are suggestive, they are not nearly sufficient to proclaim that Steller's sea cow survived into the Twentieth Century. On the other hand, it is quite probable that isolated individuals or small groups did survive beyond the official 1768 extinction date in the vastness of Russia's Siberian Pacific coast. Rating: 3.

Anomaly Evaluation. As with the thylacine (BMD12), late and current survivals are hardly anomalous---surprising perhaps but not threats to any scientific paradigms. Russia's Pacific coast boasts innumerable bays and unpopulated islands that could hide creatures as massive as Steller's sea cow. Rating: 3.

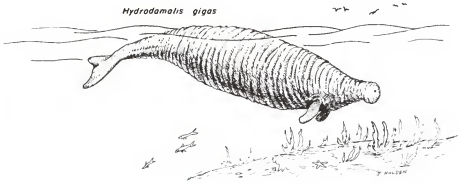
Possible Explanations. None required.

Similar and Related Phenomena. Other possible late or current survivals of large mammals (BMD10-12, BMD14).

Entries

X0. Steller's sea cow. This huge sirenian reached a length of at least 7.4 meters (23 feet), perhaps even 11 meters (35 feet). Its weight was measured in tons, some say as many as 10. Easy to kill, Steller's sea cow was the mainstay of G.W. Steller and his companions when they put in to Bering Island, in the North Pacific, to rebuild their deteriorating vessel in 1741. Steller, who was a German naturalist in the service of Russia, provided the only scientific account we have for this marine mammal with its tiny head and oddly corrugated, fat-layered body. Steller's sea cow had a whale-like tail, as does the dugong; but instead of the marching teeth of the other sirenians (BMA31 in Mammals I) its teeth were replaced with curious masticating plates. The lips were doubled; that is, they were divided into internal and external lips. This sirenian's primary food was kelp and other seaweeds. As recently as the late Pleistocene, Steller's sea cow was scattered around the shores of the North Pacific, even reaching as far south as Baja California. Unfortunately, Steller's sea cow was a culinary delight to the Russian hunters of seals and sea otters. By 1768, only 27 years after Steller formally discovered it, Steller's sea cow was just as officially declared extinct. (R4, R6)

X1. Sightings of live animals. From several Twentieth Century reports of living marine mammals resembling Steller's sea cow, we provide details on two of the most promising. Admittedly, the pickings are slim and not overwhelmingly convincing.



Steller's sea cows reached lengths of 20-30 feet and weighed several tons. Unfortunately, they were tasty and easy to kill.

1937. Sunset Beach, British Columbia. This sighting was submitted to I.T. Sanderson by a Mrs. C. Timeus, who, with her husband, had observed what seemed to be an unknown sea monster, but which happened to have some of the characteristics of Steller's sea cow. B. Heuvelmans reproduced the Timeus letter in his In the Wake of the Sea-Serpents:

> Returning from a fishing trip, toward sunset, pulling into beach at Sunset Beach, 22 miles north of Vancouver, we saw a huge mammal or monster not more than 25 feet from our boat. It had a large head which resembled a long-nosed pig only wider at snout, two large flippers and huge body, we watched it for several minutes, it did not seem alarmed but stayed there until we were out on shore. We searched the dictionary and the only thing we could find that resembled it was a manatee. (R1)

Noting that Sunset Beach is about 3,000 miles distant from the Russian Pacific coast, where the last of the Steller's sea cows supposedly met their end in 1768, Heuvelmans is not particularly impressed by this sighting, suspecting it to be some other sea creature despite the Timeus's identification as a manatee. (R1) We are not impressed either! (See BMU11 for sightings of "officially unrecognized" marine mammals.)

1962. Cape Navarin, Russian Pacific Coast. This is the best and most-often-profferred recent sighting. In July 1962, the Russian whaler Buran was near the coast of Kamchatka. The water was shallow and covered with sea cabbage, a favorite food of Steller's sea cow. About 300 feet away, the Buran's crew saw six strange animals, the details of which were reported by A.A. Berzin et al in Priroda in 1963 (#8, p. 73):

> The skin was dark, the head relatively small, with an abrupt transition towards the body, the upper lip separated in two parts and overflowing on the lower lip....the tail of the animal puzzled the observers by the sharp fringe it possessed. The animals were swimming slowly, diving periodically for a very short time, then coming out of the water in a pronounced manner. The group formed a dense herd of animals, probably of different ages, 6 to 8 meters long, swimming in the same direction. (R5; R1, R2, R4)

The members of the Buran's crew were mostly seasoned hunters and whalers. All agreed that the animals they had seen did not resemble any known seals or whales. They looked somewhat like walruses but were about twice the size of that species. Berzin et al opined that they were instead surviving Steller's sea cows. Note that the Buran description included the unusual and distinctive double lips.

X2. Washed-up carcasses. The bodies of large sea creatures that finally end up on beaches are often decomposed to such a degree that positive identification is difficult. Even experts make mistakes. The deteriorating bodies of narwhals, elephant seals, some whales, and even some sharks might well be mistaken for Steller's sea cow. In other words, caution is advised here.

1910. Gulf of Anadyr, Russia. A vague, never-confirmed report of a dead Steller's sea cow washed ashore at Cape Chaplin. (R1, R2)

1977. Anapkinskaya Bay, Russia. The following incident occurred just south of that above, along Russia's Pacific coast. D. Haley, author of Marine Mammals of the North Pacific and Arctic Waters, passed it along in her article on Steller's sea cow in Natural History.

> In 1977 the sea cow surfaced again in an article in Kamchatsky Komsomolets, a newspaper in Petropavlovsk, Kamchatka. It described a sighting by fishermen in Anapkinskaya Bay, a region south of Cape Navarin. The author, Vladimir Malukovich of the Kamchatka Museum of Local Lore, interviewed one of the fishermen, who described an "unknown animal on a tidal belt" that was neither seal nor sea lion. The translation reads: "Its skin was dark, its extremities were flippers, its tail forked like a whale. A slight outline of round ribs was noticeable. We approached the animal, touched it and were surprised as its head bore an unusual form and its snout was long." When shown a drawing of a Steller sea cow, the fisherman stated that this was the animal---the same tail, fore flippers, and head---and he was surprised to learn that it presumably no longer existed.(R3)

A Canadian biologist, E. Mitchell, wondered if the animal washed up on the shores of Anapkinskaya Bay might actually have been an errant northern elephant seal that had strayed far west from its usual haunts along North America's west coast. The northern elephant seal does have a tendency to wander, and its hind flippers, if pressed together, might look like a forked tail. (R3)

References

R1. Heuvelmans, Bernard; In the Wake of the Sea-Serpents, New York, 1968. (X1, X2)

R2. McEwan, Graham J.; Sea Serpents Sailors & Sceptics, Boston, 1978. (X1, X2)

R3. Haley, Delphine; "Saga of Steller's Sea Cow," Natural History, 87:9, November 1978. (X1)

R4. Mackal, Roy; Searching for Hidden Animals, Garden City, 1980. (X0, X1)

R5. Raynal, Michel; "Does the Steller's Sea Cow Still Survive?" INFO Journal, no. 51, p. 15, February 1987. (X1, X2)

R6. Reeves, Randall R., et al; Seals and Sirenians, San Francisco, 1992. (X0)

BMD14 Miscellaneous Potential Late Survivors

Description. Fresh-appearing fossils, sightings within historical times, and native traditions that imply that North American camels, New World horses, and Madagascar giant lemurs lived well beyond their formal extinction dates and may, possibly, even survive today.

Data Evaluation. Most of the data supporting the late survivals of the three mammals mentioned above depend upon fossil remains that "appear" to be younger than they should or occur in strata that "may" confer unexpected youth upon them. But the "freshness" of remains is not a satisfactory measure to scientists. Without carbon or stratigraphic dating, anomalously late survivals cannot be confirmed. To our knowledge, carbon dating has not been applied in the three cases considered here, nor have the strata involved been firmly dated. The only pertinent visual observations are those of the giant lemur, and these are so vague as to be useless. Still, there is just enough substance here to catalog the three species presented below. Rating: 3½.

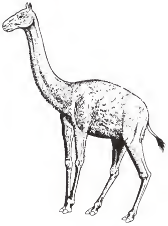
Anomaly Evaluation. No paleontologist would be perturbed if the North American camel and New World horse were shown to have lived a millennium or two beyond their formal extinction dates of 10,000 or so BP. Certainly, the data at hand do not support anything more than that. As for the giant lemur, which hung on in Madagascar until a scant 500 years ago, the discovery of the species in the remoter parts of this huge island would be newsworthy but not anomalous. Here, as in all cases of "living fossils", absolute extinction is a human presumption based upon the absence of evidence. Negative evidence has shown itself to be a poor guide in the past in such matters. Rating: 3.

Possible Explanations. None required.

Similar and Related Phenomena. Other possible late-surviving mammals (BMD10-13). For other "living fossils" in other taxonomic orders, see BBD, BRD, etc., and, especially, in BFD, the coelacanth.

Entries

X1. North American camels. The fossil record tells us that camels (Family Camelidae) actually originated in North America and spread from there to the other continents. Apparently, however, North American camels disappeared about 10,000 years ago along with many other large Pleistocene mammals, although the Genus Lama (llamas, guanacos, etc.) still thrives in South America. (R9) Old World domesticated camels have been imported into North America in recent years for zoos and, about 1870, for labor in the Southwest. Our interest here, though, is in the possible survival of the native North American camel beyond the 10,000 BP mark.



An extinct camel (Aepycamelus) that once roamed the Americas.

The unfossilized Utah skull. In 1928, A.S. Romer reported in Science on the discovery of an unfossilized camel skull that was dug up from under 2-3 feet of fine, dry eolian deposits by two high-school boys in a cave near Fillmore, Utah. (R4) Romer's paper was digested as follows in Science News-Letter:

> Radical changes in our ideas of the course of events in recent geological time---say the last half million years or so---may be brought about by the discovery in Utah of the unfossilized skull of an extinct camel, with a bit of dried flesh still clinging to the bone. The relatively fresh condition of the specimen argues that its one-time possessor died only a few centuries or millennia ago; present ideas hold that this particular sort of camel became extinct a half million years ago. If this camel really died so long ago, the bone should have been largely or wholly replaced by stone, and there should have been no flesh on it at all.
>
> .....
>
> Prof. Romer's first guess was that it might be a relic of a herd of dromedaries imported into the Southwest during the 1870's, as an experiment which terminated unsuccessfully. But a critical examination of its anatomical details showed many points of close resemblance to the skulls of very ancient extinct American camels, and marked differences from those of existing Asiatic and African forms. In his opinion the animal belonged to the genus Camelops, which is supposed to have been extinct for at least half a million years. (R3)

Since Romer's 1928 announcement, the half-million-year figure has been reduced to 10,000 years, the time when several other large North American mammals met their demises for still controverted reasons. So, the question here is really whether this North Americn camel survived until "a few centuries" ago, as suggested in the quotation.

Soon after Romer's announcement in Science, O.P. Hay cast doubt on the age figures employed by Romer, citing other animal remains that were also well preserved but obviously thousands of years old. (R2) Nevertheless, Romer maintained:

> ...that a native American camel, supposedly extinct since the early Pleistocene, has existed recently in the Great Basin region. (R5)

Romer's "recently" is much too vague. In the absence of better dating of the camel skull, it is safest to conclude that North American camels did indeed become extinct about 10,000 BP or perhaps a millennium or two later. Such late survival would be consistent with that of the ground sloth (BMD12) and the New World horse (X2 below).

Summarizing, it seems that Romer grossly underestimated the age of the camel skull. This would have been understandable in the 1920s when dating techniques were not well-developed.

X2. New World horses. When the first Europeans arrived in the New World, their horses terrified the natives. They had never seen such animals! (R1) Not even traditions of horse-like animals remained in Mayan lore, although they seemed to know something about elephants! (BMD10) Yet, some horse fossils are definitely found in conjunction with traces of ancient humans in Central and South America. This is not denied by current scientific scenarios. Mainstream opinion has the New World horse disappearing along with the North American camel and many other large Pleistocene mammals about 10,000 years ago. Humans arrived in the Americas well before that time.

But, is it possible that some of these equine remains that are closely associated with humans sites are really much younger than 10,000 years, suggesting that New World horses survived well beyond their official extinction date?

B. Heuvelmans in his On the Track of Unknown Animals mentions that fossil horse bones accompanied those of the giant ground sloth in Cueva Eberhardt in Patgonia. (R7, BMD11) They were also found in the cave of Palli-Aike, near the Strait of Magellan, where humans apparently roasted and consumed horses, guanacos, ground sloths, and whatever other animals they could kill! (R7)

Fresh-appearing horse fossils also come from Mexico:

The remains of horses have been reported from cave deposits in the state of Yucatan, Mexico, on two previous occasions. Mercer (The Hill Caves of Yucatan, Philadelphia, 1896) found horse remains in three caves in the Serrania, a low range of limestone hills lying in southwestern Yucatan and trending roughly parallel to the southwestern border of that state. The horse material was associated with pot sherds and other artifacts and showed no evidence of fossilization. Cope examined the material and considered it referable to Equus occidentalis on morphological characteristics but noted the absence of fossilization. (R6)

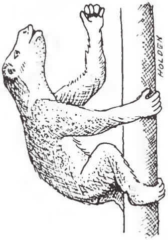
C.E. Ray, author of the above, was quick to state that these horse fossils were definitely pre-Mayan; that is, more than 2,000 years old.

It is difficult to pin the dates down with precision, but it appears that horses might have survived in North America until, perhaps, 8,000 years before the present, in analogy to the accompanying ground sloth bones in cueva Eberhardt and elsewhere, which have been carbon-dated. (BMD11) This date of 8,000 BP is not recent enough to alarm the paleontologists; nor should anomalists proclaim any scientific crisis!

X3. Giant lemurs. Lemurs evolved on Madagascar and from there colonized much of the planet by the beginning of the Tertiary. But, later, monkeys came along and outcompeted them. Although a few lemurs (i,e., galagos and lorises) hang on elsewhere, Madagascar is lemurland today. (No monkeys on Madagascar.) Besides the living lemurs so common on this huge island, paleontologists also find the bones of many lemurs that apparently became extinct within the last couple thousand years, especially after the first humans invaded Madagascar only about 1,500 years ago. (R7, R9)

One of these so-called "subfossil" lemurs, Megaladapis, was a true giant. According to Heuvelmans, it was the size of a cow---a "tree-dwelling pachyderm." (R7) In Walker's Mammals of the World, Megaladapis (actually three closely related species) is termed a "koala lemur" because its locomotion and life-

Megaladapis



Megaladapis was (or is) a giant lemur of Madagascar. It was probably still alive when Columbus sailed for the New World.

style paralleled that of Australia's living koalas---another astonishing instance of biological convergence. (See BMA1-X11 in Mammals I.) Megaladapis is believed to have survived until about 500 years ago---a mere second ago in geological time. (R9)

But, in 1658, Admiral Etienne de Flacourt, who had spent many years on Madagascar, wrote of a living animal that might have been this giant lemur. Heuvelmans provides the actual quotation:

> Tretretretre or Tratratratra is an animal as big as a two-year-old calf, with a round head and a man's face; the forefeet are like an ape's, and so are the hindfeet. It has frizzy hair, a short tail and ears like a man's. It is like the tanacht described by Ambroise Pare. One has been seen near the Lipomani lagoon in the neighborhood of which it lives. It is a very solitary animal, the people of the country are very frightened of it and run from it as it does from them. (R7)

This Tratratratra could also have been Hadropithecus, another large subfossil lemur that had a surprisingly human appearance.

Both Heuvelmans (R7) and Nowak

(R9) describe Megaladapis as mainly arboreal, but some zoologists think that it may have resembled the giant ground sloths of South America (BMD11), as in this quotation from New Scientist:

> Three species of this genus are known, the largest the size of a gorilla. It was a heavy, clumsy beast, with a very long nose and no tail, and is extremely unlikely to have been a tree-climber. Yet its hands and feet, which were 1½ feet long, seem to have been adapted for gripping, a feature which is not efficient for walking on four legs. Probably its habits were similar to those of the huge, extinct ground-sloths of South America, which reached up with their forepaws to grasp trees in feeding. Megaladapis would also have been well equipped for negotiating fallen tree trunks.
>
> Although giant lemurs are generally supposed to have become extinct during the Pleistocene, there is no apparent reason for this, since they would not have been threatened by carnivores and their food supply remained unchanged. It seems far more likely that man was the guilty party. A 17th century French explorer in Madagascar described enormous animals with a "human" face that terrified the natives and it is possible that giant lemurs may yet be found in the dense forests of the interior. The sites from which these bones were collected are marsh and lacustrine deposits and are all superficial; an old report states that "white pulpy matter" came out one "extinct" lemur's skull. Many of the bones have a suspiciously recent appearance and have been subjected to nitrogen analysis. Bones from one site contained 2.6 per cent nitrogen compared with less than 1 per cent for those from two other localities, a result that suggests that the bones are very recent, at least in this case. (R8)

Given the very recent fossils just described and the 17th. Century mention of a living animal resembling Megaladapis, some of these giant lemurs might well still cling to existence in remote parts of Madagascar.

Realistically, though, one cannot tell fcr certain from the bones alone, and the visual observations are too vague and questionable. Zoologists and even anomalists need more than this to procontinued existence.

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R1. Trouessart, E.; "Did the Horse Exist in America before This Continent Was Discovered by Europeans?" Scientific American Supplement, 76:387, 1913. (X2)

R2. Hay, Oliver P.; "An Extinct Camel from Utah," Science, 68:299, 1928. (X1)

R3. Anonymous; "Skull Promises Geological Upset," Science News-Letter, 14:81, 1928. (X1)

R4. Romer, Alfred S.; "A 'Fossil' Camel Recently Living in Utah," Science, 68:19, 1928. (X1)

R5. Romer, Alfred S.; "A Fresh Skull of an Extinct American Camel," Journal of Geology, 37:261, 1929. (X1)

R6. Ray, Clayton E.; "Pre-Columbian Horses from Yucatan," Journal of Mammalogy, 38:278, 1957. (X2)

R7. Heuvelmans, Bernard; On the Track of Unknown Animals, New York, 1958. (X2, X3)

R8. Anonymous; "Is the Giant Lemur a 'Living Fossil'?" New Scientist, 20:589, 1963. (X3)

R9. Nowak, Ronald M.; Walker's Mammals of the World, Baltimore, 1991.

BME THE FOSSIL RECORD OF MAMMALS

Key to Phenomena

BME0 Introduction

For over a century, our major window for viewing the history of earth life has been the fossil record. Today, various "molecular" techniques, such as DNA- and protein-sequence comparisons, have become increasingly important. These aspects of modern phylogeny are covered in Chapter BMG; although here we will occasionally point out instances where fossil-record and molecular comparisons seem to agree or clash.

In principle, fossils plus geological dating provide us with a clock telling us when and where taxonomic units (taxons) arose and disappeared. This information is, of course, a large part of the data base upon which the evolution paradigm rests. In this chapter (as in most chapters in the Series-B catalogs), we search for observations that seem to place the evolution paradigm at risk. This, after all, is the charter of an anomalist! The mammalian fossil record displays at least four phenomena key to such deliberations about evolution:

(1) An apparent scarcity of transitional fossils, especially at high taxonomic levels
(2) Many parallelisms and convergences of morphologies
(3) Stasis in some taxons
(4) Explosive radiations of life forms

All conclusions based on the fossil record rely ultimately upon comparisons of morphologies; that is, resemblances of shapes, sizes, physical interrelationships of body parts, etc., as seen in bones and other fossilizable structures. It must be recognized that, when evolutionary family trees are drawn up based upon fossil morphology, it is usually assumed that when two organisms look alike they are probably related to each other, and the more they look alike the closer the relationship. This, indeed, is often the case, but the assumption is there; and assumptions can be dangerous.

BME1 Scarcity of Transitional Fossils in the Class *Mammalia*

Description. The scarcity of finely graded fossils intermediate between the several taxonomic levels, particularly the phyla and other higher levels. Note that the determination of "intermediacy" is a subjective call---just because a fossil seems to be "transitional" does not mean that it really was! Furthermore, this phenomenon encompasses only skeletal morphology. In many cases, the most important evolutionary developments involve biological characteristics that do not fossilize well, if at all. Therefore, fossils are not infallible determinants of the evolution of life forms, but they are usually all evolutionists have to work with.

Data Evaluation. Fossil scarcity is a "negative" property and always subject to reevaluation when new fossils come to light. For this reason, the present phenomenon rests upon a shifting foundation. Family trees may be completely redrawn with the discovery of a single fossil! Also, fossil age is sometimes difficult to determine accurately in some stratigraphical situations. Finally, not only is fossil morphology an incomplete determinant of biological relationships, as suggested above, but it may also be grossly inaccurate due to evolutionary convergence. (See, for example, the astounding marsupial and placental-mammal "look-alikes" cataloged under BMA1 in Mammals I.) With these imponderables, it is not surprising that the claimed lack of transitional fossils has become an area of contention; and, in addition, deserving of a rather low rating here. Rating: 3.

Anomaly Evaluation. The reigning evolutionary paradigm implies that life forms evolve from one taxonomic category to another in finely graded steps. When the available fossil record denies this, we obviously have an anomaly. More recently, however, a modification of the basic paradigm has become partially acceptable. This is the theory of "punctuated equilibrium" which allows evolution by spurts ("saltations") and is, therefore, more in agreement with the apparent scarcity or coarser grading of what are assumed to be transitional fossils. The anomalousness of the subject phenomenon is thereby lessened, at least at lower taxonomic levels. At the higher levels, though, great gaps in the fossil record persist and could imply that evolution at these levels involves a mechanism different from the widely accepted mechanism of random mutation-plus-natural selection. In other words, so-called "macroevolution" may proceed differently from "microevolution." (We do not claim here that random mutation-plus-natural selection is an adequate explanation for all observed instances of microevolution or even punctuated evolution!) In sum, the presently observed scarcity of so-called "transitional" fossils challenges the established evolutionary paradigm and, in addition, raises the specter that the mechanisms of biological evolution may differ at different taxonomic levels. Rating: 1.

Possible Explanations. So-called "allopatric speciation" is theorized to occur in small, unstable, isolated gene pools. This mode of biological change could in principle lead to a "punctuated" fossil record. Exactly how allopatric speciation could account for the many synchronous changes required to evolve, say, a whale from a land mammal is unclear. (See X4 below.) Some other, generally unappreciated evolutionary processes, such as "adaptive" evolution, endosymbiosis, and hybridization may also be at work; although here, too, the details are lacking as to mechanism.

Similar and Related Phenomena. Evolutionary paradigms are questioned throughout the Series-B catalogs. See the Subject Indexes in the various volumes under: Adaptive evolution, Evolution, Complexity, Innovation, Sophistication, Self-organization, etc..

Entries

X0. Introduction. One of the great puzzles of the fossil record has been the apparent scarcity of fossils exhibiting characteristics intermediate between the various species, genera, families, etc., especially the higher taxonomic levels. Objectively, one cannot deny that some acceptable transitional fossils do indeed exist, but are there enough of them? F.H.T. Rhodes was perplexed enough by this question to pen the following paragraph is his authoritative review of evolution's "course":

> Although there are examples of continuity at all taxonomic levels, we are led to ask why continuity is not greater then this, for these examples are not typical of the fossil record. There are more gaps than sequences. We have, on the whole, very few sequences between the classes; we have numbers of transitional sequences between genera, and relatively few between species. Why do these gaps exist? Are the gaps biological or essentially physical in origin? Is normal change gradational but the record imperfect, or is the small number of described transitions atypical of the process of change as a whole? (R3)

Ordinarily, questions such as those raised by Rhodes would lie mainly in the province of science, but such is not the case here. Fundamentally opposed philosophies have muddied the waters. Strict creationists insist that all biological "kinds" were created permanently separate and distinct from one another and that, consequently, no transitional fossils can ever be found between them. Evolutionists believe, equally fervently, that life forms derive from other life forms and that, consequently, at least some record of these transformations must exist in the fossil record. At first, scientists expected to find finely graded transitional fossils. This has not happened very often, as Rhodes confirmed above. (We could supply dozens of additional authoritative quotes on this matter!) In fact, sudden appearances of new life forms without precursors are common, even where the fossil record seems relatively robust. If a large fraction of life forms have truly evolved via large jumps or "saltations" instead of by the small, almost imperceptible changes envisaged by Darwin, then evolution's machinery must be overhauled. If there exist no transitional forms at all, which does not seem to be the testimony of the fossil record available to us today, then the creationists could field a powerful weapon in the on-going philosophical and political controversy.

Already new ideas are emerging as to how evolution might, on occasion, proceed rapidly---so rapidly that the chances of finding transitional fossils would be miniscule. The recent concept of "adaptive" evolution is an example of this new brand of thinking (R44) although it must be admitted that no one yet understands the mechanism of adaptive evolution. But, once the oppressive hold of the current paradigm is broken, science will undoubtedly discover many ways in which life forms can transform rapidly in scientifically acceptable ways.

It should not be assumed, however, that all scientists (and laymen, too) will welcome such paradigm shifts. All shades of opinion can be found in the recent scientific literature. Darwinism is both mesmeric and messianic. The challenges of the creationists force most scientists to form a united front behind established doctrine. For this reason, any major scientific reworking of the evolution paradigm is still beyond the horizon.

Some scientists, such as J.A. Hopson, still hold out hope that enough transitional forms will be found to preserve the basic Darwinistic scenario of small, gradualistic changes:

> However, it can be predicted that for many groups with a good fossil record, numerous specimens exist which will bridge the gap, both morphologically and temporally, between currently recognized higher categories, and, therefore, between what creationists would acknowledge as distinct "created kinds." (R17)

The literature relevant to the scarcity of transitional fossils is immense. Our impression from reading a small portion of it is that Hopson's hope is futile. New fossil finds will certainly reduce or close some of the gaps to acceptable dimensions but not all of them. It seems that a modern Darwin must come up with a mechanism of rapid or quantized change---that does not leave a fossil trail--- to explain at least some of the many gaps now recognized.

Our approach below ignores the philosophical conflict between science and religion, and inquires whether transitional fossils do or do not exist in the Class Mammalia and, if so, what the implications are. Scores of gaps not yet filled satisfactorily by recent fossil discoveries have been identified in the literature, but we shall concentrate upon only six of the most interesting and controversial transformations.

X1. The reptile-to-mammal transformation. Evolutionists are united in the assertion that the Class Mammalia evolved directly from the Class Repilia toward the end of the Triassic some 136 million years ago. Indeed, it is authoritatively stated that this formidable transformation is well-marked by reasonable, convincing, intermediate fossil forms. Illustrating this near-universal conviction is this statement by J.A. Hopson:

> My purpose in this article is to summarize current knowledge of the reptile to mammal transition, considered by paleontologists to be the best-documented example in the fossil record of an evolutionary sequence connecting two major structural grades. (R17)

Our purpose in this entry is to ask whether this great taxonomic gap separating the reptiles from mammals is truly bridged by the small, progressive changes in the fossil record, as required by Darwinism and as advertised by the evolutionists.

The width of the reptile-mammal gap. The alleged transformation of reptile into mammal had to have been multi-dimensional; there were many physiological changes, not only in morphology but in internal physiology and bodily functions. We now list a few of these reptile-mammal differences, as compiled by G.R. Taylor:

(1) Mammals possess a four-chambered heart compared with three for reptiles.
(2) Mammals are almost all warm-blooded; reptiles, all cold-blooded.
(3) Reptiles lay eggs. In mammals (except for the monotremes) the young are born alive.
(4) Mammals boast a significantly larger brain case relative to body size.
(5) In mammals, the pelvic bones are fused into a single structure.
(6) The bones connecting the skull to the jaws in reptiles were transformed into ear ossicles in mammals. (R12) This difference is widely considered to be diagnostic when paleontologists separate reptilian and mammalian bones.

E. Shute, a creationist, listed several more important changes that had to be made in the reptile-mammal transformation:

(7) The mammalian diaphragm had to be created; reptiles have none.
(8) The muscles surrounding the alimentary canal in mammals consist of longitudinal muscles outside circular muscles; in reptiles, these muscles are inside.
(9) Mammals possess mammary glands; reptiles do not.
(10) The chief nitrogenous waste of mammals is urea; in reptiles, it is uric acid. (Curiously, during the amphibian-to-reptile transformation, the reverse switch was made---urea to uric acid!) (R2)

Another creationist, D. Dewar, in his The Transformist Illusion, added four more significant differences:

(11) Mammalian red-blood cells do not have nuclei; those of reptiles do.
(12) In mammals, one finds only one aorta; in reptiles, there are two.
(13) Mammals grow hair, not scales.
(14) Typically, mammalian skin is five-layered versus three in reptiles. (R1)

And so on and on. Quite obviously, the reptile-mammal gap is very broad. Morphological changes were accompanied by profound biological and physiological transformations. Unfortunately, many of these changes did not leave their signatures in the fossil record. The gap must be bridged entirely by the bones of reptiles that seem to have been changing their skeletons into those typical of mammals. To bridge this gap, paleontologists happily turn to some apparently intermediate animals called "mammal-like reptiles."

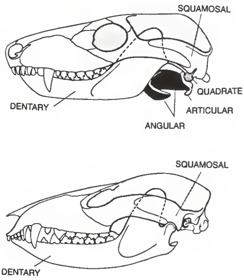
The mammal-like reptiles. When searching for a starting point for the evolution of mammals in the fossil record, the reptiles are the logical choice. They appeared earlier than the mammals; they are also vertebrates; they also have four legs, two eyes, teeth, tails, and a roughly similar external morphology. (Creationists, of course, do not need such a biological starting point! Their "kinds" were created independently and simultaneously.)

Happily, the Class Reptilia happens to include many now-extinct animals classed as mammal-like reptiles mainly on the basis that their teeth display mammalian characteristics. It is to the fossilized bones of these animals that paleontologists turn when trying to cross the reptile-mammal evolutionary chasm in a Darwinian way.

In one group of mammal-like reptiles, the ictidosaurs, the skeltons definitely hint at mammals. The legs, for example, are pulled in beneath the body in contrast to the usual splayed-out legs of reptiles, such as seen in crocodiles and monitor lizards. (Of course, we do not know much about what their soft parts looked like!)

An oft-mentioned sequence of fossils leading to mammals involves the aforementioned bones in the repilian jaw that ended up as mammalian ear bones. Creationists, such as D.T. Gish, insist that the fossil record must show small intermediate steps as these bones were reshaped, moved into a new location, and applied to radically different purposes. Evolutionist J.A. Hopson answers this demand as follows:

> Gish argues that fossils have never been found showing an intermediate stage between the reptilian many-boned lower jaw and single-boned inner ear and the mammalian single-



The skull of a mammal-like reptile (top) compared to that of a marsupial (bottom). Although superficially much alike, the bones connecting the skull to the jaws in the reptiles (lower right) are transformed into ear ossicles in the mammals. (Adapted from R17)

> boned jaw and three-boned ear. He writes: "There are no transitional forms showing, for instance, three or two jaw bones or two ear bones." In this he is correct, of course; intermediates such as he describes never did exist. But his argument is a "red herring," intended, it would seem, to mislead the uninformed. As we have seen, the four reptilian jaw bones were incorporated into the mammalian middle ear as a unit. (R17)

This quotation seems to show that evolutionists are satisfied that this "unitary" modification and migration of a group of bones is Darwinian, while creationists are not. It is really not a small change and necessitated related modifications in muscles, nerve fibers, etc. But we have to recognize that small changes in an animal's genome do have considerable leverage and can result in large changes in the phenotype; that is, the animal's body. This being so, it is not inconceivable that a single mutation might instigate such major, coordinated skeletal and required infrastructure changes. An inquiring mind would ask where the reptilian genome got the information necessary for this one-step metamorphosis when it had never occurred before. In modern computer-oriented parlance, a great many bytes were required in this transition. How many random mutations would have sufficed to create the necessary data---and how long would it have taken?

But the reptile-mammal transformation is actually much more involved than those few ear bones.

Objections to the Darwinian scenario. In his book Darwin on Trial, P.E. Johnson is exceedingly skeptical about the standard scenario for the reptile-to-mammal transition. His main point is that mammalian characteristics were distributed among several species of mammal-like reptiles (the therapsids), and that a single, simple line of descent to mammals can be charted:

> ...only by arbitrarily mixing specimens from different subgroups, and by arranging them out of their chronological sequence. If our hypothesis is that mammals evolved from therapsids [a type of mammal-like reptile] only once...,then most of the therapsids with mammal-like characteristics were not part of a macroevolutionary transition. If most were not then perhaps all were not. (R24)

Thus, the reptile side of the bridge is multipronged, and a single reptilian ancestor is hard to identify. Then, too, on the mammal side of the gap, the fossil record provides many early species of mammals with important morphological differences. Both sides of the gap are multipronged. Johnson continued:

> This baffling situation led some paleontologists to consider a disturbing theory that mammals, long assumed to be a natural "monophyletic" group (that is, descended from a common mammalian ancestor) were actually several groups which had evolved separately from different lines of therapsids. (R24)

The accepted scenario is further complicated by the observation by C. Gow that the criterion commonly used to distinguish reptiles from mammals (those jaws and ear bones again) is inadequate. In fact, paleontologists seem to be unsure as to whether some mammal-like reptiles, such as the ictidosaurs, are reptiles or mammals. (R13)

Finally, as our earlier short list of 14 important differences between reptiles and mammals suggests, tracing the evolution of skeletal material is only a very tiny part of the required scenario. As a matter of fact, M. Denton, a biologist, doubts the utility of skeletal material in determining any evolutionary relationships. He has written:

> Given the tremendous diversity of life and the ubiquity of the phenomenon of convergence, it is bound to be the case that certain fossil organsims which appear to be very close on skeletal grounds were in fact in terms of their overall biology only distantly related, like the placental and marsupial dogs. (R15)

To illustrate, those mammal-like reptiles might have had mammal-like skeletons but have been radically different in terms of their unfossilized soft parts, such as their reproductive and circulatory systems.

Conclusions. The bridge across the reptile-mammal gap is not as strong and secure as stated in virtually all biology books. Mammals may well have developed from the biological foundation constructed by the millions of years of reptilian development, but the details of the supposed transformation remain confusing and are mainly uncharted.

What does seem evident is that the reptile-mammal transformation involved prodigious anatomical changes. These in turn had to be based upon massive changes in data bases (genomes). It is doubtful that the reptilian data base was modified (mutated) bit by bit, randomly yet, on the average, progressively, in the direction of the mammals. There must have been in addition profound "software" changes; that is, ways in which the data were manipulated. The nature and cause(s) of these changes are still unmapped in scientifically satisfying detail.

X2. Evolution from "lower" to "higher" mammals. We add the quotation marks to the adjectives because the concept of "level" in evolution is a murky one. Does "higher" mean: (1) later in the fossil record; (2) more complex; (3) more specialized; (4) better adapted to the environment; or (5) something else?

Actually, all we are concerned with here is whether transitional forms can be found in the fossil record connecting the various mammalian taxonomic levels; that is, the orders, families, genera, and species. To fulfill Darwin's expectation, these connecting transitional forms should exhibit relatively small, sequential changes, such that even a creationist would admit that life forms have developed smoothly in directions channelled by natural selection.

The nature of the fossil record for mammals-in-general seems to depend upon the taxonomic level under scrutiny. At present, when paleontologists look for transitional fossils leading to the various mammalian orders---rabbits (Lagomorpha), bats (Chiroptera), whales (Cetacea), etc.---they still find serious gaps, even after long, assiduous searching. In this regard, a quotation from E. Russell's 1962 book The Diversity of Animals is appropriate:

> Even in the Mammals, whose geological history is comparatively well documented, serious gaps in the record occur at just the time when the primary differentiation of the orders is taking place. As [G.G.] Simpson points out, "The earliest and most primitive members of every order already have the basic ordinal characters, and in no case is an approximately continuous series from one order to another known. In most cases the break is so sharp and the gap so large that the origin of the order is speculative and much disputed." (As quoted in R13)

At the genus and species levels, however, more continuity is evident. In fact, the harder the paleontologists look, the more they are able to fill in the gaps in the fossil record at these lower taxonomic levels. Illustrating this effect is a very detailed study by P.D. Gingerich published in 1976.

Gingerich had studied the fossils of several species of early Eocene mammals appearing in the strata of the Big Horn

Basin in Wyoming. Gingerich found that, at the species level at least, the fossil record was essentially gapless, contradicting earlier field work in the area.

> Earlier studies of these same animals indicated abrupt transitions from one species to another followed by long periods of time during which each species persisted relatively unchanged. This "punctuated equilibrium" picture of phylogeny suggested by the previous studies is now seen to be an artifact of methodology: the previous studies adopted (1) an essentially typological species concept or (2) an insufficiently divided stratigraphic context, or both. Either of these methodological approaches, or (3) study of stratigraphic sections that include significant gaps in sedimentation, will invariably lead to a "punctuated equilibrium" model of phylogeny, if indeed any coherent picture of phylogeny emerged at all. (R5)

The question that arises asks whether the gaps seen among mammalian at higher taxonomic levels can be likewise filled in by further field work and improved methodology. Strict Darwinists certainly expect that they will. Otherwise, one has to contemplate the possibility that macroevolution (that is, evolution at higher taxonomic levels) differs in mechanism from microevolution (at the species level). If so, the prevailing evolutionary paradigm would have to be modified.

X3. Horses. With horses, as with all forms of life, evolutionists expect to see "primitive" horses yielding to a succession of more "advanced" equine forms in the fossil record. Actually, the adjective "primitive" is meaningless here. All that really counted 50 million years ago was whether an early horse successfully propagated itself in the face of competition and environmental pressures. To illustrate, a modern thoroughbred might stand little chance in the days of Eohippus, the so-called "dawn horse." With this miscellaneous observation, we turn to the famous fossil sequence that puportedly demonstrates the evolution of modern horses. The objectives are to assess the soundness of the sequence and whether it actually supports the theory of evolution.

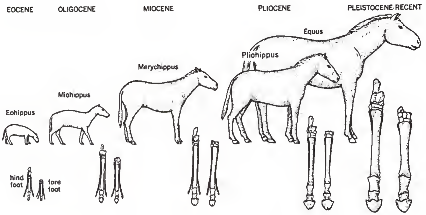
The classical horse sequence. Seen in many textbooks and museums, the horse sequence of fossils has been a staple of the evolutionists for over a century. It begins with diminutive Eohippus (see diagram) and "progresses" through several other fossil forms, which are said to demonstrate evolutionary "progressive" changes in terms of: (1) increasing size; (2) reduction of toes; and (3) changing structure of teeth.

The horse sequence is an excellent picture of what old-fashioned evolutionists believe actually happened over the eons. This particular sequence is a model that Darwinists would like to see emulated for the other mammals examined later in this section. For this reason, we shall focus on it rather carefully.

Looking back at the reptile-mammal transition (X1), we do not see there the finer gradation of fossils present in the horse sequence. This dearth of transitional forms at the class level (reptile-to-mammal) is a feature we shall return to later. It should also be recalled that the major changes in the reptile-mammal transformation were rarely if ever fossilized. In contrast, we can be fairly certain that each of the mammals shown in the horse sequence possessed a diaphragm, a four-chambered heart, etc. Species transformations are obviously simpler than transformations at the class level.

Politics of equine evolution. Opinions vary as to the scientific validity of the horse evolutionary sequence. Creationists harp upon the several possible deficiencies that have become more obvious over the years. (Some are analyzed below.) At the other end of the political spectrum, hard-line evolutionists vigorously defend the message and details of the sequence. In recent years, however, more moderate scientists have acknowledged there are indeed some problems with the many million copies of the horse sequence now in print and displayed in museum cases. It is a clash of philosophical outlooks---science versus religion---which we will try to transcend in what follows.

It is worthwhile reviewing typical statements made by extremists in this conflict. First, a strong statement by T.M. Berra on the scientific validity of



The classical and still-profferred sequence of horse evolution. Similar, supposedly-progressive changes in the skulls and teeth are often addded to the text-book and museum presentations. But, as discussed in the text, this "too-perfect" portrait of evolution is no longer considered accurate by many biologists.

the classical chart of horse evolution.

> The fossil record of horses spans 54 million years, five continents, and thousands of fossils. It shows both evolutionary trends and diversity through time. The evolution of the horses offers an excellent example of continuing adaptation to a changing environment, and evolution that left many transitional fossils. The lavish fossil record speaks loudly and clearly to the fact that evolution has occurred. (R19)

Not unexpectedly, creationist D.T. Gish sees the identical fossil record in a different light.

> To us the family tree of the horse appears to be merely a scenario put together from non-equivalent parts. Nowhere, for example, are there intermediate forms documenting transition from a non-horse ancestor (supposedly a condylarth) with five toes on each foot, to Hyracotherium with four toes on the front foot and three on the rear. Neither are there transitional forms between the four-toed Hyracotherium and the three-toed Miohippus, or between the latter, equipped with browsing teeth, and the three-toed Merychippus, equipped with high-crowned grazing teeth. Finally, the one-toed grazers, such as Equus, appear abruptly with no intermediates showing gradual evolution from the three-toed grazers. (R16)

The evolutionists have successfully used the horse sequence as an educational tool for decades. But over half a century ago, its validity was being challenged by some scientists. A sort of middle ground has been established where this long-revered model of evolutionary progress is deplored on one hand but its message essentially retained on the other. Our third exhibit features a quotation from scientist G. Hardin, as quoted by N. Macbeth in his book Darwin Retried:

> ...there was a time when the existing fossils of the horses seemed to indicate a straight-line evolution from small to large, from dog-like to horse-like, from animals with simple grinding teeth to animals with the complicated cusps of the modern horse. It looked like a straight line ---like the links of a chain. But not for long. As more fossils were uncovered, the chain splayed out into

> the usual phylogenetic net, and it was all too apparent that evolution had not been a straight line at all, but that (to consider size only) horses had now grown taller, now shorter, with the passage of time. Unfortunately before the picture was completely clear, an exhibit of horses as an example of orthogenesis [linear evolution] had been set up at the American Museum of Natural History, photographed, and much reproduced in elementary textbooks (where it is still being reprinted today). (R4, citing G. Hardin's 1961 book Nature and Man's Fate)

In effect, the model is tarnished, but its spirit lives!

Relevant observations concerning the horse sequence.

Bushiness not linearity. The "splaying out" of equine lineage mentioned by Hardin above is now usually referred to as "bushiness." It is a concept vital to later commentary and so worth a bit more space. Modern paleontological thinking on the real nature of evolution was voiced by A. Lister in a review of B.J. MacFadden's 1993 book Fossil Horses: Systematics, Paleobiology and Evolution of the Family Equidae.

> As early as 1930, Matthew realized that equid evolution fitted not a single lineage but a complex branching tree, and current taxonomy recognizes about 150 fossil and living species over a 58-million-year history. Nonetheless, the portrayal of a single line leading to Equus persists in museum displays, textbooks and undergraduate essays. MacFadden rightly criticizes this view as misrepresenting the complexity of evolutionary history and process. (R36)

Still, Lister asserts that the misleading horse sequence shows the general trend of equine evolution.

Seconding Lister, S.J. Gould, a strong proponent of evolution, adds more expressively:

> Bushes represent the proper topology of evolution. Ladders are false abstractions, made by running a steamroller over a labyrinthine pathway that hops from branch to branch through a phylogenetic bush. (R18)

Punctuated nature of the equine fossil record. Even though the horse sequence, bushy as it is, displays a much finer gradation of change than the reptile-mammal sequence (X1), it is still not a smooth record, as M. Denton has related:

> The horse series is not as perfect as is commonly assumed. As [G.G.] Simpson points out, the single line of gradual transformation from Eohippus to Equus presented in most recent texts of evolutionary biology is largely apocryphal. On the contrary, most of the morphological characteristics of the feet, skull and teeth, which are traditionally supposed to have exhibited an almost perfect sequence of change throughout the Tertiary, "progress from one stable adaptive level to another by a sequence of short steplike transitions" and some of the transitions are not represented in the fossil record. (R15)

Selectivity of fossils as to time and place. The creationists have always objected that evolutionists constructed the classical horse-evolution chart by picking just those fossils from evolution's "bush" that made a convincing story---regardless of when and where the fossils came from. Even non-creationists have the same complaint. F. Hitching expressed an extreme view:

> A complete series of horse fossils is not found in any one place in the world arranged in rock strata in the proper evolutionary order from bottom to top. The sequence depends on arranging Old World and New World fossils side by side, and there is considerable dispute as to what order they should go in. (R6)

Even with careful selection from the 150 or so species of fossil horses, the sequence is not perfect. Some of the alleged descendants of Eohippus were actually smaller in size in contradiction to the general increase in stature implied by the textbook charts. Also, both Eohippus (the dawn horse) and Equus (the modern horse) boast 18 pairs of ribs, but Orohippus has 15, Pliohippys, 19. (R38) Such changes do tend to give the horse sequence a patched-together appearance.

Life's little joke. An article by S.J. Gould in Natural History bears this title. The point made there by Gould is that, when evolutionists insist upon linear evolutionary sequences, they guarantee that their models show unsuccessful lineages. Successful families of life forms, whether horses or bacteria, are bushy in their phylogenies. The horse family tree is very bushy, with some 150 twigs, but Walker's Mammals of the World lists only 8 extant species in the Genus Equus. Gould maintains that a bush can be made linear only when all twigs but one are snipped off. Thus, horse sequence may look good, but it is an example of a failing lineage! Gould concludes by identifying another mammalian lineage that has now been trimmed down to one twig: the Genus Homo! (R18)

Does the horse sequence actually disprove evolution? Could it be that all those charts in the textbooks really undermine evolution rather than support it? Such would be another "little joke" on the evolutionists. We let M. Denton answer the above question:

> Moreover, there is another aspect of horse evolution which casts a shadow over its usefulness as the example par excellence of gradual evolutionary transformations. The diffference between Eohippus and the modern horse is relatively trivial, yet the two forms are separated by sixty million years and at least ten genera and a great number of species. The horse series therefore tends to emphasize just how vast must have been the number of genera and species if all the diverse forms of life on Earth had really evolved in the gradual way that Darwinian evolution implies. If the horse series is anything to go by, their numbers must have been indeed the "infinitude" that Darwin imagined. If ten genera separate Eohippus from the modern horse then think of the uncounted myriads there must have been linking such diverse forms as land mammals and whales or molluscs and arthropods. Yet all these myriads of life forms have vanished mysteriously, without leaving so much as a trace of their existence in the fossil record. (R15)

We have already seen what Denton means by the relative poverty of the fossil record in charting the reptile-mammal transformation. In this we see again the possibility that macroevolution (class level and higher) may differ in mechanism from microevolution (family level and lower). The main lesson derived from the classical horse sequence may not be that which evolutionists originally intended!

Are there true transitional forms in the horse sequence? The horse sequence may be far from perfect, but one cannot fail to see some morphological continuity at these low taxonomic levels. The twigs on the bush do look similar in several respects. It would be unreasonable to maintain that the 150 or so living and fossil equine species do not also have some degree of genetic continuity. So, yes, the famous horse sequence probably does contain bona fide transitional fossils, but the sequence's most important message may help transform the evolutionary paradigm itself. That is, the existence of transitional fossils between lower taxonomic levels emphasizes the great dearth of transitional fossils at the higher taxonomic levels---just where one would expect a great many such "in-between" fossils. Again, there is the implication that macroevolution may differ in mechanism from microevolution.

X4. Whales. After the horses, the next most active battleground upon which the creationists and evolutionists contend involves the cetaceans, especially the whales. There is a difference, though, because with the horses the evolutionists have fielded what they consider to be a fairly firm family tree of transitional forms for the creationists to snipe at. The family tree of the whales is not as firmly developed and canonized. Attacks on the cetacean family tree tend, therefore, to be somewhat more subjective. For example, the creationists arc fond of cartoons showing a cow transforming into a whale in two easy, quite improbable, but amusing steps. Ignoring the politics, some reasonable, potential transitional whale-like fossils have certainly been found. It is the interpretation of these skeletons that is controversial.

Even within the scientific community, one finds startlingly different assessments of the meaning and soundness of the cetacean fossil record. In 1983, S. Leatherwood and R.R. Reeves described the array of whale fossils then known as follows:

> In general, the mosaic consists of a few lonely tiles separated by broad gaps of ignorance. The uncertainty becomes progressively greater as one moves farther into the past. (R10)

But in 1994, after the discovery of several more potential transitional fossils, M.J. Novacek was much more upbeat:

> This expanding casebook on the origins of whales is one of the triumphs of modern vertebrate palaeontology. (R42)

Accepting that the outlook has improved, there remains controversy over just what the fossils mean and what the whale family tree really looks like. This state of affairs should not surprise anyone. The gap between land mammals (the foundation of virtually all cetacean evolutionary family trees) and the modern whales is much, much broader and deeper than the Eohippus-to-Equus separation---a veritable chasm rather than a gap.

The width of the land-mammal-to-whale gaps. Indeed, there may be two gaps rather than one. Some biologists argue that the toothed and baleen whales had separate origins. If so, two different family trees would have to be constructed, perhaps beginning with different land mammals. The two Suborders of whales, the Mysticeti and Odontoceti (baleen and toothed, respectively), are so different that the separate-origin theory is not entirely unreasonable. We now mention only four of these important differences here:

(1) In baleen whales, plates of baleen (made of fingernail-like material) take the place of bony teeth.

(2) The baleen whales breathe through two external blowholes or nostrils instead of the single hole used by the toothed whales.

(3) Baleen whales are not known to echolocate, although they do emit suggestive clicks. Toothed whales, in contrast, rely heavily on their sonar. (R10)

(4) Baleen-whale skulls are symmetrical; toothed-whale skulls are not. (Even the spout of the sperm whale is canted to the side!)

Most evolutionists hold that the baleen whales evolved from the toothed whales, mainly because embryonic teeth appear temporarily in the baleen whales. However, these embryonic teeth could have been carried over from an ancestor common to both baleen and toothed whales. Confusing the issue are recent mtDNA (mitochondrial DNA) data suggesting that sperm whales (always classed as toothed whales) may actually be genetically closer to the baleen whales than the other toothed whales! (R41) (See also BMG1-X1 in this volume.)

A single transformation of land mammal into a cetacean is formidable enough; but two separate, roughly parallel transformations would stretch credulity almost to the breaking point. (See illustration.) Consider the major physiological changes that even a single land mammal-to-whale transformation must account for:

(1) Modifications for deep diving, including breath holding (up to an hour or more), resistance to immense pressures, avoidance of the bends, etc.

(2) Development of a highly effective echolocation system (toothed whales only), including a sound-pulse generator, a sound-focussing lens, a receiver, and the neural circuitry and brain needed to process and interpret the echos.

(3) Modifications for underwater birthing and suckling.

(4) Conversion of forelimbs into flippers (R24)

(5) Development of a propulsive tail and the muscles required to flex it up and down. (BMA45 in Mammals 1)

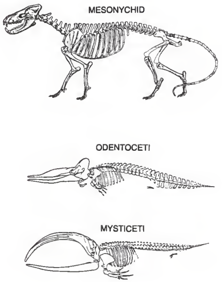
(6) Creation of a dorsal fin in some species. (Inherited from fish despite a huge taxonomic gap? Highly unlikely!) (BMA49 in Mammals 1)

(7) Migration of the nostrils up to the top of the head.

Regrettably, many of these crucial changes cannot be followed well, if at all, in the fossil record.

Claimed transitional fossils. As indicated above, a general scientific consensus holds that whales descended from land mammals rather than from such fully aquatic mammals as seals, manatees, sea otters, etc. Fossil evidence firmly links the cetaceans to the land mammals classified as artiodactyls. The artiodactyls are the even-toed ungulates and include the deer, camels, giraffes, pigs, and so on. (R29) However, the molecular evidence is somewhat ambiguous; not all of it supports the accepted close artiodactyl-cetacean connection. (R21)

Specifically, the whales share many features with an extinct group of ungulates called mesonychids. In today's thinking, these animals, some of which were carnivorous, form the rootstock of all cetaceans. (R19) As the illustration demonstrates, the transformation of a typical mesonychid skeleton into those of the two Suborders of whales is a



(Top) Skeleton of one of the mesonychids, a now-extinct group of ungulates that is believed to have been the evolutionary starting point of modern whales. (Bottom) Skeletons of typical modern Odontoceti (toothed whales) and Mysticeti (baleen whales). There are obviously great morphological differences between the mesonychids and the two modern whales, as well as between the two types of modern whales themselves.

challenge to evolution---a transformation requiring, one would expect, the deposition of many transitional forms in the fossil record, plus the many other changes that are not readily fossilizable.

The whale fossil record accepted circa 1982. In the early 1980s, the most convincing transitional fossils connecting the land mammals (the mesonychids) with the whales were the so-called archaeocetes ("ancient whales"). These primitive whales were apparently quite diverse, for some paleontologists have called the Archaeoceti a "taxonomic wastebasket." (R21) (The illustration must show a "generic" archaeocete!) In 1982, the evolution of whales and dolphins was explained almost exclusively in terms of these "primitive" cetaceans, as elaborated upon by F. Edwords.

> The first fossil was a mesonychid, a member of a family of land mammals that lived fifty million years ago and had skulls similar to that of modern wolves or dogs. Its nostrils were at the tip of the snout, as would be expected for this type of mammal. The second fossil was a forty-five million year old Protocetus. This amphibious mammal had an elongated skull in which the snout was extended forward ahead of the nostrils. The third fossil was a Durudon, a forty-million-year-old, fully aquatic mammal with the snout even further out from the nostrils. The fourth example was from the family Squalodontidae, being a porpoiselike mamanimal from twenty-five million years ago with its nostrils on its forehead between the eyes. The last example was a modern bottlenose dolphin. This animal first appeared fifteen million years ago and has nostrils above its eyes. (R27)

Edwords wrote the foregoing summary based upon a 1979 article in National Geographic (155:506). Note that today, a decade and a half later, hoofed ungulates rather than wolf-like land mammals are considered the proper ancestors of the cetaceans. Nor does one find Prorocetus or Durudon mentioned in today's ladder of descent. The reason is that the 1980s and early 1990s have seen the discoveries of several more-convincing whale transitional fossils. The situation is apparently fluid, and the cetacean family tree is obviously not well-defined as yet.

Recently discovered transitional cetacean fossils. The gap separating the land mammals and modern cetaceans has been partially filled in during the past 15 years by several fossil finds. Seeing that the archaeocetes comprise a "taxonomic wastebasket", we suppose that the four fossils now described will fit easily into that category. (But who can predict what taxonomists will do?) In any case, the new discoveries are impressive and certainly will confound the creationists who see few if any transitional fossils anywhere.

In the early 1980s, P.D. Gingerich, while fossil-hunting in the early Eocene in Pakistan, came upon a very early but undoubted whale fossil. Named Pakicetus inachus, the location of the remains suggested that whales descended from terrestrial carnivorous mammals and made the land-to-sea transition in the early Eocene as they spent more and more time feeding on fish in shallow marine waters. Gingerich thus asserted that whales began as shore-dwellers, not four-legged amphibious mammals. (R9)

Pakicetus has been called the oldest cetacean (52 million years old) and, to many, it represents a very convincing transitional form. (R31) But creationist D.T. Gish scoffs at this characterization of Pakicetus, calling it "just another land mammal"! (R43)

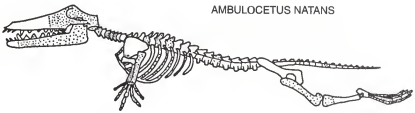
Moving next to Egypt and the middle Eocene, Gingerich and his colleagues reported in 1990 on their discovery of still another transitional fossil, Basilosaurus isis, which was an early whale sporting functional hind limbs. The real purpose of these appendages is unknown. Perhaps there were copulatory aids like the claspers in sharks! (R20) (It is pertinent that an occasional modern whale is found with a vestigial hind leg protruding.) (R8)

Basilosaurus isis has not impressed everyone as being a legitimate transitional fossil leading to modern whales. J. Trefil doubts that it is on the direct line of descent (R25)---rather, it was only a twig ending in extinction.

It was back to Pakistan for the next important fossil find. In an early-1994 issue of Science, J.G.M. Thewissen et al described a new genus and new species of fossil cetacean from Eocene beds 120 meters above those that yielded Pakicetus. Naturally, a new name was proclaimed: Ambulocetus natans, implying that this whale could walk on dry land. Furthermore, this "walking whale" apparently swam by undulating its vertebral column in a vertical plane, thereby forcing its hind feet up and down, so that it swam much like modern otters. On land, Ambulocetus probably hunched along after the fashion of sea lions. (R39)

The thought of a "walking whale" does seem preposterous, but Ambulocetus measured only about 3 meters long including its tail. It was not a huge mass of muscle and blubber like a humpback! But creationist D.T. Gish was not satisfied. He scoffed that it required a lot of imagination to call "a creature with powerful forelimbs and hind limbs (the latter bearing hooves), unable to dive to any significant depth or to hear directionally under water, was nevertheless a whale." (R43) In truth, Gish does have a point.

One more primitive whale has been mentioned prominently in the recent



This fossil from Pakistan may be another transitional form in the evolution of whales. (R41) literature: Rodhocetus kasrani, another new genus and species. Again from Pakistan and again found by Gingerich and team, this purported transitional whale is dated as being 46-47 million years old. Rodhocetus was apparently fully adapted for tail-swimming, as contrasted to Ambulocetus, which used its feet otter-like. (R40) A significant feature of the Rodhocetus discovery was that it was fossilized in strata laid down in deep water. Perhaps this mammal had become truly marine and was not confined to near-shore environments. (R42)

Some remaining questions. No one can honestly complain that there are no fossils that might bridge the gap between land mammals and modern cetaceans. Some may not be in the direct line of descent; others may not be whales at all. The interpretation of fossils in terms of flesh-and-blood creatures is always difficult. Even so, the gap is not the vacuum desired by the creationists, but neither is it filled with finely graded fossils.

We see two important questions remaining to be answered:

(1) The gap between land mammals and modern whales is much wider than that between Eohippus and Equus, yet the whales evolved in only 10 million years or so, but the horses required about 50 million years for much smaller changes. One would expect that the cetaceans' radical biological reengineering would have taken much longer than the relatively modest changes in the horse sequence. Why the difference? (R22) Was a different evolutionary mechanism at work?

(2) Are whales monophyletic; that is, did baleen whales really descend from the toothed whales or were there two separate origins followed by parallel evolution? Such a remarkable convergence would be difficult to account for; and we shall see (in X6) that a similar situation exists with the bats.

X5. Primates. The mammals comprising the Order Primates exhibit rather unspecialized physical characteristics. Most, but not all, have five fingers and five toes. Thumbs are usually opposable and, except for humans, so are the first digits on the feet. The eyes are directed forward, and the braincases are relatively large. (R34)

That the Order Primates is not sharply defined and is in flux can be seen in the recent realignment of the tree shrews. These rat-like mammals were formerly considered to be insectivores and as having a recent common ancestor with the earliest primates. (See chart.) The tree shrews are now placed in a separate Order: Scandentia. (R23) Another recently suggested and hotly contested change involves the the idea that the megabats (Megachiroptcra) are actually primates! (See X6 below and BMA1-X9 in Mammals I.)

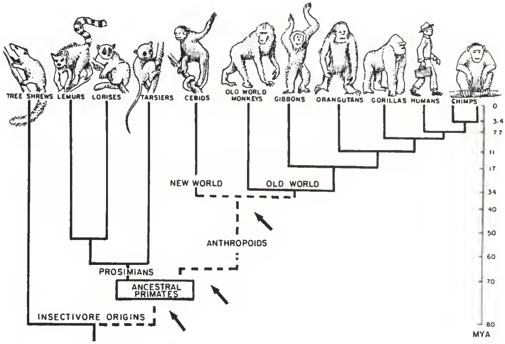
Even in the face of such taxonomic turmoil, many stalwart evolutionists testify that the evolution of primates is well and firmly documented in the fossil record. As far back as 1876 in his book Man's Place in Nature, T.H. Huxley asserted:

> Perhaps no order of mammals presents us with so extraordinary a series of gradation as this---leading us insensibly from the crown and summit of the animal creation down to creatures, from which there is but a step, as it seems, to the lowest, smallest, and least intelligent of the placental mammals. (As quoted in R15)

Huxley wrote this when paleontology was in its infancy. Almost a century later, after many more digs, E.L. Simons admitted that:

> In spite of recent finds, the time and place of origin of Order Primates remains shrouded in mystery. (R13, citing New York Academy of Sciences, Annals, 167:319, 1969)

Referring to the primate family tree drawn by T.M. Berra in 1990, we see that the primates are presently split into two large branches (Suborders): the prosimians and the anthropoids. The latter, in turn, are divided into the New World and Old World primates. Despite what Huxley declared in 1876 and desite much more searching, significant gaps in the fossil record seem to exist at the two splits just mentioned and, in addition, at the stem where the primates originated. Restating this, transitional fossils seem to be absent or extremely



The primate family tree as presently envisioned by paleontologists. The three arrows indicate the three critical "points of origin" mentioned in the text.

scarce at:

- the point-of-origin of the primates
- the point-of-origin of the anthropoids
- the point-of-origin of the New World monkeys.

(Incidentally, Berra's family tree, R19, shows the tarsiers as prosimians. They are now thought to be closer to the anthropoids. (R23) Taxonomists are always redrawing family trees---a sure indication that much remains to be learned in evolutionary biology!)

Next, we look more closely at the three above-mentioned points-of-origin.

Primate origins. In the second edition of Physical Anthropology (1974), A. Kelso essentially dismissed as useless that part of the fossil record linking the "lower" mammals to the primates:

> While the fossil record of insectivore evolution is reasonably good in some lines, the transition from insectivore to primate is not documented by fossils. The basis of knowledge about the transition is by inference from living forms. (As quoted in R13)

Other scientists of the 1970s and later doubtless disagreed with Kelso's flat statement. They could have pointed out that the fossil primates called adapids and omomyids were obvious transititional fossils filling that wide gap between the insectivores and earliest primates. The adapids and omomyids do fit into the primate family tree somewhere, but recent fossil discoveries have muddied the waters, and it is now uncertain where they fit on the primate family tree.

Doubts about the part played by the adapids and omomyids in primate evolution were accentuated by the report in 1991 of a new primitive tarsier (Shoshonius cooperi) unearthed in Wyoming. (R28) This fossil primate apparently pushes the origin of primates back to 80 million years, in effect eliminating the adapids and omomyids as precursors of modern primates; that is, they were not in the direct line of descent after all. If the 80-million-year figure holds up, primates could have been contemporaries of the dinosaurs! (R26, R27)

Further illustrating the deep uncertainties about primate evolution is the fate of the plesiadapiforms, long considered primitive primates from the Paleocene. As recently as 1983, P.D. Ginrich desribed in great detail how these squirrel-like early primates arose in North America well before rodents appeared upon the scene. (R11) But his assessment of the plesiadapiforms' place in primate evolution was based on fragmentary fossil evidence. Later in the 1980s, more-complete plesiadapiform skeletons were unearthed in Wyoming. These proved beyond a doubt that the plesiadapiforms were not primates at all but instead were probably related to the colugos (flying lemurs). (R27, R37)

In summary, it appears that some controversial transitional fossils do exist in that gap preceding the origin of the Order Primates. They are, however, few and their significance uncertain. Making matters worse, the discovery of the Shoshonius fossils has opened up a new gap. L. Krishtalka of Pittsburgh's Museum of Natural History contends that:

> These new specimens show that the fossil record does not account for at least 10 million years of primate evolution. (R28)

Anthropoid origins. At present, paleoanthropologists are contemplating at least four theories that might account for the appearance of the anthropoids (monkeys, apes, etc.) in the fossil record. Whenever one sees such a multiplicity of theories, it is almost certain that data are wanting in quantity and/or quality. E. Culotta confirmed this is a 1992 survey of anthropoid paleontology in the journal Science.

> Paleoanthropologists have had trouble pinning down the origins of anthropoids partly because ancient primates have left a muddy and incomplete trail of fossil clues. What is known is that about 55 million years ago, primates as well as other mammals began to radiate into a dazzling array of new species. At some point, one group diverged from the lower primates (or prosimians) and gave rise to the anthropoids. But no one can say with certainty what this ancestor looked like, because there's a large gap in the fossil record between primitive and advanced forms. "You put all the primates into a pile and you can always sort the anthropoids from the others," says John G. Fleagle of the State University of New York at Stony Brook. "They're so distinctive it's hard to figure out where they came from. (R33)

One of the four potential anthropoid family trees being proposed today shows the anthropoids themselves as an ancient group extending all the way back to the origin of the Order Primates, and thereby bypassing the adapids, omomyids, and any claimed other intermediate forms. (R45)

Anthropoid fossils continue to be elusive as one moves up the anthropoid family tree. P. Andrews has complained:

> ...the lack of a hominid fossil record before about 5 million years ago---and any fossil record for the African apes---is still a frustrating barrier. (R32)

Manifestly, transitional fossils are lacking in the anthropoid line of descent. But new finds are being announced almost weekly, and many parts of the world, especially Africa, remain largely unexplored. As with all claimed fossil gaps---and any negative claim---tomorrow's shovelful may uncover that hoped-for transitional bit of bone.

New World monkeys. The monkeys found in South and Central America differ significantly from their Old World relatives. Generally, they are smaller and more arboreal. They sport long, prehensile tails, and their thumbs are only slightly opposable. If you can get close enough to one, you will see that there is a wider gap between the nostrils than observable on Old World species. (R19)

Very little is known concerning the origin of these New World monkeys. The fossil record tells us only that they appeared, apparently suddenly, in the late Eocene (about 35-40 million years ago) and radiated explosively into many species. Curiously, the Old World monkeys were also speciating rapidly at the same time! (Was there a common environmental impetus?) Some mammalogists hold that the New World monkeys must have had an independent origin. (R34) Others believe they evolved from the Old World clan. The fossil record cannot confirm either scenario for certain. However, the latter hypothesis is now dominant, as confirmed in Walker's Mammals of the World:

> A recent consensus of opinion is that the Catarrhini and Platyrrhini [Old World and New World monkeys, respectively] had a common ancestor in Africa and that the precursors of the latter crossed the South Atlantic Ocean in the late Eocene. At that time, Africa and South America were much closer together than they are now, there were numerous islands between the two continents, and the relatively small oceanic gaps that remained could have been traversed when animals became isolated on large masses of drifting vegetation. (R23)

No fossils record the landfall of these sea-voyaging primates. Note that some other "distribution" anomalies are also accounted for by transoceanic rafts of floating vegetation; viz., the porcupines. (BMA1 in Mammals 1) Such "arks" are not particularly convincing.

Conclusions. The primate fossil record displays many gaps which cannot help but lead to shifting family trees and controversies over origin. Evolutionists, of course, expect that these gaps will eventually be closed by new discoveries ---and the large number of recent fossil-primate discoveries seems to support this expectation. However, the primate fossil record is definitely not as solid as Huxley proclaimed in 1876. Primate family trees have changed markedly in the last century; and they will doubtless be quite different a decade from now.

Probably the most anomalous features of primate evolution are the several explosive radiations of species. Two salient examples are: (1) The seemingly parallel rapid speciations of both New and Old World monkeys; and (2) The radiation of lemurs on the isolated island of Madagascar. If primates can really be traced back 80 million years to the time of the dinosaurs, then they, too, probably participated in the general rapid radiation of mammals that occurred about 65 million years ago at the Cretaceous-Tertiary boundary event (assumed to be a large asteroid impact). Whatever the initial stimuli, these "sudden appearances" or "saltations" remain unexplained as to mechanism. They may represent a different mode of evolution.

X6. Bats. In the fossil records of the horses, whales, and primates (discussed above), paleontologists can point to a few, not-unreasonable, potential transitional fossils. The bats, though, appear in the fossil record unannounced by any intermediate forms that show how their wings and echolocating apparatus might have evolved in the required step-by-step fashion. A third unrecorded feature of the Order Chiroptera is the supposed split into the Suborders Microchiroptera and Megachiroptera; that is, the microbats and the Old World fruit bats, also called "megabats" and "flying foxes". We will now look at each of the three problem areas---briefly, because in the absence of fossils, it is mostly speculation!

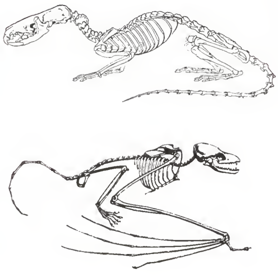
Bats as fliers. The origin of sustained, powered flight in mammals is remarkable, as it is also in insects and birds and was in reptiles---an amazing four-fold parallelism. Although an entire section is devoted to bat flight in Mammals I (BMA41), it is appropriate to complement that discussion with two additional opinions concerning the fossil record of this momentous biological development. First, K.H. Redford and J.F. Eisenberg remark:

> Bats are poorly represented in the early fossil record. Their small size and delicate bones apparently reduce the probability of preservation. The earliest bat is known from the Eocene of North America. This fossil clearly indicates that the bat was completely volant; thus the early ancestors of bats showing preflight adaptations are as yet unknown or unrecognized in the fossil record. (R34)

Next, we quote from J.G.M. Thewissen and S.K. Babcock:

> Unfortunatcly, the fossils available only complicate matters. They do not

represent transitional morphologies between quadrupedal (four-footed) mammals and flying bats, and they represent animals nearly as specialized as their modern relatives. Little is known of the oldest bat fossils from the late Paleocene of Wyoming, but nothing indicates that they were different from their Eocene descendants. There is no Archaeopteryx for bats. (R35)



(Top) Skeleton of a modern shrew. (Below) A very early bat skeleton. Bats may have evolved from shrews, but no transitional fossils have yet been found.

If the microbats and megabats actually originated and evolved separately as some maintain (see below), and wings along with the power of flight arose twice, the fossil record is mute on the subject.

Bats as echolocators. The microbats are superb echolocators in contrast to the megabats where the talent is mostly absent and where present is very weak. (BMT3 in Mammals I) Echolocation is no trivial faculty. It demands the near-synchronous evolution of a directional sound source, sensitive ears, and a nervous system-plus-brain that can convert weak echos into a "picture" of targets and surroundings. Some of this sophisticated apparatus turns out to be fossilizable. In fact, specializations for echolocation are evident is the earliest bat fossils found, pegged at 50 million years ago. The ear and larynx structures of the oldest bats are emphatic on this point. M.J. Novacek, contradicting some researchers, asserts that the fossil record of the earliest bats is "excellent." Nevertheless, bat echolocation seems to have burst upon the biological scene as suddenly and unannounced as bat flight. This fact also has implications for the widely accepted splitting of the Order Chiroptera into the micro- and megabats.

> It has been proposed...that the oldest bats are members of a group more primitive and possibly ancestral to the Microchiroptera and the visually oriented Megachiroptera. Previously undescribed specimens now show, however, that Icaronycteris and Palaeochiropteryx share special basicranial features with microchiropterans which suggest comparable refinement of ultrasonic echolocation. These results support the theory that a sophisticated sonar system was present in the earliest records of microchiropteran history. (R14)

If the very earliest bats were echolocators and modern megabats are not, the megabats must either have lost this useful capability or have originated and evolved separately without developing the echolocation faculty.

Bats as examples of parallel evolution. For most biologists, the belief is that all bats arose from insectivore ancestors, but in truth this is all surmise. As M.B. Fenton testifies, the fossil record tells us little that is useful here; there are as yet no transitional fossils leading to the bats.

> Since these earliest specimens are clearly bats, and not part bat and part something else, it is difficult to say for certain just what kinds of mammals gave rise to the Chiroptera. Although vernacular names for bats often associate then with mice, fossil evidence makes it clear that bats did not evolve from rodents. Most bio-

logists would agree that the shrews and their relatives (the Order Insectivora) are as closely related to bats as they are to any other living mammals. (R30)

Neither is the fossil record crystal-clear on the matter of single or dual origin of the bats. The megabats have a dentition distinctly different from that of the microbats. The teeth of the microbats could well have been derived from the insectivores, but not the teeth of the megabats. In fact, the brain, the central nervous system, the circulatory system, and the reproductive system of the megabats is closer to that of the primates than the microbats! (R22, and BMA1-X9 in Mammals 1) But the counter-argument enlists those amazing wing structures, both based on a remarkable reengineering of the hand, and which are so much alike in both micro- and megabats. It is difficult to believe that such unique structures could have arisen independently. Furthermore, with the chiropterans, we have a case where molecular data can help resolve the issue. And recent molecular data clearly support a single origin for bats (R29), despite the testimony of the megabat teeth and the other obvious physiological differences that separate the two suborders.

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BME2 Persistence of Certain Mammalian Morphological Forms in the Fossil Record

Description. The persistence of a small number of mammalian morphological types over millions of years, often but not always to the present day. These nearly static types are often termed "living fossils". The general phenomenon is called by several names: (1) evolutionary stasis; (2) arrested evolution; and (3) bradytelic; i.e., "very slow"; evolution. An important point: this phenomenon is based solely on those morphological characteristics that are fossilizable. It is possible that non-fossilizable structures of living fossils (and, accordingly, their genomes) may not have been static.

Data Evaluation. Many of the living fossils mentioned below are widely distributed and possess good fossil records. Paleontologists do not deny that some few mammalian types have changed very little if at all in the known fossil record. The basic data are not disputed, although their interpretation is. Rating: 1.

Anomaly Evaluation. Living fossils challenge the Darwinian model of gradualistic evolution, because they apparently exhibit much lower rates of evolutionary change than closely related species or lineages. Any phenomenon casting doubt on Darwinian evolution is highly anomalous. Rating: 1.

Possible Explanations. The hypothesis of punctuated equilibrium accords better than Darwinism with the living-fossil phenomenon. This theory holds that periods of slow, gradual, Darwinian evolution are interrupted by sudden, very short paroxysms of speciation. Since the evolutionary hiatuses are exceptionally long with the living fossils, the punctuated evolutionists must explain why the paroxysms of speciation are so far separated in time for the living fossils when compared to the evolutionary timetables of their close relatives. Also, how are these bursts of speciation triggered and accomplished.

Similar and Related Phenomena. Apparent scarcity of transitional fossils (BME1); explosive speciation (BME3, ESB2 in Anomalies in Geology). See also the Series-B Subject Indexes under: Punctuated evolution.

Entries

X0. Philosophical background. Even in Darwin's time, it was abundantly clear from the limited fossil record available that some animal types had changed little, if at all, down the geological eons. It was in fact Darwin himself who coined the appellation "living fossil". Over the ensuing decades, as the fossil record expanded, more and more living fossils were identified. So robust has the "living-fossil" phenomenon become that in 1984 two scientists, N. Eldredge and S.M. Stanley, devoted an entire book to the subject. (R6) In it, they described 34 species and lineages that seem to have survived almost unchanged over millions of years. Of course, all were not mammals, but enough were to warrant this catalog entry.

Eldredge and Stanley favor the "punctuated equilibrium" theory, in which evolution proceeds in bursts of speciation (saltations) separated by hiatuses rather than gradually as Darwin believed. In the interim between saltations, the species are thought to remain relatively unchanged. In the case of a living fossil, the interim period or hiatus is very long. In this sense, the existence of living fossils supports the hypothesis of punctuated equilibrium.

Many creationists, on the other hand, see living fossils as proof that their supernaturally created "kinds" of life are fixed and do not evolve, although minor adaptations are permitted.

Positioned somewhere between the punctuated evolutionists and creationists, N. Macbeth, a critic of dogmatic evolution, interpreted living fossils as a key challenge to the Darwinists who insist upon gradual change. Macbeth wrote:

> There are in nature certain forms that have existed unchanged through enormous stretches of time; e.g., the platypus, the little brachiopod Lingula, the oyster, the opossum, the ginkgo tree, the Australian lungfish, and the recently discovered fish called Latimeria [the coelacanth]. These are known as "living fossils" or "persistent types." They puzzle and annoy the evolutionists, who feel obligated to explain why, in a world of change, these forms continue in their old placid way without either changing or becoming extinct. In hundreds of millions of years there must have been changes in climate, changes in the environment, new enemies, new parasites, new diseases. Yet these creatures, without showing any special virtues or abilities, continue unchanged. (R2)

So far, our discussion has portrayed evolutionary stasis and the living fossils that help define it as a simple phenomenon; that is, merely as a handful of species that apparently have shown little change over long stretches of geological time. Things are not really so crystal clear, as we shall see in X2 below. First, though, we look at a sampling of the basic data.

X1. A parade of living fossils. There are about a dozen generally accepted living fossils in the Class Mammalia. Let us review quickly the more prominent of these. It is appropriate, though, to first remark that a dozen is a small number compared to the 4400 or so recognized species of mammals. Stasis or arrested evolution among the mammals is very restricted in its scope. If these statistics are correct, there could be many more living fossils among the mammals that have not yet received prominence in the literature.

The opossum lineage. These New World marsupials are the most-often-cited of the mammalian living fossils. There are some 77 species of opossums listed in Walker's Mammals of the World, so we are talking about a lineage here rather than a single species. Of this ancient lineage, G.G. Simpson wrote:

> The opposum lineage, for instance, is not completely known, but there are Cretaceous opossums strikingly like the living forms. In 70,000,000 years or so the line leading to the recent opossum certainly changed far less than did the line leading to the recent horse in 50,000,000 years. The rate of evolution must have been very much lower in the former than in the latter. (R1)

Notice that Simpson did not assert that the opossums did not change at all, merely that they changed much more slowly than horses. The contrast would have been still greater if he had used whales as an example. (See BME1-X4.)

Okapis. The first live okapi was not captured until 1903, yet this curious animal has been lurking in the African forests for millions of years! A close relative of the giraffe, the okapi is not usually listed among the living fossils. However, biologist E.H. Colber has concluded:

> A detailed osteological study of Okapia, whereby it is compared with all the other genera of Giraffidae, both living and fossil, and with other types of pecorans, shows that it is a truly primitive giraffid, in many ways more primitive than the earliest of the fossil giraffes. Generally speaking, the okapi may be considered as a 'living fossil' that has persisted with but relatively few changes from the Upper Miocene period to the present day. (As quoted in R4)

The okapi, a "truly primitive giraffid" and considered by some to be a living fossil.

The squirrel lineage. This large group of mammals has shown little change over the last 35 million years. R. Emry and R. Thorington have confirmed this:

> In the sense that they represent the least derived family of a very diverse order, squirrels in general might be called living fossils. The recently discovered skeleton of Protosciurus (perhaps the earliest squirrel fossil) shows that the earliest recognized sciurid is strikingly similar in its osteology to living Sciurus. In the sense that it has evolved very little from what is apparently the primitive squirrel morphotype, Sciurus is a living fossil. (As quoted in R7)

As almost always the case, the discussion here is restricted to skeletal morphology. No one knows what was happening to the nonfossilizable parts of the squirrels during the eons!

The tapir lineage.

The family Tapiridae contains only

four living species. During the past 15 My, only two genera are known to have existed. Diversity was apparently also low in the Oligocene and Early Miocene, when there were a few additional genera but "generic distinctions are slight" (Romer, 1966, p. 220). Very little change in form is apparent since the Oligocene. (R5)

The above reference is to: Romer, A.S.; Vertebrate Paleontology, Chicago, 1966.

Other species and lineages. To conserve space, we now list a few other mammals widely considered to be living fossils.

- New World porcupines. (R5)
- Aardvarks (R5)
- Sewellels ("mountain beavers") (R5)
- Pangolins (R5)
- Platypuses (R2)
- Bovids (R7)
- Tarsiers (R7)
- Elephant shrews (R7)
- Tree shrews (R7)
- Malaysian rhinos (R3)

Tarsiers are diminutive (only 150 grams or so) Asian primates. They are classed among the living fossils, for they have changed little in millions of years.

X2. Complicating factors in the living-fossil phenomenon. The living-fossil phenomenon is neither sharply defined nor straightforward. These characteristics limit its usefulness in resolving evolutionary puzzles. We see five sorts of complications:

(1) The phenomenon is based almost exclusively upon skeletal morphology. Unfortunately, an animal's skeleton may remain static while unfossilizable parts (the central nervous system, for example) are changing. Living fossils, though seeming to prove stasis, may not be telling the whole story.

(2) Living fossils have probably never been completely static. Fossilizable changes usually have occurred, but they were small compared to those seen in the fossils of closely related species. (Why these different rates of change occurred in similar genomes is still another enigma of Darwinian evolution. It suggests that similar molecular clocks may not run at the same speed, as indeed seems to be the case with the molecular clocks of humans and chimpanzees. See BHG18 in Humans III.) Rephrasing, living fossils do not belie gradualistic evolution in the final analysis. Absolute stasis is very likely impossible. The basic parameter is the rate of change.

(3) Many living fossils appear to be the surviving twigs of long lineages that have been severely pruned back over the eons. Yet, these survivors possess no obvious advantages over their extinct close relatives. It is of course possible that the characteristics that led to the demise of these close relatives were unfossilizable!

(4) Living fossils may remain relatively static morphologically but still produce strikingly different offshoots, which qualify as distinct species. S.M. Stanley has noticed that the two-horned Malaysian rhino, though itself remaining almost unchanged for 35 million years, was apparently the species from which sprang other distinctive rhino species. (R3) This can hardly be called evolutionary stasis!

(5) Living fossils are few in number compared to the 4400 or so mammals with

"proper" rates of evolutionary change. Are the genomes of the living fossils more resistant to mutation or have environmental pressures been kinder to them?

X3. Overview. The reality of living fossils cannot be denied, nor can they be filed away among the "special cases" and swept under the rug. There may be only a few species of them, but some, like the New World opossums are very successful and are still extending their ranges.

One school of thought, numbering Darwin himself as a member, opines that living fossils endured only because they have led sheltered lives in narrow, benign "refugia." Unchallenged by environment or competitors, they had no impetus to evolve. Even so, one has to suppose that their genomes continued to change randomly but that the resulting new species were unsuited to the narrow niche. (Not a particularly convincing argument!)

G.G. Simpson took a very different view. Living fossils, he maintained, were actually broadly adaptable and could adjust readily to changing environments, new predators, new diseases, etc., without evolving at all! They were so adaptable they didn't need to!

Thus, the same facts have led to widely divergent interpretations. S.M. Stanley has had to admit that, in the end:

> Living fossils share no obvious adaptive feature that can explain why natural selection should have largely ignored them for millions of years while working enormous changes on other well-established forms of life. (R5)

Even though he asks "why" in the above quotation, Stanley asserts that living fossils fit into the model of punctuated evolution better than the gradualistic model, as mentioned in X0. In this view, the real enigma is not the hiatus separating the saltations but rather the short paroxysms of speciation---that is, the saltations themselves. This phenomenon is the subject of the next entry, BME3.

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BME3 Explosive Radiations in Mammalian Evolution

Description. The appearance in the mammalian fossil record of sudden, short-lived episodes of high rates of speciation. Termed "explosive radiations," these sharp increases in biodiversity are seen in the fossil records of many other taxonomic groups. The phenomenon is often preceded by biological extinctions and/or natural or human-produced environmental changes, whereby new biological opportunities are created.

Data Evaluation. Although paleontologists mostly agree that explosive radiations are real, the fossil record is certainly far from complete. Fossilization is often fortuitous and always dependent on organisms possessing fossilizable characteristics. Rates of speciation are, therefore, sometimes speculative. Rating: 2.

Anomaly Evaluation. Explosive radiations are contrary to the once widely accepted idea that evolution must proceed in small, measured steps; that is, gradualism prevails. The usual explanation of explosive radiation involves the removal of some of the fetters applied by natural selection. Environmental changes, decline of predators, opening of new niches, etc., all are thought to contribute to accelerated speciation. This sounds reasonable, but if mutation rates remain steady ---and why shouldn't they?---why should speciation sometimes rise dramatically? There is much here that we do not yet understand in terms of coupling external events to genome changes. Rating: 2.

Possible Explanations. Rapid speciation may always be latent but suppressed by natural selection, which acts to stabilize diversity levels. In other words, transitional forms that might lead to new taxonomic entities may always be generated at high rates, but these are pruned rigorously by natural selection---until externally applied forces change.

Similar and Related Phenomena. Apparent scarcity of transitional fossils (BME1); biological extinctions in the fossil record (BME4, ESB1 in Anomalies in Geology); paleontological signatures of biological explosions (ESB2 in Anomalies in Geology). In the Series-B Subject indexes, see also under: Punctuated equilibrium.

Entries

X0. Background. The fossil record from the beginning of the Cambrian, 570 million years ago, through recent time is characterized by repeated "explosions" and "extinctions" of biological diversity. These two types of episodic change in the fortunes of terrestrial life are treated from geological and paleontological perspectives in ESB2 and ESB1, respectively, in Anomalies in Geology. Our present objective is to understand how mammalian evolution fits into this ebb and flow that seems to be portrayed by the fossil record.

Mammals have been around for about 200 million years, but they hardly figured at all in the panorama of life on earth until about 65 million years ago. H. Curtis described this long latent period and subsequent flowering:

> For about 130 million years, these small mammals led furtive existences in a land dominated by reptiles. Then suddenly, as geologic time is measured, the giant reptiles, the dinosaurs, disappeared. The cause of the dinosaur extinction is one of the great biological mysteries. No species of land animals weighing more than 9 kilograms survived. The disappearance of the dinosaurs occurred at a time when, geologists believe, there was a drop in the average temperature and, perhaps more important, a marked increase in seasonal tempera-

ture fluctuations. In any case, by the end of the Cretaceous period all of the dinosaurs had disappeared forever, and about 65 million years ago an explosive radiation of the mammals began. (R2)

The 65-million-year figure given by Curtis marks a crucial episode in the history of our planet---the Cretaceous-Tertiary (KT) boundary event. According to scientific consensus in 1996, a giant asteroid or comet impacted the earth and, in effect, reshuffled the cards in evolution's deck. One of the first new cards dealt by this catastrophe was the "mammal card"!

X1. Mammals in general. A paragraph from G.R. Taylor's The Great Evolution Mystery takes up the story at the KT boundary, where H. Curtis left off:

> The mammals are as good an example as any of explosive radiation. Though they showed up some 200 million years ago---as we judge from scattered instances of forms long extinct, like Eozostrodon and the Symmetrodonta---they only began to ramify seriously about 75 million years ago, at the start of the Paleocene. (Even this assertion is only an inference as regards most lines, since the first fossil forms only appear at the end of the Paleocene.) Most mammals arose, it would seem, in the remarkably short space of 12 million years. Suddenly we find remains of carnivores, of cetaceans (whales, dolphins), of rodents, of marsupials, of toothless creatures like the anteaters, of horses, camels, elephants, rabbits, bats and many others. The great majority of these new mammalian forms are still extant. Only a few versions, such as the Creodonts and the Desmostyles, gave up the struggle to survive. (R3)

This radiation, the greatest in mammalian history, is thought by many to have been initiated by the availability of many new niches opened up by the precipitous decline of reptilian competitors---a sort of loosening of evolutionary shackles. The evolution paradigm asserts that random genome changes were sufficient to account for such rapid speciation. But were they?

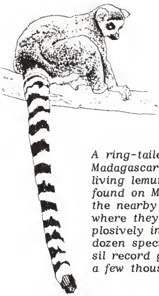
Taylor has painted this mammalian explosive radiation with a broad brush. Two fine points of this radiation also attract the attention of anomalists: (1) Generally speaking, mammals have evolved more rapidly than most of the other groups of life forms; and (2) The higher rates of evolution affect only certain characteristics of the mammals, while the remaining aspects evolve at "normal" rates. L. Van Valen applies the term "epistandard evolution" to those characteristics evolving faster than "normal." He differentiates between the two modes as follows:

> Molecular evolution and linear ("size") measurements retain the standard mode in the Mammalia, whereas origination, extinction, community evolution, structural innovation and complexity ("shape"), chromosome number, and hybrid inviability seem to change to the epistandard mode there. (R4)

So, we have three puzzles here: (1) Exactly how can external events be translated into very rapid, favorable genome changes? (2) Why do mammals evolve faster than most other life forms? (3) Why do some characteristics evolve more rapidly than others?

X2. Explosive radiation in isolated locales. While most mammalian lineages participated in the first and greatest radiation following the KT-boundary event, lesser radiations have followed, especially where a small "founder" populstion has become isolated. Remote islands have often seen radiations when small number of invaders, freed from mainland competition and bestowed with an abundance of new opportunities, have proliferated and speciated. Darwin's finches on the Galapagos and the Hawaiian fruit flies are notable examples. Among the mammals, Madagascar's lemurs epitomize explosive radiation in geographically isolated regions. (R5)

On occasion, morphological change is so rapid that we can almost see it occurring before our eyes. Newfoundland is a case in point. We quote S.M. Stanley here:



A ring-tailed lemur from Madagascar. Actually, most living lemurs are to be found on Madagascar and the nearby Comoro Islands, where they radiated explosively into about a dozen species. Their fossil record goes back only a few thousand years.

One of the most striking [cases] is the origin of new subspecies of mammals on the island of Newfoundland. These divergent populations have apparently been isolated for only about 12,000 years. Because a water barrier had to be crossed for their evolution from mainland ancestors, they were presumably founded by small numbers of individuals. It is quite possible that most of their divergent evolution was concentrated in an initial interval much briefer than 12,000 years, while populations were even smaller than they are today. Of 14 species represented, 10 have evolved into new subspecies. The Newfoundland beaver, Castor canadensis caecator, is almost so distinct as to warrant placement in a new species. (R1)

In Newfoundland and even with the Galapagos finches, we see only minor morphological changes. The Newfoundland beaver may look a bit different from its mainland progenitors, but it is not officially a new species. Perhaps we see here only a population shift in which the new environment brought to the fore characteristics already coded in the genome but formerly suppressed. In any event, this is microevolution at the most---nothing like the macroevolution that supposedly transformed hoofed land mammals into whales! (BME1-X4) Still, we see the potential for speciation in these small changes in the beaver which have taken place with surprising suddenness.

If a short period of isolation can change a beaver so much, perhaps an asteroid impact can effect macroevolution. But, in neither microevolution nor macroevolution do we know, in molecular detail, how environmental changes are translated so suddenly into the genome changes that ultimately define taxonomic positions. Are random mutation plus natural selection really up to these tasks? Evolutionists assume so.

References

R1. Stanley, Steven M.; Macroevolution: Pattern and Process, San Francisco, 1979. (X2)

R2. Curtis, Helena; Biology, New York, 1979. (X0)

R3. Taylor, Gaylord Rattray; The Great Evolution Mystery, New York, 1983. (X1)

R4. Van Valen, Leigh; "Why and How Do Mammals Evolve Unusually Rapidly?" Evolutionary Theory, 7:45, 1985. (X1)

R5. Burney, David A., and Ross, D.E. MacPhee; "Mysterious Island," Natural History, 97:47, July 1988. (X2)

BME4 Unexplained Extinctions of Large Mammals

Description. The existence of fossils suggesting the sudden extinction of many species of large, terrestrial mammals in certain geographical regions. Other megafauna---birds, reptiles, etc.---may or may not have been involved. Three factors make the subject phenomenon particularly interesting: (1) selectivity as to mammal size; (2) selectivity as to geography; and (3) the exclusion of marine mammals.

Data Evaluation. The fossil record provides many examples of biological extinctions from the Precambrian up until and including historical times. The two very recent mammalian extinctions cataloged here are not disputed by most paleontologists who have examined the fossil evidence. However, the data are not yet sufficient to choose between at least three possible mechanisms of extinction: climatic change, human overkill, and pandemics---or some combination of them. Rating: 3.

Anomaly Evaluation. None of the three mechanisms just listed is intrinsically anomalous. The problem, as just stated, is that no combination of them can yet explain all aspects of the phenomenon. Hypothesizing that all may be involved is a cop out. When science cannot yet decide between several competing, reasonable hypotheses, there is little that is anomalous, because no important paradigms are threatened. Rating: 3.

Possible Explanations. Climatic change, human overkill, disease, or some combination thereof. Of course, climatic changes may themselves be anomalous, but such is treated in other catalog volumes. (Series-G and -E)

Similar and Related Phenomena. Paleontological signatures of extinction (ESB1 in Anomalies in Geology); (BME5); possible late survival of mammalian megafauna (BMD10, BMD11); Pleistocene dwarfing of large land mammals (BME11); anomalously early contacts of humans with the New World (Series-M catalogs).

Entries

X0. Introduction. When the dinosaurs perished some 65 million years ago---perhaps done in by the impact of an asteroid or comet---most of the small mammals then extant somehow survived. These survivors provided the foundation for the spectacular radiation of mammals that ensued. (BME3) Today, mammals are abundant on the planet, with about 4400 species making a living on all continents and in all oceans. But, in some parts of the planet, today's mammals are markedly smaller than they were a scant 12,000 years ago. Gone are the giant sloths, the mammoths, and giant lemurs. So recently did these large mammals live that their bones are scarcely fossilized, but instead lie in heaps in caverns and poke out en masse from Arctic river banks and other shallow deposits. What happened? Was it a fickle climate, disease, or were humans responsible for these end-Pleistocene extinctions? Or some combination of these factors?

X1. The late Pleistocene extinction. Early biologists looking at the meager fossil record then available were struck by the accumulations of bones of large mammals that no longer walked the earth. In 1876, A.R. Wallace felt impelled to write:

> We live in a zoologically impoverished world, from which all the hugest and fiercest and strangest forms have all disappeared...It is surely a marve-

lous fact and one that has hardly been sufficiently dwelt upon, this dying out of so many large Mammalia, not in one place only, but over half the land surface of the globe. (as quoted in R2)

Wallace was concerned about what we term the end-Pleistocene extinction. This dying-out was remarkable in three respects. First, it was very selective as to size. With very few exceptions, only terrestrial mammals weighing over 40 kilograms (88 pounds) were wiped out. Smaller terrestrial mammals and those mammals living in the oceans escaped almost completely. Second, the extinction event was very short---just a couple thousand years, and probably took place 10,000 to 12,000 years ago. Third, some areas of the globe were somehow protected from the executioner, as shown in this table. (R2)

Continent	Genera lost	Percent
North America	33	73
South America	46	80
Australia	15	94
Europe	7	30
Africa	2	5
Asia	?	?

What shielded Africa and, to a lesser extent, Europe?

Next, a quick look at the casualty list, as compiled by L. Krishtalka.

North America.

> The extinctions and extirpations struck two entire orders, the Proboscidea (mammoths, mastodons, gomphotheres) and Perissodactyla (horses, tapirs), the families of camels, ground sloths, glyptodonts and peccaries,

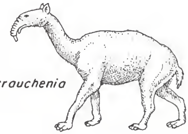
Nothrotheriops shastensis

The Shasta ground sloth was one of the very large North American mammals that did not survive the Pleistocene extinction.

> and genera of cheetah, sabertooth cat, bears, giant rodents, deer, musk oxen and moose. (R1)

South America.

> ...the 46 genera that became extinct were all large mammals: edentates, rodents, carnivores, endemic ungulates (litopterns, notoungulates), horses, mastodonts, peccaries, camels, and deer. (R1)

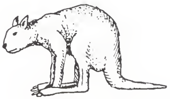


Macrauchenia

In South America, a wide range of mammals, including this litoptern, succumbed during the Pleistocene.

Australia.

> The megafaunal tombstone reads two echidnas, two marsupial carnivores, three wombats, seven diprotodonts (large marsupial herbivores), 33 macropodids (kangaroos, wallabies and their relatives...(R1)



Procoptodon goliah

Australian marsupials were also devastated during the Pleistocene. One casualty was the giant, short-faced kangaroo.

In Europe and Africa the carnage was much less severe. Asia, too, seems to have escaped, but accurate lists are not available for that continent.

The search for causes. The finger of blame has been pointed at three agents: climate, diseases, and humans. Most investigators have exonerated disease as a factor. Diseases, they suppose, would not have been so selective in the matter of size.

Rather, climate, which underwent rapid and profound changes during the Pleistocene, is more likely a cause. Paleoclimatologists can point to widespread modifications in forest and grassland distribution in the Americas. Desertification struck hard in the North American southwest, and in Australia, as well. Such changes must have played havoc with coevolved, finely attuned herbivorous megafauna and the predators that depended upon them. (R1, R2)

A time-correlation of climate change and extinction does not constitute proof. Why didn't the mammoths, wooly rhinos, and other large plant-eaters just move to more favorable locales? (Or did climate change too rapidly, as suggested by those quick-frozen mammoths of Alaska and Siberia?) Why weren't the large mammals of northern Eurasia affected as severely as those of North America? How come plants, reptiles, amphibians, and insects came through almost entirely unscathed? Perhaps most telling is the fact that the earlier Pleistocene had seen similar climatic changes without attracting the scythe of extinction. (R1, R2)

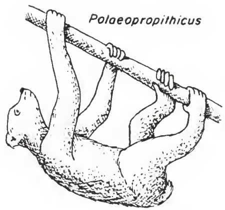
Also coincident with the demise of the North American megafauna was the appearance of appreciable numbers of humans on the continent about 12,000 years ago. (Considerable evidence has accrued suggesting a much earlier arrival! See the Series-M catalogs.) Here, we have the "prehistoric overkill" hypothesis championed by P. Martin. Martin sees these huge animals, still without any fear of man, being slaughtered wholesale. Humans, in his view, next moved south all the way to Patagonia, killing as they went. Something similar might have happened in Australia, but this continent was peopled about 40,000 years ago, meaning that humans and the giant marsupials coexisted relatively peacefully for almost 30,000 years. (R1, R2)

Skeptics ask: Where are all the kill sites yielding human implements and the bones showing butchering marks? How could such small numbers of humans bearing crude weapons decimate the immense herds of large, fierce animals? Martin replies with a "blitzkrieg" version of his hypothesis. It all happened so suddenly that the human hunters left few signs of what they did. (R1, R2)

It all boils down to an admission by all scientists considering this enigma that both climate and humans, perhaps even disease, too, were involved; both in the New World and Australia. But, perhaps we are missing something here. Mammalogists have observed that North America has seen no large mammals pushed into extinction since the end of the Pleistocene. (R3) It was a close call with the bison, though!

X2. The Madagascar extinction. The island of Madagascar still boasts a spectacular array of "primitive" primates, to say nothing of more than 10,000 species of plants and colossal earthworms. Two thousand years ago, the primates of Madagascar resembled the megafauna of North America in the sense that many were large compared to the primates occupying the island today. They also exhibited strange parallelisms to mammals found elsewhere. (This phenomenon is interesting but unrelated to the extinction question!) The giant lemur, Palaeopropithecus, hung sloth-like from branches, while another lemur, Megaladapis, also very large, emulated the Australian koala. (BMA1-X11 in Mammals I) Not only were many of these lemurs large, but they had invaded many niches, and had evolved into about 49 species. The time was then 1,000 BC and, then, the scythe of extinction descended. Today, only 32 species survive, all weighing less than 10 kilograms (22 pounds)! Other megafauna succumbed, too. The 500-kilogram elephant bird perished; so did a giant tortoise.

As for explanations, it was deja vu. Suspicion again fell upon the same vicissitudes of climate, on diseases, and on humans, especially, who just happened to have invaded Madagascar about 2,000 years ago. But, as before, there is little evidence besides coincidence that humans played a major role. Archeologists can find few signs that humans hunted the giant lemurs to extinction. In fact, one of the giant mammals, Megaladapis, managed to hang on until just 600 years ago in the face of a burgeoning human population. In sum, there is not yet enough evidence to indict any single factor. All three may have worked in concert. (R3)



During the Madagascar extinction, many large primates were eliminated, such as this giant lemur.

References

R1. Krishtalka, Leonard; "The Pleistocene Ways of Death," Nature, 312: 225, 1984. (X1)
R2. Stuart, Anthony; "Who (or What) Killed the Giant Armadillo?" New Scientist, p. 29, July 17, 1986. (X1)
R3. Culotta, Elizabeth; "Many Suspects to Blame in Madagascar Extinctions," Science, 268:1568, 1995. (X1, X2)

BME5 The Failure of Evolution to Improve Mammal Survivability

Description. The inability of evolutionary processes to increase the survivability of many mammalian taxonomic groups over the last 200 million years, as one would expect if mutations and natural selection enhance the fitness of life forms.

Data Evaluation. Some paleontological studies support the claimed phenomenon, but a few do not. Therefore, there is some doubt that the phenomenon is real. Added to this uncertainty is the acknowledged imperfection of the fossil record.
Since this catalog entry is based only on a single overview article (in a respected scientific magazine), it is very possible that coverage of this phenomenon is incomplete. Rating: 3.

Anomaly Evaluation. First of all, the idea that evolution is not progressive and does not necessarily lead to "improved" life forms---such as humans!---is counter to popular expectations. This view, however, is not shared by most scientists, who recognize that "progression," as defined by most people, has no meaning in evolutionary thinking. "Survival" is what really counts. But even when the subject phenomenon is stripped of popular preconceptions, evolutionists are taxed to explain why today's mammals are no better equipped for survival than the earliest members of the Class Mammalia. Nevertheless, several reasonable explanations of the phenomenon have been put forward below. When a phenomenon seems tractable in terms of current biological theory, as this one seems to be, a low anomaly rating is in order. Rating: 3.

Possible Explanations. Two basic types of explanation have been proposed: "biotic" (competition, disease, etc.) and "physical" (asteroid impacts, etc.), as discussed more thoroughly in X2. Combinations of these two "forces" are also possible. On a more speculative plane, mammalian lineages may be subject to ultimate natural limits on survivability, in the same way that humans are denied immortality.

Similar and Related Phenomenon. Limited longevities in humans and mammals (BHH11 in Humans II). The persistence of certain mammalian morphologies; that is, "living fossils" (BME2); radiations and extinctions of mammals (BME3 and BME4, respectively.

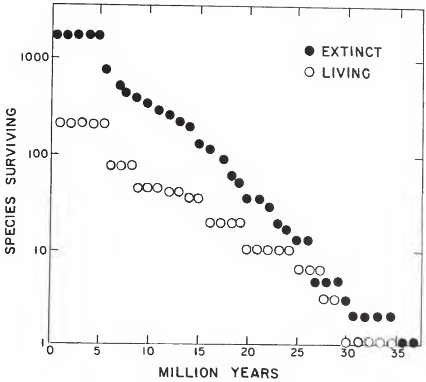
Entries

X0. Introduction. If one takes a large view of life and its ebb and flow through the last 600 million years, one's intuitive expectation is that life forms will become increasingly better adapted to their physical environment, competition, diseases, and other forces. In this view, groups of organisms should gradually increase their survivability. Today's mammals, for example, should cope better and survive longer than the mammals of 200 million years ago. In the limit, a "perfected" lineage would be immortal; that is, it would survive indefinitely. Nature apparently does not work this way, despite the existence of a few "living fossils"! It's like the Second Law of Thermodynamics, a specific lineage cannot win in the long run; extinction is inevitable, as the dinosaurs found out.

X1. The survivability data. Counter-intuitive though it may be, the probability of extinction of any group of organisms seems to have remained fairly constant throughout geological time. In 1973, L. Van Valen published a paper entitled: "A New Evolutionary Law," in which he showed---contrary to his expectation---that the survivability of any taxonomic group does not improve with time. This can be seen in the graph, where present-day mammals---taken as groups---are just as likely to become extinct as their now-extinct relatives of some 200 million years ago. This graph describes the Law of Constant Extinction. In effect, the Law denies any evolutionary improvements to survivability over the long haul.

The survivability trends for other organisms tell the same story. Data on microfossils, such as coccoliths, obtained from deep-sea cores, lead to similar graphs. On the other hand, research on gastropods and bivalves by D. DeAngelis of the University of Michigan seems to contradict the Law of Constant Extinction. More studies of the fossil record may resolve such contradictions.

X2. Differing theories. As already mentioned, the anomaly in the Law of Constant Extinction really lies in our expectation that evolution is a progressive sort of process. Our outlook has been fostered by a paradigm that is popularly portrayed as gradually advancing life from "lower" to "higher" forms as the eons wheeled by. What really counts is what survives, not a big brain nor opposable thumbs nor any other property humans happen to favor. Even so, one does anticipate that evolution will increase adaptation to the general environment and, therefore, the longevity of the species. This does not seem to



Species of modern mammals are just as likely to become extinct as their ancestors that lived millions of years ago. (R1)

happen.

Two deeper, more analytical, models of how evolution might be linked to survivability have been advanced.

Van Valen has framed his Red Queen hypothesis to explain the Law of Constant Extinction. In Through the Looking Glass, the Red Queen complained to Alice that "...here, you see, it takes all the running you can do, to keep in the same place." Translated into evolutionary terms, the Red Queen hypothesis means that no matter how much a group struggles to elude predators, catch prey, or combat disease, competing groups or lineages will match its efforts, and vice versa. Eventually, an equilibrium is reached, where no group can progress. No one can win the game of life!

Competing with the Red Queen hypothesis is the Stationary model, formulated by N. Stenseth. Stenseth holds that evolution is driven mainly by physical forces rather than the biological factors advanced by Van Valen. "Physical" here means natural disasters, climate shifts, etc. When evolution is driven by such environmental forces, the survivability graph sould be step-like rather than a smooth curve.

In reality, evolution may be driven by both biological and ecological forces. This would add bumps to the smooth survivability graph drawn by Van Valen. At the present time, the data do not allow a clear choice of one hypothesis over the other, or over any combination of them.

Reference

R1. Benton, Michael; "At the Court of the Red Queen," New Scientist, p. 52, November 28, 1985. (X1, X2)

BME6 Anomalously Early Fossils

Description. The existence of fossils in strata dated much earlier than current paradigms allow for the species in question. The earliest accepted dates are, of course, often a function of geography. We catalog here only fossils that push back the beginning of a species by more than 10 million years.

Data Evaluation. The fossils in both of the following entries are teeth---very small teeth and not very many of them. Although teeth are usually good indicators of the fossil's taxonomic classification, there is frequently room for misinterpretation. We will have to see how the current identifications hold up under further scrutiny. Rating: 2.

Anomaly Evaluation. Paleontologists frequently report anomalously early fossils. Such discoveries are less common for Class Mammalia, though, and especially so when a species' history is extended backwards by more than 10 million years. Still, no biological laws are at risk in most cases. In X2, below, however, a rather profound reassessment of Australian biological history seems to be required. This increases the anomaly level a bit. Rating: 2.

Possible Explanations. Referring to X2, marsupials are not inferior to placentals.

Similar and Related Phenomena. Possible lacks of transitional fossils (BME1); the unexpected competitiveness of marsupials with placentals (BMB1 in Mammals I).

Entries

X1. Anthropoids. In the January 22, 1992, issue of Nature, L. Krishtalka allotted a paragraph to the recent discovery of four small teeth in Algerian strata. These have "recalibrated" anthropoid phylogeny.

> The recovery of four anthropoid teeth from the early or middle Eocene of Algeria (M. Godinot and M. Mahboubi, Universite des Sciences, Montpellier) pushes back the evolutionary divergence of higher primates by about 15 million years. Before the find, the oldest known anthropoids were from 36-million-year-old sediments in the Egyptian Fayum and elsewhere in North Africa. (R1)

Actually, two species were indicated, both very small: a tarsier-size anthropoid and another half this size.

X2. Placental mammals in Australia. In 1991, it was announced that the fossils of two placental mammals were unearthed in Australia, the continent whose marsupial cargo was supposedly isolated from competition with placental mammals for tens of millions of years. The fossils were in a 55-million-year-old clay deposit in the backyard of a house in Murgon, Queensland. Previous to this, the oldest known Australian fossils of placental mammals were dated at 5-to-6 million years. By this time in earth history, Australia had drifted far enough northward toward Indonesia that land mammals could conceivably have floated to Australia on rafts of vegetation. The Murgon discoveries, however, set back the presence of placental mammals in Australia by 50 million years!

One of the species found was a bat, which of course could have flown to Australia from Southeast Asia. But, it is worth mentioning because it, along with a bat of similar age from France, is the earliest bat known. Apparently, bats were well distributed geographically

55 million years ago. (See BME1-X6 for the the possible lack of transitional fossils in the bat order.)

The second fossil find in the Murgon backyard was that of a tiny tooth (only 1.4 x 2.2 millimeters) closely resembling the teeth of a condylarth. The condylarths were rat-like herbivores known to have lived in Europe and North America 45-70 million years ago. Unlike the bat, the condylarths were flightless, and paleontologists wonder how they could have reached Australia half a world away. Perhaps from South America, before the breakup of Gondwanaland 40 million years ago, suggests L. Krishtalka. South America was teeming with primitive placental herbivores at this time. (R1)

Whatever route they took, the purported condylarths imply that placental mammals had indeed reached Australia before its separation from Gondwanaland and land-contact with reservoirs of placental mammals. Contrary to long-held belief, marsupials and placentals apparently coexisted and competed in Australia 55 million years ago. This raises the question of why the supposedly superior placental mammals did not displace the marsupials rather than vice versa.

> "It has been assumed that marsupials couldn't hack it in the northern hemisphere and that the only animals you get here [Australia] are rejects from the north," says Michael Archer, a palaeontologist working at the University of New South Wales. "But we believe that marsupials and placental mammals started the race together in Australia at least 55 million years ago, and the marsupials won." (R3)

References

R1. Krishtalka, Leonard; "In the Grube in the Eocene," Nature, 355:296, 1992. (X1, X2)

R2. Monastersky, R.; "Tiny Tooth Upends Australian History," Science News, 141:228, 1992. (X2)

R3. Anderson, Ian; "'Long in the Tooth' Mammal Upsets Marsupial History," New Scientist, p. 17, April 18, 1992. (X2)

BME7 Track - Like Markings in Ancient Strata

Description. The appearance in ancient geological strata of markings superficially resembling the footprints made by more recent mammals. Such markings are considered anomalous enough to catalog if they are found in strata 10 million years or more older than the earliest known fossils of the species or lineage involved. Supposed horse hoof-prints are the most common examples of this phenomenon.

Data Evaluation. Several impressive "trackways" have been found in the United States and Great Britain, countries that have been well-explored by geologists. In all likelihood there are more elsewhere. Although geologists and paleontologists may be puzzled by such track-like markings, none ventures to claim that they prove that some mammals existed 10+ million years before their conventionally scheduled times. Alternative explanations are always profferred and quickly adopted, even though some of the tracks are remarkably convincing. But, the alternative, mainstream explanations are quite reasonable. In this light, we are forced to assign a low anomaly rating. Rating: 3.

Anomaly Evaluation. Convincing mammalian tracks of anomalously early ages would be damaging to accepted geological and biological time-based scenarios. Such merits a high rating here. However, even within the compiler's lifetime, these time scales have been drastically revised; and they will certainly be revised again in the future. It is really today's passionate certainty that present temporal frameworks are correct that make this phenomenon so anomalous. Rating: 1.

Possible Explanations. The controversial markings could be the products of: (1) abiotic phenomena (ESX6 in Neglected Geological Anomalies); (2) chemical and geological distortion of footprints made by animals legitimately belonging to the time period assigned to the strata; and (3) fraud.

Similar and Related Phenomena. Curious markings on rocks (ESX6 in Neglected Geological Anomalies); other anomalously early mammalian fossils (BME6).

Entries

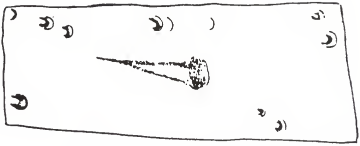
X0. Background. Fossilized animal tracks (called "ichnites") are not uncommon in old sedimentary rocks, especially the sandstones. Dinosaur tracks are to be seen in many exposed strata of the proper age. Even scientifically approved human tracks are found in Africa---the famous "Laetoli tracks." The creationist literature has paid much attention to sandstone strata along the Paluxy River, Texas, where putative human footprints seem to mingle with dinosaur tracks. The Paluxy tracks have been dismissed by science as modified dinosaur tracks, and we have not cataloged them either here or in Humans III. However, some other possible mammal tracks are curious enough to catalog in this volume.

The history of the Class Mammalia, according to present reckoning, extends back about 200 million years. (See BME1-X1.) It is, therefore, scientifically acceptable to find bona fide mammal tracks in sedimentary rocks more recent than that. Older mammal tracks would be considered anomalous. In their diligent search for anomalies that would contradict conventional geological dating and the evolutionary unfolding of life, scientific creationists have focussed on several groups of track-like markings found in strata much older than 200 million years. We present these below, giving in addition those scientific sources we have not examined but which were cited in the creationist literature.

X1. Horse-like tracks. Grand Canyon. Track-like markings, resembling those made by horses, appear in the Permian Esplanade sandstone of the Supai Group, in the Grand Canyon. In fact, the Supai Indians had once attributed these markings to those made by a herd of horses. But the Permian period dates back 245-286 million years, well before any mammals are supposed to have evolved. Actually, horses go back only 50 million years or so. (BME1-X3) If the Grand Canyon markings were truly made by horses, geologists and evolutionists would be just as amazed if human footprints were really found mixed with dinosaur tracks!

C.W. Gilmore, of the U.S. National Museum, looked into the Grand Canyon markings, calling them "pseudo-track-like markings." His reasoning went as follows:

> None of these markings occurred in regular sequence and none was found giving evidence of having been impressed into the surface of the sand. After a careful examination it was my conclusion that they do not present a series of fossil tracks, but were nothing more than a staining of the sandstone, the deeper coloration making them stand out clearly against the lighter colored background of the sandstone. A few through weathering showed surface depression but a section obtained in one place clearly indicated that this deep coloration



While almost certainly abiological in origin, these impressions in Permian sandstone in the Grand Canyon do resemble the hoofprints of horses.

extended downward into the sandstone for at least four inches. (R1)

Gilmore opined that the stains might have come from the decay of jellyfish stranded on a sandy beach. More on these particular markings can be found in ESX6-X8 in Neglected Geological Anomalies, where they are treated along with other curious, probably abiological, rock markings.

G.R. Morton, a creationist, mentioned the Grand Canyon markings in his 1984 survey of anomalous tracks. (R2) He was also able to add another reference beyond that of Gilmore: McKee, Edwin D.; "Distribution and Age of Fauna and Flora. The Supai Group of Grand Canyon," U.S. Geological Survey Professional Paper 1173, p. 75, 1982.

X2. Mammal-like tracks. Connecticut.

Horse-like ichnites. From Triassic sandstone in Connecticut, E. Hitchcock described still more time-anomalous hoof prints. So horse-like were they that he named the supposed animal Hoplichnus equus. (R1) Since the Triassic spanned the period from 208 to 245 million years, any verifiable evidence of horses would be highly anomalous. (In R2, Morton provides the complete reference for the original Hitchcock report: Hitchcock, Edward; Ichnology of New England: A Report on the Sandstone of the Connecticut Valley, Especially its Footmarks, Boston, 1858)

Mammal-like ichnites. E. Hitchcock also mentioned paw-like markings from a Triassic red sandstone near Portland, Connecticut. R.C. Calais summarized these as follows:

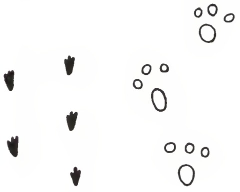
> More mammal-like ichnites were exposed in arkosic sandstone among the footprints of early dinosaurian forms in the far-famed Connecticut Valley. Hitchcock published descriptions of several prints, which he believed were marsupial tracks, from the Upper Portland series (Triassic) around Turners Falls, MA, and Portland, CT. The size, general morphology and the presence of dermal granulations in the forward depressions all suggest a mammalian origin. (R3)

Curious impressions in Triassic sandstone near Portland, Connecticut. The four "digits" (right) seem to display dermal granulations. Ball of the "foot" is at the left. Could this be a mammal or marsupial track?

X3. Hoof-like markings. Scotland. More curious hoof marks were described in a 1853 report by W. Jardine. C.W. Gilmore briefly summarized Jardine's account:

> Sir William Jardine described some hoof-like tracks from the New Red Sandstone of Scotland under the name Chelichnus gigas. While these have the same hoof-like shape without the appearance of toes or claws, they do show a distinct pace and uniform alternate progression. (R1)

The complete reference to the Jardine report was given by Morton (R2): Jardine, William; The Ichnology of Annadale, or Illustrations of Footmarks Impressed on the New Red Sandstone of Corncockle Muir, Edinburgh, 1853.



Two "trackways" found in Carboniferous sandstone, Northumberland.

X4. Two mammal-like trackways. Northumberland. In 1873, T. Barkas recorded two series of mammal-like tracks found in Carboniferous sandstone in Northumberland, England. Both sets of markings were impressed into ripple-marked sandstone, which also bore traces of worms and crustaceans. From the figure, it is apparent that the supposed animals were different species though headed in the same direction. The tracks on the right defintely impress one as having been made by a small mammal. But the Carboniferous period is even older than the Permian and Triassic periods---about 300 million years in the past. Mammal tracks this old would overturn the usual evolutionary sequencing. (R3)

R.C. Calais, also a creationist, located Barkas' original report as well as a more recent notice of the Northumberland "tracks" in a scientific journal: Barkas, Thomas; Illustrated Guide to Fish, Amphibian, Reptilian and Supposed Mammalian Remains of the Northumberland Carboniferous Strata, 1873. Sarjeant, William A.S.; "A History and Bibliography of the Study of Fossil Vertebrate Footprints in the British Isles," Palaeogeography, Palaeoclimatology, Palaeoecology, 16:328, 1974.

References

R1. Gilmore, Charles W.; "Fossil Footprints from the Grand Canyon," Smithsonian Miscellaneous Collections, vol. 77, no. 9, 1926. (X1-X3)

R2. Morton, Glenn R.; "Horses in the Permian," Creation Research Society Quarterly, 20:235, 1984. (X1-X3)

R3. Calais, Ron C.; "Another Crypto-Ichnological Excursion," Creation Research Society Quarterly, 23:176, 1987. (X2, X4)

BME8 Mammals with Histories Known Only from Subfossils

Description. The existence of living mammals whose evolutionary history is known only from subfossils; that is, from skeletal and tissue remains found on or very near the surface that have not been mineralized or decayed. Very recent age is implied.

Data Evaluation. This phenomenon is based upon the apparent nonexistence of certain fossils. Such "negative" data are always weak, since a single discovery can negate any claims based on nonexistence. Rating: 3.

Anomaly Evaluation. The absence of a fossil record beyond a few-thousand-years' worth of subfossils, suggests that very recent speciation has occurred, perhaps within historical times. Speciation in the Class Mammalia has never been directly observed by science, although remarkable variations and subspeciation are common. (BMA2 in Mammals 1) The recent, apparently sudden, appearance of well-known species, such as the polar bear, is surprising and noteworthy, but hardly anomalous. After all, the powerful evolution paradigm predicts that change will occur if permitted by natural selection. The subject phenomenon, therefore, is merely "interesting." Rating: 4.

Possible Explanations. None required.

Similar and Related Phenomena. The scarcity of transitional fossils (BME1); limits on the variation of mammals (BMA2 in Mammals 1); distribution anomalies in the fossil record (BME9).

Entries

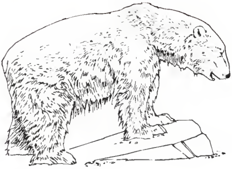
X1. Lemurs. The 12 known species in the Family Lemuridae are confined to Madagascar. Their fossil record is similarly restricted geographically. Timewise, it is also very limited, for the appearance of lemurs seems to have been very recent. From Walker's Mammals of the World we have:

> Although the geological range of the lemurs is said to extend back into the Pleistocene, the oldest known remains are actually subfossils dating from about 2,850 B.P. The subfossil material evidently represents several of the species that are still extant, as well as two extinct species of Varecia. (R3)

X2. Polar bears. The white (with a tinge of yellow) polar bear is well-known to zoo-goers and all too familiar to Arctic explorers, who are regarded as legitimate food items. The polar bear's marine proclivities and taste for seals and any other animals it can catch set it aside from the brown bear (Ursus arctos). Despite its widely different habits and specialized teeth, the polar bear (Ursus maritimus) is genetically very close to the brown bear. The two hybridize and produce fertile offspring. Still, the polar bear maintains a discrete gene pool and is geographically isolated from the brown bear. It deserves its separate species rating. (R1)

More interesting is the probability that the polar bear and brown bear diverged very recently. S.M. Stanley writes:

> It is not to be taken lightly that, despite living in an aquatic habitat where preservation of bones is favored, the polar bear has almost no



Is the polar bear a product of "quantum evolution"?

fossil record. Possible remains are few and are known only from sediments dated at forty thousand years or less. To explain the appearance of the polar bear and most other new genera of the Pleistocene, we seem to have no choice but to invoke the rapid divergence of populations too small to leave legible fossil records. Some genera may have formed by two or more rapid speciation events of this kind. A single step of rapid branching is, however, probable for some, such as the polar bear, which clearly formed from the brown bear (the species Ursus arctos, which contains several varieties, including the European brown bear, the grizzly, and the Kodiak). (R2)

Stanley states the the polar bear is an example of "quantum evolution." (R1)

Note that R.R. Reeves et al date the oldest polar bear fossils at 100,000 years. No reference given. (R4) See also another polar-bear conumdrum in BME9-X4.

References

R1. Stanley, Steven M.; Macroevolution, San Francisco, 1979. (X2)

R2. Stanley, Steven M.; The New Evolutionary Timetable, New York, 1981. (X2)

R3. Nowak, Ronald M.; Walker's Mammals of the World, Baltimore, 1991. (X1)

R4. Reeves, Randall R., et al; Seals and Sirenians, San Francisco, 1992. (X2)

BME9 Anomalous Distribution of Mammalian Skeletal Material

Description. The discovery of mammalian fossils in locations that belie the territories and diffusion routes ordained by prevailing biogeographical paradigms. Put more simply, some mammalian fossils are found where historical geology says they should not exist.

Anomaly Evauation. The fossil evidence supporting this type of phenomenon is generally very limited in quantity---often just a single fossil. Worsening the situation, some of the data cited below are considered "questionable" by some scientists. Rating: 3.

Anomaly Evaluation. New paleontological discoveries frequently force the alteration of once-accepted territories and diffusion routes. By way of comparison, today's naturalists are forever expanding the known territories of living mammals, even after centuries of exploration. It is hardly surprising that similar adjustments are necessary as the developing fossil record sketches out the distributions of mammals that lived millions of years ago. In this light, the discovery of fossils in unexpected places is only minimally anomalous. Rating: 3.

Possible Explanations. The fossil record is still incomplete.

Similar and Related Phenomena. Anomalous distribution of hominid skeletal material (BHE12); recency of polar bear evolution (BME8).

Entries

X1. Primate Migration. Scientists have long assumed that the primates originated in Africa, then spread to Europe, and then "jumped over" to North America. This hypothesis may be overturned by the discovery of fossils of early primates in Wyoming. The revised migration route would be Africa-Asia-North America, the reverse of the prevailing theory. The referenced article also remarks that: "Remains of early 'true' primates have not been uncovered in Africa." The reason given is that the deposits that should contain them have all been eroded away. (R1)

One wonders especially about the "missing" African strata and fossils. Perhaps they never existed. Here is an instance where theory requires certain data, as with evolution's transitional fossils. (BME1) Sometimes "missing" data are really missing.

X2. Pinniped migration. The fossil record of the pinnipeds (sea lions, seals, walruses) is complex and confusing. Fossils demonstrate that the first pinnipeds originated in the Pacific about 22 million years ago. These primitive pinnipeds evolved into the first sea lions and walruses---the true seals came much later. It was not until roughly 14 million years ago that any kind of pinniped appeared in the Atlantic. And it is in the Atlantic that the true seals are believed to have evolved. Superficially, nothing seems amiss in this little history, but timing and geography raise two questions. P. Shipman explains:

> The problem is that there was no Isthmus of Panama then separating the two oceans, so the animals should have moved from one ocean to the other easily. Yet walruses don't show up in the Atlantic for another 7 million years, nor seals in the Pacific until 4 million years after that. Trying to figure out what happened will keep pinniped detectives busy for a while. (R2)

X3. Xenarthran migration. The xenarthrans (sloths, armadillos, anteaters) are presently strictly New World denizens. Their fossil record extends back into the Paleocene some 65 million years. The enigma that appears here is that some "questionable" xenarthran fossils have turned up in Europe. Since continental drift had inserted an ocean between the New World and Europe over 100 million years before the first xenarthrans appeared in the Americas, how did they ever get to Europe? (R3)

No wonder the European fossils are "questionable"! The width of the Atlantic makes the usual raft-of-vegetation explanation a bit forced.

X4. Polar bears. Given the unquestioning fealty accorded the Ice Ages, it is not especially odd that information reported below, as extracted from an Associated Press dispatch, has not received more attention.

In 1991, construction workers at Tysfjord, Norway, 125 miles north of the Arctic Circle, accidentally dug up polar-bear bones that were later radiometrically dated as at least 42,000 years old, probably 60,000. R. Lie, a zoologist at the University of Bergen, and other scientists subsequently found the bones of two more polar bears in the area. These were dated as about 20,000 years old. An associated wolf's jaw was pegged at 32,000 years.

The problem is that Norway and many other northern circumpolar lands are believed to have been buried under a thick ice cap during the Ice Ages. In particular, northern Norway is thought to have been solidly encased in ice from 80,000 to 10,000 years ago. Polar bears could not have made a living there during this period. Clearly, something is wrong somewhere.

References

R1. Bower, B.; "Wyoming Fossils Shake Up Views of Early Primate Migration," Science News, 129:71, 1986. (X1)
R2. Shipman, Pat; "All in the Family," Discover, 10:44, July 1989. (X2)
R3. Nowak, Ronald M.; Walker's Mammals of the World, Baltimore, 1991. (X3)
R4. Anonymous; "Polar Bear Bones Cast Doubt on Ice Age Beliefs," Colorado Springs Gazette, August 23, 1993. Cr. COUD-I via S. Parker. COUD-I = Collectors of Unusual Data-International. (X4)
R5. Anonymous; "Bones in Norway Challenge Theories about Ice Age," Columbus Dispatch, August 22, 1993. Cr. S. Parker. (X4)

BME10 Parallelisms in the Mammalian Fossil Record

Description. Morphological parallelisms between the fossils of some mammals and the fossils and skeletal material of other distantly related mammals, living or extinct. Such parallelisms are usually ascribed to "convergent" or "parallel" evolution.

Data Evaluation. The fossil record for two of the three entries below (sabercats and horses) is considered very good. The third entry (marsupial "rhinos") is based only on a single partial skeleton. Rating: 2.

Anomaly Evaluation. The currently accepted neo-Darwinian paradigm holds that random mutations guided by natural selection operating in similar environments can, given sufficient time, account for all parallelisms. Given that random mutations are nearly infinitely variable, this claim of the evolutionists is impossible to refute in principle. In this sense, no anomaly exists in the convergence of characteristics, since random mutation can explain virtually anything! However, the compiler and others, even some scientists, have reservations about the evolutionary paradigm. Some of the parallelisms among distantly related animals, as recorded below, are so remarkable that random mutation plus natural selection seem inadequate. In other words, a suspicion exists that other, yet unrecognized factors may be involved. In these situations, which occur frequently in this Catalog, no anomaly rating is attempted. For elaboration of this stance, see the discussion in BMO1.

Possible Explanations. (1) Parallelism or convergence arises through separate, independent chains of random mutations modulated by natural selection. This is the prevailing paradigm. (2) So-called "morphic resonance," a radical concept proposed by R. Sheldrake, may accelerate such processes. (3) Parallelisms may be the consequence of traits inherited from a distant common ancestor. (4) "Directed" or "adaptive" evolution, a highly controversial process, may greatly accelerate the evolutionary accommodation of an animals to new environmental conditions. If the environmental parameters are similar, parallelisms in different species may arise. (5) Still unrecognized, nonsupernatural factors may be involved. To illustrate this possibility, recall that no one could explain the seemingly limitless energy of the sun until the discovery of nuclear energy. Could there be similar, still-unsuspected biological factors?

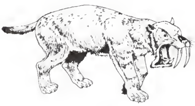
Similar and Related Phenomena. Morphological parallelisms observed between living mammals (BMA1 in Mammals I). Morphological parallelisms are abundant throughout the earth's fauna and flora (BBA, BRA, BFA, etc.). See the Subject Index under Parallelisms for examples in this volume, Mammals I, and other Series-B volumes.

Entries

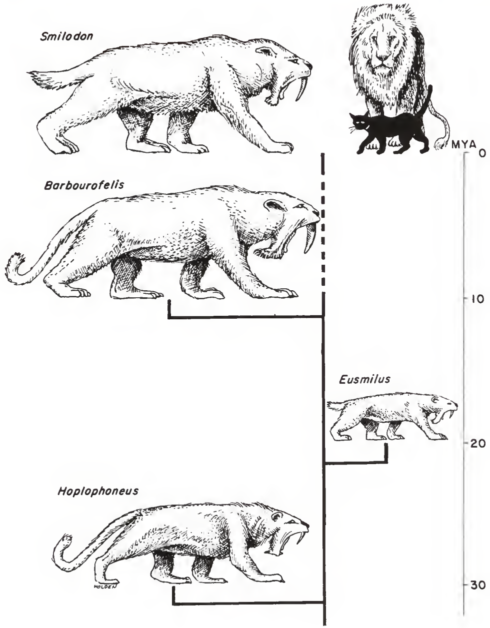
X1. Sabercats. Pictured in almost every popular book tracing the history of life on earth is the saber-tooth tiger, known to biologists as Smilodon. Paleontologists are fairly agreed that the saber-tooth tiger was a true cat and squarely on an evolutionary branch leading to our present-day lions, tigers, and house cats. What constitutes grist for the anomalist is the existence of at least three other saber-toothed, cat-like, placental mammals that evolved, prospered, and died out millions of years before the saber-tooth tigers terrorized the our ancestors. These other sabercats may not really have been in the cat lineage at all. As the diagram depicts, paleontologists dispute one of the branches on the evolutionary tree. Whatever the final consensus on that shaky branch, the fact remains that evolution's machinery ground out---separately and apparently independently---at least four placental mammals that looked very much alike. True, Eusmilus was only the size of a housecat while Barbourofilis pushed 500 pounds, but all four had those saber teeth, that immense gape, and all those associated skull structures and muscles needed to apply them effectively. (R5)

A fifth "sabercat"---not shown on the accompanying family tree---was a marsupial cat-like animal. Nevertheless, it looked very much like the placental sabercats. Did the marsupial "sabercat" mimic the placentals, or was it the other way around? Actually, no matter how much this fifth "sabercat" looks like the placental sabercats, it was a marsupial and radically different in several other anatomical features (pouch, brain structure, etc.).

The parallelisms are striking. How did these remarkable, narrowly specialized, killing machines evolve five or



In an even more impressive example of parallel evolution, the saber-tooth plan manifested itself in the marsupial lineage (Thylacosmilus).



Family tree of the placental sabercats, leading to the famous saber-tooth tiger and today's cats. (Scale in in millions of years.)

more times, each separated by millions of years? Very simple, say the paleontologists: parallel or convergent evolution, as elaborated upon by D.B. Adams:

> In parallel evolution, a line of organisms that has split from a common stock develops characteristics similar to another line from that same stock. Parallelism, like convergence, apparently arises because animals that pursue similar ways of life need similar structures to survive. The independent development of four different dirk-toothed sabercats is one of the more striking examples of parallel evolution. (R5)

Note: "convergent" evolution differs from "parallel" evolution in that the animals involved are not as closely related as in "parallel" evolution. It is assumed that all saber-cats are closely related, though perhaps not all directly on that branch leading our household kitty! In X2 and X3, we will be dealing with parallelisms involving mammals much farther apart on the evolutionary tree.

Modern paleontologists use the terms "parallel evolution" and "convergent evolution" very facilely, as if the terms are explanations in themselves. In reality they are merely naming a mechanism about which we know very little on the detailed, molecular level. We understand virtually nothing about how "similar ways of life" are translated into those genome changes required to effect the needed morphological changes. Can it all be done through random mutations and natural selection? Evolutionists assume so. Indeed, there is no other scientific mechanism known at present. Anomalists must keep the door open to new ideas, and that is why we catalog so many phenomena where evolution seems too "easy" and superficial an explanation.

Science was not always so dogmatic about the "truth" of evolution. A half century before Adams wrote his sabercat article (R5), W.B. Scott, a Princeton paleontologist was also struck by the repeated replications of the saber-cat theme in the fossil record. We quote next from an item in a 1936 issue of Science News Letter (now Science News), in which a new rendition of the sabercat had just been found.

> But closer examination [of the fossil], especially of the teeth, showed that it was an entirely different kind of beast, which Dr. Scott termed a "most amazing imitation of a sabertooth." Once before, an imitation sabertooth of still another kind of animal had been found in South America. This repetition of the sabertooth anatomy and way of life in three widely different kind of animals, Dr. Scott explained, constitutes a striking case of what scientists call convergent evolution. The probabilities are almost nil that such near identity could take place on a basis of purely chance variations, as is postulated by the natural selection theory of Darwin. (R2)

How many of today's paleontologists would dare to make such a statement?

Before moving on to another famous instance of fossilized parallelisms, it seems appropriate to dispel a myth surrounding the sabercat, if only because it again illustrates the facile oversimplification permeating the writing of many modern evolutionists.

The renowned biologist G.G. Simpson has understandably complained about the bad press accorded the sabercats. They were, it has often been said, an example of evolution gone wrong. Those big teeth just kept growing and growing until they became so large they were useless. Sabercat extinction was inevitable. Simpson retorted to such extravagant statements as follows:

> To characterize as finally ineffective a mechanism that persisted without essential change in a group abundant and obviously highly successful for some 35,000,000 years seems quaintly illogical! In short, the "inadaptive trend" of the sabertooth is a mere fairy tale, or more fairly, it was an error based on too facile conclusion from imperfect information and it has since been perpetuated as a scientific legend. (R4)

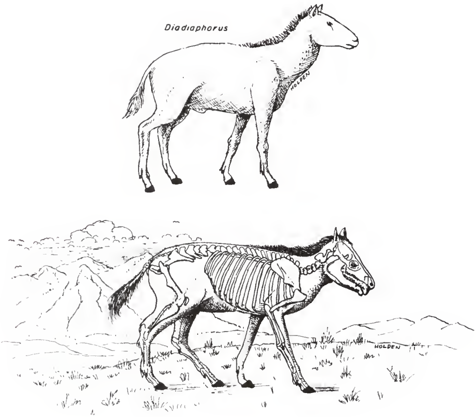
Unfortunately humans, scientists included, are prone to perpetuating myths.

X2. "Real" horses and "false" horses. An intriguing episode in the history of evolutionary thinking led to the recognition of the "real" horses of North America and the "false" horses of South America.

When Darwin himself and, later, the distinguished Argentine paleontologist F. Ameghino first looked upon the bones of what are now called "false" horses or "horse-like litopterans," they did not hesitate to label them "real" horses. However, modern paleontologists now explain that the litopterans are very far removed taxonomically from the "real" horses. Any resemblances between them ---and there are many---is simply an amazing example of evolutionary convergence. (R3)

How much alike are the "real" and "false" horses? As the illustration demonstrates, their feet are astonishingly similar, even to the one- and three-toed varieties seen in the famous evolutionary sequence of the "real" horses. (BME1-X3) The Litopteran teeth, too, imitated those of the "real" horses. Further, the "false" horses were evidently well-proportioned, agile, and graceful creatures ---in many respects just like those you see in today's pastures. (R6)

Nevertheless, the horse-like Litopterans are not even in the Order Perissodactyla that encompasses modern one-toed ungulates such as the "real" horse. The conventional evolutionary tale goes like this: During the Paleocene and Eocene, primitive, hoofed, herbivores called Condylarths had spread to all continents except Australia. When North and South America were severed as the Isthmus of Panama foundered, the North American Condylarths evolved into the odd-toed Order Perissodactyla and even-toed Order Artiodactyla, the "real" horses being among the former. In

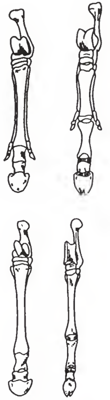


A three-toed South American "false horse". Externally and internally, including even the teeth, it looked much like a "true horse."

South America, the Condylarths split into the Orders Litopterna and Notoungulata, the "false" horses being in the former.

Ultimately, the two South American orders succumbed, leaving only bones behind, some of them very equinesque! But the horse-like Litopterans succumbed in a peculiar way. The one-toed variety disappeared before the three-toed version---just the opposite from what supposedly happened in with the "real" horses in the Northern Hemisphere.

E. Von Fange, a creationist, wonders whether the horse-like Litopterans had to be called "false" because they seemed to belie the "proper" evolutionary sequence established for the Northern Hemisphere. In fact, Von Fange, being suspicious of evolutionists, hints that the whole Order Litoptera might have been created just to avoid undermining the agreed-upon three-toe to one-toe



The feet of the "false horses" (right) paralleled those of the "true horses" (left). (R. von Fange, R6)

sequence for "real" horses that was enshrined in the 1890s by O.C. Marsh! (R6) The Litopterans, it seems, were evolving the wrong way and must not be taxonomically linked to the right-way "real" horses.

Assuming that the conventional picture is correct, we have at the minimum a remarkable case of convergence.

X3. Rhinoceros-like animals. Marsupials and the placental mammals are about as far apart, taxonomically speaking, as one can get and still stay within the mammalian corral. Yet, we find amazing examples of morphological convergence among living marsupials and placentals. (BMA1 in Mammals 1) The phenomenon persists when one looks back in the fossil record.

> As the result of an examination of a nearly complete skeleton of an extinct marsupial Nototherium mitchelli, hitherto known only from fragmentary remains, found near Smithton (Tasmania) this year, Messrs. H.H. Scott and Clive Lord have come to the conclusion that the Nototherium was a marsupial rhinoceros. The structure and shape of the horn are matters for conjecture as no remains of it have been found but the specially constructed cervical vertebrae, the structure of the nasal regions and the curious nasal cartilage---all point to the conclusion that the animal possessed a rhinoceros-like horn. If so, it is a curious case of parallel evolution for the true rhinoceros belongs to a different and "higher" group than that of the marsupials, none of which at the present day possesses anything remotely resembling horns, nasal or otherwise. (R1)

Of course, we should properly call this rhinoceros parallelism a "convergence," since the root stocks are so far apart on the mammalian family tree. But one sees even more extreme convergences with the fins and flippers of marine mammals, penguins, and fish!

References

R1. Anonymous; "A Marsupial Rhinoceros," Scientific American, 123:301, 1920. (X3)

R2. Anonymous; "Jawbone of Unknown Beast Disputes Darwin's Theory," Science News Letter, 30:350, 1936. (X1)

R3. Anonymous; "Extinct South American Horse-Like Animal Was Evolved Independently," Earth Science Digest, 4:9, 1950. (X2)

R4. Simpson, George Gaylord; The Meaning of Evolution, New Haven, 1967. (X1, X2)

R5. Adams, Daniel B.; "Nine Lives of the Sabercat," Science 81, 2:42, January-February 1981. (X1)

R6. von Fange, Erich A.; "The Litopterna---A Lesson In Taxonomy: The Strange Story of the South American "False" Horses," Creation Research Society Quarterly, 25:184, 1989. (X2)

BME11 Pleistocene Dwarfing of Some Mammals

Description. The sharp reduction in body dimensions of some large mammals during the Pleistocene. Apparently, this phenomenon was mostly confined to islands far enough from a mainland to isolate gene pools. Changes in weight were several-fold and occurred in the space of a few thousand years. This phenomenon was roughly coincident with the extinction of many large mammals.

Data Evaluation. We have so far found only two references relating to specific mammals, but the general phenomenon is well-established in the scientific literature. For example, in R1 below, A.M. Lister appended a bibliography of 27 references. Rating: 1.

Anomaly Evaluation. To begin, dwarfism is not necessarily "devolution" in the sense of evolutionary retreat. Dwarfism is probably adaptive in most cases. Smaller body size is favored under some environmental conditions. In most cases of dwarfism, new species are not created; rather, we see a population shift. True, the extent and rapidity seen in the two entries below are surprising, but human breeders of farm animals and pets have done much the same with their "toy" horses and miniature poodles. In this respect, there seems little beyond curiosity value in this phenomenon. Rating: 3.

Possible Explanations. Dwarfism is inherent in many mammalian genomes and may be selected for by natural environmental forces as well as human selection.

Similar and Related Phenomena. Selective Pleistocene extinctions of some large mammals (BME4); human "devolution" (BHE4 in Humans III); breeding experiments with domesticated animals (BMA1 in Mammals I); the significant increase in human body size in the last few hundred years.

Entries

X0. Cross reference. About 12,000 years ago, near the end of the Pleistocene, a wave of extinction swept across North America, South America, Australia and, to a much lesser extent, the rest of the planet. This biological devastation is summarized in BME4. Just as remarkable as the geographical selectivity of the extinction was the physical size of the mammals that met their demise. Only mammals weighing more than 40 kilograms (88 pounds) were affected. The most famous victims were the mammoths, the giant sloths, and the giant lemurs, but many other large mammals fell, too.

Roughly coincident with this strangely discriminatory extinction---and probably causally associated with it---was an apparently very rapid dwarfing of some large mammalian species---a phenomenon that was most striking on islands well-separated from mainland gene pools.

X1. Mammals in general. A.M. Lister, a zoologist at the University of Cambridge, is a student of the dwarfing phenomenon. In Nature, in 1989, he summarized:

> The dwarfing of large mammals on islands occurred repeatedly in the Pleistocene. Elephants, deer, hippopotami and other species became dwarfed on islands in Indonesia, the Mediterranean, the east Pacific and elsewhere. (R1)

In most of these cases of island dwarfism, the species involved can be related to full-sized forms on an adjacent mainland.

X2. Red deer. To discover how long the dwarfing process might take, A.M. Lister studied fossils of the red deer on the island of Jersey, now positioned about 25 kilometers off the French coast. Even though deer are good swimmers, Lister believed that the red deer were genetically isolated on Jersey during the Pleistocene when sea levels were much higher. Lister concluded that the message of the red-deer fossils on Jersey was that the body weight of these animals shrank to one-sixth of the usual weight for the mainland form in less than 6,000 years. This is remarkably fast, especially since the mainland red deer had survived for about 400,000 years with only minor changes.

Lister considers that this six-fold weight reduction was probably in response to the restricted resources on the island and freedom from predation. (R1)

X3. Mammoths. Many a sensational article has been written about how the Siberian mammoth population was deep-frozen by a sudden climate change due to a shift in the earth's poles or some other catastrophic event circa 10,000 years ago. But a Russian scientist, A. Sher, and two colleagues claim that a dwarf version of the wooly mammoth survived on Wrangel Island, 120 miles off the Siberian coast until about 3,700 years ago. The Wrangel Island dwarf mammoths stood only about 2 meters high and weighed roughly 2 tons---perhaps only one-fourth the weight of the mainland form that went extinct some 6,000 years earlier. (R2)

If the full-size Siberian mammoths really met their demise because of a catastrophic climate change, how did the dwarf mammoths occupying roughly the same region escape?

Lister's remarks about other dwarfed island inhabitants (in X1) brings to mind the dwarf elephants of Santa Rosa, off the California coast, which apparently were the main course in early human feasts. But, curiously, island isolation also leads to gigantism, as seen in the moas of New Zealand. This seeming contradiction needs explaining.

References

R1. Lister, A.M.; "Rapid Dwarfing of Red Deer on Jersey in the Last Interglacial," Nature, 342:539, 1989. (X1, X2)

R2. Bower, B.; "'Dwarf' Mammoths Outlived Last Ice Age," Science News, 143:197, 1993. (X3)

BME12 Variations in Mammalian Teeth and Skeletons Show A Definite Direction

Description. The appearance of directed, inheritable changes in series of mammalian fossils. In other words, evolution seems, in some cases at least, to proceed toward specific goals.

Data Evaluation. This entry is based upon a single article in an 1890 issue of Science by a well-respected paleontologist. The facts he sets forth seem immutable, but his interpretation of them is incompatible with the present evolutionary paradigm. Our evaluation, however, is based on the observables that he presented, not upon his interpretation. Rating: 1.

Anomaly Evaluation. Wherever data support the inheritability of acquired characters (Lamarckism), we recognize a first-class anomaly. Rating: 1.

Possible Explanations. The facts delineated below were misinterpreted. Or, we could assume that: (1) The facts and their interpretation are actually correct; and that (2) The vaunted horse evolutionary sequence itself is actually flawed (See BME1-X3.); then the conclusion that Lamarckism reigned would be incorrect. In other words, the error may be in the order in which the horse fossils are customarily arranged, not in the facts and their interpretation!

Similar and Related Phenomena. The horse evolutionary sequence (BME1-X3). See the Series-B Subject Indexes under: Evolution, adaptive; Lamarckism; Self-organization.

Entries

X0. Background. Lamarckism has not expired completely, even though it is passed over in college courses as a thoroughly discredited idea. In fact, in some fields of biological research, we see reconsiderations of the possibility of "transmission of acquired characters." Immunology is just one of these fields. (R2) Since any evidence for Lamarckism must be judged to be anomalous, it is appropriate to this chapter to mention that, over a century ago, the mammalian fossil record was believed by some paleonologists to support Lamarckism. The facts adduced by these paleonologists have not gone away. This, plus the fact that Lamarckism is still on science's proscription list, is justification enough for this catalog entry. But this dusty report also provides insight as to how the famous horse-fossil sequence was interpreted by a well-known scientist of the 1890s.

X1. Mammals in general. H.F. Osborn, the author of the period piece that forms the foundation for this catalog entry, analyzed the morphologies of the teeth and feet portrayed in the classical horse evolutionary sequence (see BME1-X3) and used them to prove the following generalization:

> Excepting in two or three side-lines, the teeth of all Mammalia have passed through closely parallel early stages of evolution, enabling us to formulate a law: The new main elements of the crown make their appearance at the first points of contact and chief points of wear of the teeth in preceeding periods. Whatever may be true of spontaneous variations in other parts of the organism, these new cusps arise in perfectly definite

> lines of growth. Now, upon the hypothesis that the modifications induced in the organism by use and disuse have no direct influence upon variations, all these instances of sequence must be considered coincidences. If there is no causal relationship, what other meaning can this sequence have? Even if useful new adjustments of elements already existing may arise independently of use, why should the origin of new elements conform to this law? Granting the possibility that the struggle for existence is so intense that a minute new cusp will be selected if it happens to arise at the right point, where are the non-selected new elements, the experimental failures of nature? We do not find them. Paleontology has, indeed, nothing to say upon individual selection, but chapters upon unsuccessful species and genera. Here is a practical confirmation of many of the most forcible theoretical objections against the selection theory. (R1)

Thus, bumps on a series of fossil teeth seem to show Lamarckism superior to Darwinism in this matter.

Osborn, in fact, held that Lamarckism should not be discarded but, rather, be employed in tandem with Darwinism. With regard to Lamarckism he concluded:

> The evidence in this field for, is still much stronger than that against, this theory. To sum up: the new variations in the skeleton and teeth of the fossil series are observed to have a definite direction; in seeking an explanation of this direction, we observe that it universally conforms to the reactions produced in the individual by the laws of growth; we infer that these reactions are transmitted. If the individual is the mere pendant of a chain (Galton), or upshoot from the continuous root of ancestral plasm (Weismann), we are left at present with no explanation of this well-observed definite direction. But how can this transmission take place? If, from the evident necessity of a working theory of heredity, the <u>onus probandi</u> falls upon the Lamarckian, ---if it be demonstrated that this transmission does not take place,--- then we are driven to the necessity of postulating some as yet unknown factor in evolution to explain these purposive or directive laws in variation, for, in this field at least, the old view of the random introduction and selection of new characters must be abandoned, not only upon theoretical grounds, but upon actual observation. (R1)

Of particular interest to an anomalist is Osborn's final sentence in which a possible "unknown factor" in evolution is introduced. Now, more than a century later, evidence for such a "factor" is piling up, leading to such new terms as "adaptive evolution" and "purposeful evolution." (R3)

References

R1. Osborn, Henry Fairfield; "The Paleontological Evidence for the Transmission of Acquired Characters," <u>Science</u>, 15:110, 1890. (X1)

R2. Taylor, R.B.; "Lamarckism Revival in Immunology," <u>Nature</u>, 286:837, 1990. (X0)

R3. Shapiro, James A.; "Adaptive Mutation: Who's Really in the Garden?" <u>Science</u>, 268:373, 1995. (X1)

BMF BODILY FUNCTIONS

Key to Phenomena

BMF0 Introduction

All living animals must assign top priority to breathing, digesting food, and reproducing. Beyond these three imperatives are some less important bodily functions, such as sleeping (not all mammals need it!) and weeping (some mammals do need it!). And for all mammals, all known functions end with death, but some mammals even manage to die in unusual ways. Even at the end of life there are anomalies.

Mammals have met their environmental challenges with a host of remarkable adaptations of their bodily functions. Hibernation, underwater suckling of young, and "big-bang" reproduction are just a few. Again and again in this chapter, the efficacy of the prevailing evolution paradigm comes to the fore. Unquestionably, this subject is belabored in the Series-B catalogs; and it should be! The concepts of evolution and natural selection not only shape the thinking of all biologists but the philosophical outlook of humankind as well. Challenging the evolution paradigm is, therefore, one of the most important tasks of anomalists. In accordance with this "bad" attitude, readers should not be surprised to find evidence favoring Lamarckism in this chapter, as seen in the inheritance of the effects of rotation. Finally, some of the observations that follow are cataloged just because they are so bizarre and unlikely or, if you will, Fortean.

BMF1 Water-Breathing in Mammals

Description. The ability of some mammals to breathe water fortified with added oxygen and salts and, in some cases, survive the return to air-breathing.

Data Evaluation. Several series of experiments with different mammals, by different scientific groups, are duly recorded in several science magazines. Rating: 1.

Anomaly Evaluation. Physiologically, there is no reason why mammalian lungs cannot extract sufficient oxygen for metabolism from water, as long as the concentration of oxygen in the water has been substantially increased over that in air. Although a bit bizarre, this phenomenon cannot be labelled anomalous. It is merely "curious." Rating: 3.

Possible Explanations. None required.

Similar and Related Phenomena. The Aquatic Ape hypothesis (BMC4- X1) (See also this entry in the Subject Indexes in Humans 1, III, III and Mammals 1.)

Entries

X0. Introduction. Scientific consensus has it that life began in the sea. Early marine animals (and most modern ones) that require oxygen for their metabolism extract this gas directly from sea water. Respiration via gills and/or the skin are just two of the methods employed. When, according to the evolutionary scenario, life forms eventually invaded dry land, a new type of organ was required to remove oxygen from the atmosphere; this was the lung. (Actually, lungs of a sort had already been evolved independently by some fish and land-dwelling snails.)

Internal, air-breathing lungs differ radically from external water-immersed gills. Although the concentration of oxygen in air is much higher than it is in water, lungs require a pumping mechanism and appropriate valves. Given these great differences, it comes as quite a surprise to learn that some mammals can actually breathe water under special conditions.

J.A. Kylstra, an early investigator of this unexpected phenomenon, wrote:

> Mice and dogs, under certain conditions, can be submerged in water for considerable periods of time without drowning. Under these circumstances the animals actually breathe the way a fish does; their lungs, acting as gills, extract oxygen from the water.
>
> Submerged adult mammals usually drown because water in contact with them does not contain enough dissolved oxygen. But if the oxygen pressure above the water in raised, more oxygen dissolves. The rate of increase is such that under eight atmospheres of pressure the amount of oxygen dissolved in water is roughly equal to the amount of oxygen in air. Under these circumstances water now "resembles" air a bit more closely and experiments have shown that, with some salts added, mice and dogs can breathe water and survive. (R3)

X1. Mice. J.A. Kylstra described a typical experiment with mice as follows:

> Adult "Swiss" mice of both sexes were used. A small chamber was part-

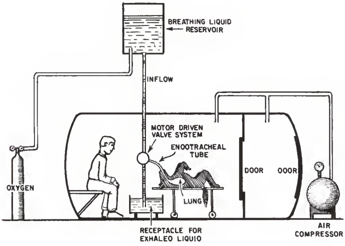


Diagram of one of J.A. Klystra's experiments with water-breathing in dogs. (Adapted from R2) ly filled with water to which various salts had been added in similar amounts as those present in blood. Air in the chamber was replaced by compressed oxygen. The fluid was agitated to hasten solution of the gases. After approximately thirty minutes, a mouse was introduced into the chamber via a lock. The mouse was prevented from surfacing by a grid.

This basic procedure was followed with a number of mice at an oxygen pressure of eight atmospheres. The mice continued to breathe for several minutes and, in some cases, hours. The longest survival times occurred when the temperature of the solution was 68°F. The mice were initially active and alert while submerged and did not appear to be in severe distress. (R3)

Unfortunately, the mice do not survive reversal of the process. They succumbed when their lungs were drained. Still, it is remarkable that they avoided drowning for hours---up to 18 hours in some cases! (R2)

X2. Dogs. Similar experiments have been carried out with completely submerged dogs. As with the mice, the dogs did not drown and could be observed pumping the water in and out of their lungs. When the water was drained from the dogs' lungs and the lungs reinflated with air, the dogs recovered. (R2, R3)

In a variation of the experiment, shown in the accompanying figure, the oxygenated fluid was introduced into the dog's lungs via an endotracheal tube. (R2)

X3. Humans. A human volunteer, one F.J. Falejczyk, a deep-sea diver, submitted to modified version of the "dog" experiment---essentially the same as that shown in the accompanying diagram. However, only one lung was filled with fluid. Falejczyk remained conscious during the experiment and reported no discomfort. (R4)

References

R1. Anonymous; "Water-Breathing Rodents," Scientific American, 208:83, April 1963. (X1)

R2. Hughes, G.M., and Kylstra, J.A.; "Breathing in Water," New Scientist, 24:566, 1964. (X1, X2)

R3. Kylstra, Johannes A.; "Mammals Can Breathe Water," Sea Frontiers, 10:209, 1964. (X1, X2)

R4. Brown, Joseph E.; "The Birth of Aquaman," Science Digest, 77:66, June 1975. (X3)

BMF2 Remarkable Adaptations in Diving Mammals

Description. The presence in some marine mammals of profound physiological adaptations of their respiratory and circulatory systems that permit lengthy, deep dives in their pursuit of prey.

Data Evaluation. The information presented below was found in two authoritative guides to marine mammals. Rating: 1.

Anomaly Evaluation. For the reader's convenience, we repeat with minor editing the relevant discussion from BMT7 (Remarkable Diving Capabilities of Distantly Related Mammals) found in Mammals I.

In order for mammals to dive successfully to great depths, extensive physiological modifications must be in place: (1) Their bodies must be able to withstand crushing pressures; (2) Their circulatory systems must prevent the formation of nitrogen bubbles during ascent (the cause of the bends) and nitrogen poisoning (the cause of "rapture of the deep"); and (3) Their bodies must conserve oxygen during prolonged submersion. That these major biological changes have been successfully accomplished in both the cetaceans and seals is all the more remarkable, for these two orders of mammals are not closely related. Either parallel evolution or independent invention seems to have been at work. In this sense, the double evolution of deep-diving capabilities must be counted as almost as remarkable as the repeated development of flight in animals. Even though it is conceivable that random mutation and natural selection can produce deep-diving mammals once, even twice, we must view these superficial evolutionary scenarios with great suspicion. Two reasons: (1) The "half-a-wing" problem, or can viable, reasonable transitional forms exist? and (2) The complexity problem, or can random mutation or spontaneous organization really create in a coordinated way all the skeletal, neurological, chemical, and other biological innovations required by a deep-diving mammal?

We do not attempt to quantify anomalousness in situations like this, where the reigning mainstream paradigms can explain the phenomena in principle but, nevertheless, seem inadequate and incomplete in the mind of the compiler. See BMO1 for more on these admittedly intuitive reservations.

Possible Explanations. See above.

Similar and Related Phenomena. Water-breathing in mammals (BMF1).

Entries

X0. Introduction. Under catalog code BMT7 (in Mammals I), we spotlighted some of the amazing diving capabilities of marine mammals. Elephant seals, for example, can stay submerged up to two hours and reach depths of more than a mile. Bottle-nosed whales can dispense with the atmosphere for equally long periods and dive to almost two miles. Great physiological changes had to be made before seals and whales---thought to have evolved from different lineages of land mammals---could perform such feats.

Marine mammals did not develop new organs to invade the deep oceans; they simply modified the respiratory systems they had inherited from their recent terrestrial ancestors. Of course, even farther back in time, their ancestors possessed gills. But, shunning such atavisms that still might be surviving in their genes, seals and whales opted to merely adapt their lungs, hearts, and circulatory systems to the requirements of their new niches. These adaptations were major and quite impressive.

Anomalists instinctively wince when they read that a particular animal "opted" or "acquired" or "evolved" this or that organ or function. In all honesty, biologists do not know what happened on the molecular level; that is, which genes were altered and how. All we really know is that, in deep-diving marine mammals, there are four important physiological adaptations that separate them from terrestrial mammals. This suite of adaptations allows marine mammals to dive to great depths and to forage for an hour or more instead of the few minutes allotted to human pearl divers and abalone fanciers.

X1. Oxygen storage. When human swimmers dive below the surface, they instinctively fill their lungs with air. A couple gulps of air will suffice for only 3-4 minutes for the best of divers. When a seal prepares to dive it actually exhales. Where, then, does it get the oxygen it must have?

First of all, seals (and whales) have higher relative blood volumes than other mammals. Second, the concentration of oxygen-carrying red-blood cells is considerably higher in marine mammals. The third clue is in the characteristic dark red color of seal flesh. Myoglobin in seal muscles stores up oxygen, too. The blood and muscles of marine mammals are, in effect, oxygen reservoirs. (R3)

This increase in oxygen storage capacity in many marine mammals involved only an extension of capabilities already in existence. In fact, humans living at high altitudes adapt in similar ways. Such minor adaptations seem well-accounted-for by the evolutionary paradigm.

Even with the oxygen economies, calculations suggest that elephant seals, for example, reduce their metabolism rate by as much as 60%. It is reasonable to ask how these large seals can capture active prey while they are in a "zombie" state. The answer here is elusive. (R4)

X2. Avoidance of the bends. As with humans, marine mammals would get the bends during rapid ascents from deep dives if they did not somehow sequester and render harmless the nitrogen in the air they breathe. Nature has come up with a physiological trick that keeps most of the nitrogen in their lungs from being absorbed into the blood.

> Research has shown that in at least some pinnipeds the lungs collapse entirely below about 25-70 m, forcing all air into cartilage-supported structures that are poorly vascularized, thus preventing nitrogen from being forced into the bloodstream and preventing blood vessels from rupturing into air spaces during dives. (R3)

When the animal surfaces, the lungs reinflate, withdrawing the stored air.

This adaptation required two innovations: the development of the storage reservoirs and lung collapse and subsequent reinflation.

X3. Oxygen conservation. Dives may be prolonged if oxygen can be conserved in some way. Marine mammals have developed a so-called "diving reflex" in which blood circulation is automatically restricted to all parts of the body except the heart and brain. (Curiously, humans also possess this diving reflex, as presented in BHT21 in Humans I.) This redirection of blood flow reduces oxygen consumption. It is also claimed that, as part of the diving reflex, the heart rates of marine mammals are reduced when a dive commences--a condition called "bradycardia." (R1)

The automatic diving reflex obviously required the evolution of appropriate valving and neurological controls. It is deceptively easy to make such statements; it is much harder to imagine the required changes arising in two distantly related groups of mammals solely from random mutations or spontaneous organization! Still, we must also recognize that such is possible in principle.

X4. Nervous-system control. One other physiological aspect of deep diving that marine mammals have mastered is their maintenance of nervous-system control under high pressures. The nervous systems of most mammals malfunction at depths below 600 feet. The membranes of the neurons are squeezed so forcefully that the nerves misfire, leading to seizures and even death. Elephant seals, however, routinely dive to depths several times the 600-foot barrier. B. Le Boeuf, a researcher at the University of California at Santa Cruz, suggests that elephant seals may be flooding their neurons with nitrogen, which suppresses neuron sensitivity and, in consequence, the unwanted pressure-induced signals. (R4) If Le Boeuf's "nitrogen hypothesis" is correct, we have still one more remarkable physiological adaptation that evolutionists must account for in working out the great changes seen in the biology of deep-diving mammals.

References

R1. Leatherwood, Stephen, and Reeves, Randall R.; Whales and Dolphins, San Francisco, 1983. (X0, X3)

R2. Bright, Michael; The Living World, New York, 1987. (X1)

R3. Reeves, Randall R., et al; Seals and Sirenians, San Francisco, 1992. (X1-X3)

R4. Zimmer, Carl; "Portrait in Blubber," Discover, 13:86, March 1992. (X1, X4)

BMF3 Oddities of Digestion

Description. Quasi-ruminancy, coprophagy, and other curious phenomena associated with digestion in mammals.

Data Evaluation. Quasi-ruminancy and coprophagy are discussed frequently in the zoological journals and mammal guides. Both are useful, well-established functions in mammals. Rating: 1.

Anomaly Evaluation. The subject digestive phenomena seem well within the explanatory powers of existing biological paradigms. They are cataloged for their curiosity value. Rating: 4.

Possible Explanations. None required.

Similar and Related Phenomena. Quasi-ruminancy in birds, specifically, the hoatzin (BBF); the production of ambergris by sperm whales.

Entries

X1. Quasi-rumination. Many well-known herbivores are ruminants; that is, they rapidly swallow large quantities of low-nutrient vegetation and then retire to a safe, secluded spot. There, they regurgitate the vegetable matter from their rumen, or paunch, for rechewing; i.e., cud-chewing. Typical ruminants are: cattle, deer, sheep, and giraffes, all of which have four-chambered stomachs. The camel family and mouse deer are also ruminants but possess three-chambered stomachs. There are some "in-between" cases that pique our curiosity.

The babirusa. Pigs do not chew the cud, and they have two-chambered stomachs. In general, pigs are not ruminants, but the babirusa (an Indonesian pig) may qualify as a quasi-ruminant. Unlike other pigs, it often browses leaves and shoots, suggesting that it may partially digest cellulose in its first stomach through bacterial action. (R5) This is an important part of the rumination process, as seen next in some marsupials.

Kangaroos and wallabies. These marsupials also qualify as quasi-ruminants.

> The occurrence of ruminantlike bacterial digestion in the kangaroos and wallabies enables these marsupials to colonize areas that would be nutritionally unfavorable to most other large mammals. In this kind of digestion, the food is fermented by a dense bacterial population in the esophagus, stomach, and upper regions of the small intestine, thus providing the available energy for chemical breakdown of food over a longer period of time and enhancing the uptake of nitrogen and other nutrients. (R6)

The quokka (a wallaby) especially seems to be intermediate between ruminants and nonruminants. (R6)

X2. Reingestion or coprophagy. Ruminants process their coarse vegetable food twice through regurgitation and cud-chewing. Reingestion employs the same idea but, instead of the cud, reingestion utilizes the feces. In the sense that food is processed twice, reingestion is another form of rumination. Like rumination, reingestion is rather common among the herbivorous mammals. We now list those we have identified so far.

Lagomorphs (rabbits, hares, pikas). The lagomorphs are the most frequently cited reingesters. The process and advantage of reingestion are described in Walker's Mammals of the World.

> Lagomorphs eat only vegetation. Grasses and other herbaceous plants are usually preferred, but when food is scarce they eat the bark of young trees and shrubs and even small stems of shrubs. They have a remarkable provision for obtaining the maximum value from their food. Their fecal material consists of two types: moist pellets, which are expelled and later eaten, and dry pellets which are not eaten. The moist pellets are swallowed with little or no chewing, so most of the food passes through the digestive tract twice. This process may have the same function as "chewing the cud" in ruminant mammals. (R6)

Other placental mammals. Several other groups of placental mammals indulge in coprophagy.

- Many shrews (R2)
- Many pocket gophers (R3)
- The mountain beaver or sewellel (R1)
- The weasel lemur (*Lepilemur eucopus*), a primate.

Marsupials. Nor are the marsupials, those supposedly more "primitive" animals, left out.

- Ringtail possums (R4)
- The koala (R4, R6)

In the koala, and probably other reingesters, the consumption of fecal matter by young animals transfers vital microorganisms from parents to offspring. J. Vandenbeld expanded on this:

> Earlier in its life, when it was about to emerge from the pouch, the young koala was primed for another, even more vital part of tree life. As well as milk, it was fed a pap of soft green faeces from its mother's cloaca. The pap, which is thought to contain some of the mother's digestive microorganisms, may equip the young koala's gut with the means to process its eventual diet of leaves. (R4)

References

R1. Ingles, Lloyd G.; "Reingestion in the Mountain Beaver," Journal of Mam-

malogy, 42:411, 1961. (X2)
R2. Sharma, D.R.; "Coprophagy in Shrews," Journal of Mammalogy, 43: 262, 1962. (X2)
R3. Wilks, B.J.; "Reingestion of Geomyid Rodents," Journal of Mammalogy, 43:267, 1962. (X2)
R4. Vandenbeld, John; Nature of Australia, New York, 1988. (X2)
R5. Rice, Ellen K.; "The Babirusa: A Most Unusual Southeast Asian Pig," Animal Kingdon, 91:46, March/April 1988. (X1)
R6. Nowak, Ronald M.; Walker's Mammals of the World, Baltimore, 1991. (X1, X2)

BMF4 Perpetual Growth in Mammals

Description. The capacity of some mammals to keep growing throughout life, even after maturity, often attaining great sizes.

Data Evaluation. This catalog entry is based entirely upon brief statements in popular books. No verification has been found in the scientific literature. In actuality, the phenomenon may be difficult to detect in the field, because most wild animals never reach "old age." Rating: 3.

Anomaly Evaluation. "Lower" animals, such as fish and reptiles, keep growing indefinitely. Carp and anacondas, by way of illustration, may reach enormous sizes. As a general rule, mammals essentialy stop growing larger after reaching adulthood. Of course, we exclude obesity here. Why mammals should be thus limited when fish and reptiles are not is uncertain. It is even more puzzling when a very few mammals do not adhere to the general rule followed by over 4,000 species in the Class Mammalia. How and why are they different? Rating: 2.

Possible Explanations. The capacity for unlimited growth may be inherited from fish and reptiles---a sort of atavism. Some mammals are more "primitive" than others!

Similar and Related Phenomena. Giant fish (BFA) and reptiles (BRA).

Entries

X1. Passing observations. The following two species and one entire genus are said to never stop growing with age. Undoubtedly there are even more.

Beavers.

The beaver has been around for 30 million years and is a rarity among mammals, because, like the reptiles, it never stops growing. (R2)

Note that the beaver also has a

cloaca, another characteristic that is very rare in mammals, but common in reptiles and birds.

Red Kangaroos. This marsupial is also said to grow without limit. (R1) It would be surprising if the other closely related kangaroos did not do the same.

Voles. Voles of the genus Arvicola apparently never stop growing and do not age in the usual sense. (R3)

References

R1. Dunbar, Robin, ed.; Remarkable Animals, Enfield, 1983. (X1)
R2. Thomas, Warren D., and Kaufman, Daniel; Dolphin Conferences, Elephant Midwives, and Other Astonishing Facts about Animals, Los Angeles, 1990. (X1)
R3. Mcdawar, P.B.; The Uniqueness of the Individual, New York, 1981. (X1)

BMF5 Limb Regeneration in Mammals

Description. The regeneration by mammals of limbs or portions thereof that have been severed. Such powers of regeneration are usually considered to be the exclusive properties of the "lower" animals," such as the reptiles and amphibians. A particularly puzzling feature of mammalian regeneration is its extreme sensitivity to the position of the injury.

Data Evaluation. The limited regeneration of limbs and digits in rodents and humans is well-verified. A substantial literature is growing up around the phenomenon. However, the role of electricity and (in humans) hypnotism in stimulating regeneration remains controversial. Rating: 2.

Anomaly Evaluation. The biological processes involved in limb regeneration are not well understood, especially the phenomenon's sensitivity to the injury's location. Why does a sharp, precise line divide total, perfect regeneration from no regeneration at all? Finally, one must ask why such a valuable capability as limb regeneration has been largely lost by the "higher" animals during their evolution. Rating: 1.

Possible Explanations. None offered.

Similar and Related Phenomena. The inverse relationship between regenerative power and cancer incidence (BHH35 in Humans II); fingertip regeneration in humans (BHF13 in Humans II); partial regneration of break-off tails in mammals (BMA44 in Mammals I).

Entries

X0. Background. The regeneration of severed limbs is popularly believed to be a talent reserved for creatures much lower on the evolutionary scale than mammals. Some amphibians, for example, can nicely regenerate a lost limb or tail. In mammals, this capability seems to have been largely lost, but not completely. There are a few surprises.

To illustrate, the tails of several species of rodents break off readily, as in some reptiles, allowing their former owners to escape. These mammals can then partially regenerate the lost tails, but not to the perfection found in reptiles. (BMA44 in Mammals I) When it comes to limbs, however, mammals are notably deficient compared to the "lower" animals.

Another pertinent and fascinating aspect of regeneration is its inverse relationship with the incidence of cancer. The more "advanced" an animal, the poorer its powers of regeneration and the higher its incidence of cancer. (BHH35 in Humans II)

X1. General observations.

Mice. Contrary to the popular belief that mammals cannot regenerate lost digits like the "lower" vertebrates, not only can mice regrow the tips of their foretoes, but young humans can also regrow cosmetically perfect fingertips. However, the amputation cannot be too far back, and therein lies another puzzle.

Foretoe regeneration in mice (and humans) is astoundingly sensitive to the site of the amputation. Move the site only 0.2-0.3 millimeters farther back and no regrowth will occur. No one understands why such a tiny change in distance completely changes the body's response. (R3)

Rats. A major investigator of regeneration in animals has been R.O. Becker, an orthopedic surgeon and campaigner against electromagnetic pollution of the environment. In 1971, some of his experiments with rats were outlined in Science News.

> Becker has partially regenerated the amputated limbs of several dozen rats. The forelimbs were cut off between what corresponds to the shoulder and the elbow in humans. Miniscule amounts of electric current then applied to the severed sites stimulated the limbs to grow down to the elbow.
>
> .....
>
> Becker's is the most advanced success yet in regenerating a limb in an animal as high up the evolutionary ladder as the rat. Limbs have previously regrown in a newborn opossum and in adult frogs. Becker's work is also noteworthy because it was undertaken to prove a theory he has doggedly pursued for 15 years. The reason man and other mammals are not able to regenerate damaged limbs is that they have lost the ability to generate enough electricity to provide ample stimulus to the formation of a new limb bud. (R1; R2)

Becker has also shown that rats can regenerate portions of their intestines which have been excised. (R4)

Opossums. As noted above under "mice".

Humans. Also mentioned above under "mice" and in some detail in BHF13 in Humans II.

References

R1. Anonymous; "Limb Regeneration in Mammals," Science News, 100:322, 1971. (X1)

R2. Becker, Robert O.; "Electromagnetic Forces and Life Processes," Technology Review, 75:32, December 1972. (X1)

R3. Borgens, Richard B.; "Mice Regrow the Tips of Their Foretoes," Science, 217:747, 1982. (X1)

R4. Becker, Robert O.; The Body Electric, New York, 1985. (X1)

BMF6 Anomalies of Hibernation in Monotremes

Description. The discovery in the echidna, a supposedly primitive "monotreme," of the supposedly "advanced" trait of hibernation. A bit divergent but also included here is the observation that the energy source used by the echidna during its hibernation is different from that employed by placental mammals.

Data Evaluation. A single report in a respected science magazine based upon research by a team of Australian scientists. Generally speaking, the phenomenon of monotreme hibernation is just beginning to be explored. Rating: 2.

Anomaly Evaluation. The perceptions that monotremes are "primitive" animals and hibernation an "advanced" evolutionary development are today only weakly held paradigms. They cannot be compared with the passionately defended evolutionary paradigm. Given this lower level of philosophical importance, we can only accord monotreme hibernation a low anomaly rating, even though some aspects of it remain rather puzzling. Rating: 3.

Possible Explanations. Monotremes are not actually retarded evolution-wise; they are just different from marsupials and placental mammals.

Similar and Related Phenomena. Hibernation in bears (BMF7) and arctic ground squirrels (BMF8). The adaptedness of marsupials as compared with placental mammals (BMB1 in Mammals I).

Entries

X0. Introduction. Hibernation is a state of prolonged, profound torpor wherein an animal's body temperature falls to just a few degrees above the ambient temperature, and bodily functions, such as heart rate, are greatly reduced. Hibernation allows animals to survive during cold periods when food is scarce and weather harsh. Estivation is a similar state but is associated with hot, dry weather. Hibernation per se is not considered anomalous in this catalog, even though there exist a few minor, unresolved puzzles; as illustrated by a hibernating animal's increased resistance to radiation, parasites, and infection.

Hibernation is widespread throughout the animal kingdom. Many reptiles, amphibians, and invertebrates "sleep" through the winter. Among the mammals, ground squirrels, European hedgehogs, and woodchucks (marmots) are "deep" hibernators; that is, they do not wake up until spring; heartbeats drop to just a beat or two per minute. In contrast, prairie dogs and tree squirrels are "partial" hibernators. One often sees them out and around during warm spells. During these periods, their bodily functions rise to normal levels.

Hibernation should be distinguished from ordinary torpor in which body temperatures drop to near ambient levels when the animal is at rest. Torpor is not as profound as hibernation. Many bats conserve energy by becoming torpid when not out hunting for food.

Hibernation is not confined to the rodents. Some marsupials and even a few primates (some of the lemurs) hibernate or estivate. Even though hibernation is common and well-investigated, we shall see in this section and the two that follow (BMF7, BMF8) that some mammals seem to break the rules.

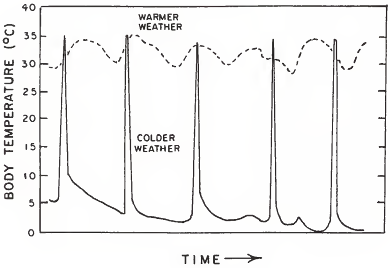
X1. General observations. Hibernation among the marsupials, as in some of the opossums, has long been recognized--- not so with the monotremes. These egg-laying mammals (echidnas and platypuses) are widely considered as being more "primitive" than the marsupials and especially the placental mammals. Since hibernation has usually been considered an "advanced" characteristic of mammals, early hints that echidnas might hibernate met with disbelief.

As early as 1915, echidnas were admitted to fall into torpor, but even in 1978 true hibernation was denied these monotremes. Only in 1989 was the fact of echidna hibernation demonstrated, when Australian scientists placed radio transmitters in the peritoneal cavities of five echidnas and monitored temperatures over a period of 10 months. This period, which included the southern winter, showed clearly the classic swings of body temperature characteristic of partial hibernation, as seen in prairie dogs. (See figure.) And, indeed, echidnas are occasionally seen probing around for food during the winter like American gray squirrels.

This belated confirmation of echidna hibernation (not yet seen in platypuses) demonstrates that either: (1) Hibernation is a more "primitive" characteristic than generally supposed; or (2) Echidnas are more "advanced" than usually credited! The latter might be the case, for echidnas (and platypuses) possess sophisticated electroreceptors (BMO8), suggesting significant evolutionary progress in still another direction. All of this conferring of such labels as "advanced" and "primitive" is mostly a product of human presumption and as such is only a very "soft" sort of anomalousness---a paradigm of perception, if you will. For a "harder" anomaly, we turn to something about the echidna's winter sleep that is more significant scientifically.

> They [the Australian scientists] are puzzled over what energy source the echidna uses during hibernation. The animal does not have brown fat, an energy reserve associated with hibernation in placental mammals. But the echidna does gain weight before beginning hibernation, just as more advanced [?] mammals do. Nor do the researchers know what source of heat the echidna uses in the early stages of spontaneous arousal, although they believe it is not the result of shivering. (R1)

So, echidnas do hibernate despite being low on the evolutionary ladder,



The echidna's body temperature stays fairly constant during the warm months (dashed line), but during cold weather it drops to low levels, (solid line) except for brief periods occurring every few weeks, when the animal wakes---probably to urinate.

but they accomplish it in a different and poorly understood manner.

Reference

R1. Anderson, Ian; "Zoologists Wake Up to the Echidna's Hibernating Habit," New Scientist, p. 30, October 7, 1989. (X1)

BMF7 The "Winter Sleep" of Bears

Description. The presence in some bears of a unique, innovative biochemical process that allows these animals to maintain high metabolic levels during winter dormancy. The use of the term "hibernation" for this unusual state is deemed inappropriate by some biologists.

Data Evaluation. Several scientifically sound references acknowledge the existence of this unique form of dormancy in some bears. Our literature search so far has not uncovered any of the biochemical details. Rating: 2.

Anomaly Evaluation. Unique, innovative characteristics are found frequently in the natural world. These can be labelled "anomalous" if their evolution and persistence seem unlikely through random mutation and natural selection. As elaborated upon in X1 below, there does not seem to be any pressing need for the bear's unusual type of winter sleep---ordinary hibernation apparently being a good solution in very cold environments. In other words, there does not seem to have been any biological imperative for the evolution of the subject phenomenon. The fact of the bear's evolutionary innovation is more difficult to evaluate, since its biochemical details have not been found in our survey so far. Undoubtedly, a coordinated suite of neurological changes and organ modifications had to be synchronized to attain this unique state. Standard evolutionary theory and "self-organization" can, of course, account for such developments, even though they do not satisfy many observers. As customary, we do not rate such situations.

Possible Explanations. Both the theory of evolution and the concept of self-organization can explain virtually anything biological.

Similar and Related Phenomena. The biochemical mechanism by which the hibernating arctic ground squirrel avoids death by freezing (BMF8); monotreme hibernation (BMF6).

Entries

X1. General observations. In much fact and fiction, black bears are said to hibernate. Scientific opinion, however, is divided on this matter. In reality, the dormant period of black bears is a unique and peculiar "state" among the mammals. Those who deny black bear hibernation point out that the sleeping bear's temperature drops only a few degrees, most bodily functions continue, and the animal is easily aroused. On the other side of the controversy, the bear's heart rate drops to less than half its normal value and some important physiological changes occur---enough changes to warrant the term "hibernation" in the view of some mammalogists. (R3, R4) What all do agree upon and what is singled out in this catalog is that the black bear's "winter sleep" is different.

Just how different it is is seen in the bear's metabolism. Although the sleeping bear's metabolic machinery keeps ticking away, the animal does not eat, defecate, or urinate during the entire 3-5 months of dormancy. Sleeping females even give birth and suckle their cubs without awakening. Protein synthesis continues, even increases. Somehow, the black bear recycles amino acids, keeps its body temperature close to ambient, and still manages to avoid the buildup of urea in its body. (R1)

> A buildup of urea in the blood should ultimately result in the animal's death---it is the same as kidney failure---and so the bear has got around this with a unique biochemical trick. The waste nitrogen is redirected to a new chemical pathway where it is rebuilt into amino acids that are incorporated into new proteins that the bear can reabsorb and reuse. (R2)

In other words, the bear has almost become a self-contained system, limited only by the amount of fuel (brown fat) that it has been able to store during the favorable part of the year and, of course, a supply of air. No conventional hibernators can perform this trick!

But what exactly is this "unique biochemical trick? What is this "new chemical pathway"? We have not found any specifics in the literature examined so far.

We need also to know how and why the black bear's unique "sleeping" state evolved. The "unique biochemical trick" is obviously an innovation, the origins of which are worth exploring. Since the entire metabolic system is involved, there must have been many chemical and physiological changes that had to be coordinated and orchestrated together.

From the aspect of natural selection, one questions the need for the unique state, when both deep and partial hibernation work well for many polar mammals. Indeed, the arctic fox, caribou, muskox, and other arctic mammals do not hibernate at all. Even the polar bear, thought to be a very recent twig on the bear family tree, does not always hibernate. The males rarely do and instead prowl the long arctic night looking for seals, while pregnant females dig a den in the snow and hibernate like the black bears. These things being so, why did selection favor the black bear's "unique state"?

References

R1. Curtis, Helena; Biology, New York, 1979. (X1)
R2. Bright, Michael; The Living World, New York, 1987. (X1)
R3. Nowak, Ronald M.; Walker's Mammals of the World, Baltimore, 1991. (X1)
R4. Milius, Susan; "Giants of the North," International Wildlife, 24:32. September/October 1994. (X1)

BMF8 Freeze-Avoidance in Hibernating Mammals

Description. The ability of some hibernating mammals to survive subfreezing body temperatures without the production of the antifreeze solutes or proteins found in some cold-blooded hibernators.

Data Evaluation. Controlled experiments with instrumented, hibernating mammals demonstrate conclusively that survival of body temperatures below 0°C is possible. Accompanying chemical analyses, however, give no hints as to how death-by-freezing is avoided. To date, the phenomenon has been confirmed only in arctic ground squirrels. Rating: 2.

Anomaly Evaluation. In addition to being contrary to expectations regarding warm-blooded mammals, this phenomenon has not yet been explained in terms of those biochemical techniques employed by fish, amphibians, and other cold-blooded hibernators. In all likelihood, further research will identify the method(s) used by mammals. Until this is done, we won't know if any important paradigms are in danger. No evaluation is possible for the moment.

Possible Explanations. None offered.

Similar and Related Phenomena. The unique biochemical innovation seen in hibernating bears (BMF7); the remarkable adaptation of some mammals to very low temperatures (BMF9, BMF10); the production of antifreeze solutes and proteins by reptiles and amphibians (BRF) and fish (BFF).

Entries

X0. Background. Some cold-blooded animals can survive body temperatures below freezing through: (1) The production of antifreeze proteins that inhibit the growth of ice crystals in their bodies; or (2) The synthesis of a solute that lowers the freezing point of their body fluids. Some polar fish, for example, remain active with body temperatures of only -1.9°C. Painted turtles and several species of frogs hibernate successfully with body temperatures ranging between -3 and -7°C. (R2)

Arctic mammals are warm-blooded and, until recently, were not thought capable of surviving body temperatures below freezing. Of course, some arctic animals, such as seals and polar bears, remain active during the winter and, given sufficient food, can maintain their body temperatures well above freezing. Those arctic mammals that hibernate must struggle to keep from freezing by tapping stored energy (brown fat). When their hibernaculums drop well below freezing, their body temperatures may follow, and they *might* perish. But at least one mammal manages to survive body temperatures below freezing, and we don't yet know how it accomplishes this remarkable feat---at least it's remarkable for mammals!

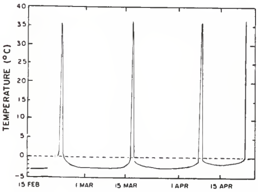
X1. General observations.

Ground squirrels. The literature prior to 1958 contains scattered, mainly anecdotal, accounts of hibernating mammals with subfreezing body temperatures---usually rodents, but at least one bat. Generally, however, hibernating mammals were not then considered capable of surviving body temperatures below 0°C.

In the winter of 1952, A. Svihla conducted a more systematic series of measurements on dormant ground squirrels (*Spermophilus undulatus*). He recorded air and cheek-pouch temperatures. The former varied between 15 and 22°F (well below freezing); the latter between 29 and 32°F (just below and exactly on freezing). Svihla ended his report with:

> My conclusion from the data recorded above is that, during dormancy, tolerances of the ground squirrel to temperatures at or below freezing are greater than has been previously surmised. (R1)

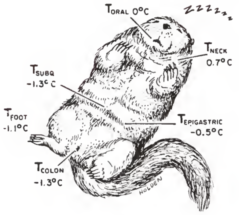
More recently, in 1987, B.M. Barnes carried out similar measurements with another species of arctic ground squirrel (Spermophilus parryii). Barnes implanted temperature-sensitive radio transmitters on the abdomens of a dozen ground squirrels, which afterwards dug their burrows in outdoor cages, where they hibernated for the next 8 months. Their abdominal temperatures (see figure) displayed the sharp peaks typical of partial hibernators. Although briefly aroused about every three weeks (to eliminate wastes), their body temperatures otherwise stayed 1 to 2°C below freezing. (R2)



Body temperature of a hibernating female arctic ground squirrel as measured by an abdominal temperature-sensitive radio transmitter.

Barnes also studied hibernating ground squirrels under more-controlled conditions:

> Laboratory-housed ground squirrels hibernating in ambient temperatures of -4.3°C maintained above 0°C thoracic temperatures but decreased colonic temperatures to as low as -1.3°C. Plasma sampled from animals with below 0°C body temperatures had normal solute concentrations and showed no evidence of containing antifreeze molecules. (R2)



Body temperatures at various places on and in a hibernating arctic ground squirrel.

The final sentence pinpoints the anomaly: No antifreeze molecules and no solutes to lower the freezing point of body fluids. The biochemical method(s) employed by the arctic ground squirrels to circumvent freezing remains a mystery. (R3)

Hoary marmots. B.M. Barnes planned to study next the hoary marmot, the "woodchuck" of the far north. These mammals, too, are probably "supercooled." Barnes reasoned:

> These animals live in a very cold climate; if they couldn't reduce their body temperatures to such a low degree, the ice around their burrows might melt and drown them. (R3)

References

R1. Svihla. Arthur; "Subfreezing Body Temperatures in Dormant Ground Squirrels," Journal of Mammalogy,

39:296, 1958. (X1)
R2. Barnes, Brian M.; "Freeze Avoidance in a Mammal: Body Temperatures below 0°C in an Arctic Hibernator," Science, 244:1593, 1989. (X0, X1)
R3. Kemp, Mark; "Supercool Mammals," Discover, 10:24, November 1989. (X1)

BMF9 Cold-Blooded Mammals (Poikilotherms)

Description. The existence of a few cold-blooded mammals that have lost (or never evolved) the ability to control their body temperatures. The physiological states of hibernation and controllable torpidity are not considered cold-blooded or, in more formal language, poikilothermy.

Data Evaluation. Cold-bloodedness is well-established for naked mole-rats and the sloths in the references examined so far. Some anteaters and armadillos may also fall into this category, but scientific confirmation is needed. Science journals and magazines have provided the bulk of the information used. Rating: 2.

Anomaly Evaluation. That a few mammals are cold-blooded may surprise those accustomed to the usual definition of mammals as warm-blooded animals; but a poor definition does not make an anomaly. Since at least 99% of the mammals are warm-blooded, it is likely that the trait evolved when the Class Mammalia was founded some 200 million years ago. It follows that those rare mammals that are cold-blooded probably lost this trait and reverted to the older cold-blooded state characteristic of reptiles. In this view, mammalian poikilothermy is a regression or atavism. This interpretation is in agreement with the observation that all confirmed cold-blooded mammals live in perpetually hot climates, where warm-bloodedness is an unnecessary accouterment. Mammalian poikilothermy, then, may a consequence of nature's "use it or lose it" philosophy. Such reversions are considered only mildly anomalous, if only because we do not understand all the details of how capabilities and organs are lost through disuse. If mammalian cold-bloodedness turns out to be an innovation unrelated to, say, reptilian cold-bloodedness, we would have to revise our rating upward. Rating: 3.

Possible Explanations. See above discussion.

Similar and Related Phenomena. Mammalian hibernation and torpidity (BMF6-8); inheritance of cold tolerance (BMF10).

Entries

X0. Background. At the popular level, animals are usually classified as either warm-blooded (birds and mammals) or cold-blooded (insects, fish, reptiles, etc.). It was also this way in the early days of biology, but soon a few warm-blooded insects, fish, and reptiles were discovered. The simplistic body-temperature classification was further undermined by a hibernating bird (poor-will) and mammals (ground squirrels), as well as those representatives of these two classes that descend into torpid states when inactive (hummingbirds and bats). Nevertheless, the hibernators and those that enter torpid states do possess some control over their body temperatures; they are not completely at the mercy of the environment. They are, therefore, not true poikilotherms; that is, animals whose body temperatures are dictated entirely by the ambient temperature. Unfortunately for those wishing to use this simple criterion to separate the Mammalia from other classes of animals, a few mammals have been found to be true poikilotherms or almost so.

X1. Poikilothermy in mammals.

Naked mole rats. In 1991, during the scientific enchantment with the many peculiarities of the naked mole rats, it was discovered that these mammals are truly cold-blooded. R. Buffenstein and S. Yahav, at South Africa's University of Witwatersrand, showed that the body temperature of the naked mole rat is aways about 0.5°C above the ambient temperature over a range from 12 to 37°C.

> The naked mole rat therefore provides an exception to the rule that resting mammals have an effective system for endothermic thermoregulation. However, it is not simply a degenerate mammal in this respect, but has probably sacrificed a redundant physiology for some other adaptive benefit. It may be that reduced metabolic rates lower the possibility of overheating in an enclosed and humid burrow. Or perhaps the energetic savings on abandoning endothermy are crucial to balancing the energy budget in a food-scarce habitat. (R3)

These are interesting speculations, but only the first sentence represents observed fact.

In a laboratory environment at very low temperatures, the naked mole rats just "freeze up" in temporary rigor mortis. In their African home, their burrows never reach such low temperatures. (R4)

The Order Xenarthra. This Order, now confined to the New World, has more than its share of odd creatures. It is here that we find other mammals that are true poikilotherms or nearly so.

Sloths in general.

> Unlike that of most mammals, the body temperature of sloths varies considerably, depending on the temperature of their surroundings. As a result, they are physiologically restricted to a limited equatorial habitat of constant temperature. Choloepus has the lowest and most variable body temperature of any mammal, ranging from a low of 24°C to a high of 33°C. (R2)

Note that the temperature range applied during tests of the naked mole rats greatly exceeded that just quoted for sloths in natural settings.

Anteaters and armadillos in general. These xenarthrans also display highly variable body temperatures. (R1)

The Order Primates.

Lemurs. We have a fleeting reference stating that these primates also have variable body temperatures. (R1) It would be nice to confirm this. Perhaps it is only a reference to their occasional hibernation.

References

R1. Shute, Evan; Flaws in the Theory of Evolution, Philadelphia, 1961. (X1)
R2. Nowak, Ronald M.; Walker's Mammals of the World, Baltimore, 1991.

(X1)
R3. Cossins, Andrew R.; "Cold Facts and Naked Truth," Nature, 353:699, 1991. (X0, X1)
R4. Anonymous; "Hairless and Cold-Blooded," Discover, 13:15, March 1992. (X1)

BMF10 Transmission to Progeny of Adaptations Induced by Low Temperature

Description. The appearance in successive generations of mammals of physiological adaptations induced by low temperatures in preceding generations.

Data Evaluation. We have found reports in the scientific literature of two sets of similar, independent experiments suggesting the reality of the subject phenomenon. Given the radical interpretation of the results (the truth of Lamarckism) that is possible, additional replications are desirable. Rating: 2.

Anomaly Evaluation. The inheritance of acquired characters or Lamarckism is still vehemently disavowed by mainstream science. For this reason, experimental results favorable to Lamarckism are strongly anomalous. Rating: 1.

Possible Explanations. Acquired characteristics can be inherited. More specifically, environmental conditions can, in ways not yet appreciated, induce changes in genomes. It is also possible that changes in the genome are not involved at all but, rather, that some sort of maternal effect is operative, as suggested in X2 below.

Similar and Related Phenomena. The possible inheritance of effects induced by rotation (BMF11). In the Series-B catalogs, check the Subject Indexes under: Larmarckism.

Entries

X0. Introduction. Our systematic search for anomalies in scientific publications has led to the retrieval of descriptions of two independent series of experiments in which laboratory mice were subjected to low temperatures over several generations. The low temperatures led to measurable physical changes in both series---some anticipated, others not---and these changes usually showed up in the animals' progeny. Are we seeing the inheritance of acquired characteristics;

that is, Lamarckism? Both authors quoted below are careful not to claim proof of Lamarckism, although the first cagily uses the word "reappearance" in the title of his report!

X1. The Sumner experiments. The introductory paragraphs of F.B. Sumner's 1910 paper in the American Naturalist set the stage nicely.

> In a recent paper I have described a series of experiments conducted during the past few years upon white mice. I have there shown that large enough differences of temperature, operating throughout the period of growth, bring about considerable, and in some cases quite obvious, differences in the length of peripheral parts (tail, foot and ear), and probably changes in the quantity of hair as well. The peripheral parts were found to be longer in the warm-room lots (12 to more than 30 per cent. longer, in the case of the tail); the amount of hair, on the contrary, was less. It was pointed out, furthermore, that differences of precisely this sort have long been known to distinguish northern from southern races of mammals.
>
> The question of most vital interest was not, however, touched upon the the earlier paper, although it has furnished my real motive for pursuing these experiments throughout. Are these modifications purely transitory, that is to say confined to the generation immediately affected, or do they reappear, if only to a slight degree, in the offspring? I have long felt that satisfactory evidence for or against the transmission of such modifications would be lacking, so long as zoologists confined themselves to a search for directly visible qualitative differences. (R1)

Sumner divided his laboratory mice into warm-room and cold-room groups and proceeded to measure such quantitative characteristics as weights and the lengths of tails, feet, and ears. The offspring of warm-room mice, on the average, weighed less and had longer extremities than the descendants of the cold-room mice.

Sumner presented seven potential explanations of his results. One of these was pure Lamarckism, which he dismissed as impossible because:

> ...in a warm-blooded animal differences of temperature, as such, could not affect either the fetus or the germ cells to any appreciable extent. (R1)

This is, of course, today's mainstream assumption regarding the question of the inheritance of acquired characteristics.

Explanations based on coincidence and personal bias were also put forward by Sumner but again discounted. His seventh and last explanation, though, deserves mention:

> Finally, we have the view that the changes undergone by the parent body are in some way registered in the germ cells, so as to be repeated, in a certain measure, in the offspring. The "classical" attempt to make this process intelligible is of course Darwin's hypothesis of "pangenesis." (R1)

In other words, temperature did not change the genome directly but rather through the physiological changes it had wrought. Shorter tails induced by the cold would, for example, be duly registered by the genome.

Sumner did not subscribe to any of his proffered explanations.

X2. The Barnett experiments. S.A. Barnett, a zoologist at the University of Glasgow, was intrigued by the discovery, made during World War II, that meat lockers kept at about -10°C were sometimes infested with large colonies of house mice. These mice had adapted well to the low temperature and not only feasted on the frozen carcasses but actually nested in the body cavities. The observed physical changes in the mice were essentially the same as those measured meticulously by Sumner. (X1) But, during his extensive experiments with mice exposed to very cold conditions, Barnett observed other changes worth mentioning here.

> When mice are transferred to the cold

as adults they often lose many nestlings; and when their offspring are bred, they lose even more. The worst breeders are often those of the first and second generations reared in the cold.

What about subsequent generations? These have displayed certain extraordinary features as yet unexplained.

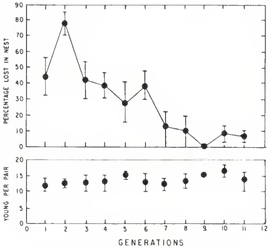
Consider first a genetically mixed stock of mice---with individuals of many colours and differing in other respects also. Such mice have been bred at -3°C, and selected for success in the cold. Over the generations an improvement would be expected; this would be attributed to selection of genetically more cold-resistant individuals. In one experment of this sort, during the first three generations, the nestling mortality averaged about forty per cent; after the twelfth generation it had fallen to less than ten per cent. There was also an increase in body size which perhaps conferred a small advantage in the cold.

By contrast, if a highly inbred strain were transferred to the cold, no such progressive change could be expected. A highly inbred strain is genetically fairly uniform, and so gives little scope for improvement by artificial selection.

Nevertheless, two inbred strains transferred to the cold did in fact display a substantial improvement over a number of generations. Each began with a nestling mortality of fifty percent or more; but in both the rate declined to a figure similar to that of their cousins maintained at 21°C. The number of young born to each pair did not change over the generations.

.....

The strange, almost bizarre, modification in the mice kept for many generations in a cold environment suggests at first sight a genetical change; but it cannot be one. Evidently it is some sort of cumulative maternal effect. It may be that a disease organism is present; that it is transmitted from mother to young; and that it has become progressively less virulent over the generations. This is only one possible kind of maternal effect.



Decline of nestling mortality in succeeding generations under cold conditions.

The principal fact is that inbred mice have become better adapted to a cold environment as a result of breeding there for a number of generations. This unexpected observation, whatever the detailed explanation, suggests that the cold-adaptation of mammals has features which cannot be fully revealed by short-term experiments. (R2)

Interestingly enough, both Sumner and Barnett go out of their ways to deny the possibility of temperature directly changing the genome. In the end, neither has a satisfactory explanation for his experimental results.

Today's explanation would have random mutations producing cold-tolerating characteristics along with many other changes unrelated to the environmental problem at hand. Many of the accompanying changes would likely be disadvantageous. Only those useful to the organism would be selected. A problem arises, however, in the observation of the nearly identical effects seen in both genetically mixed and inbred mice. One would expect the latter to be much less adaptable.

References

R1. Sumner, Francis B.; "The Reappearance in the Offspring of Artificially Produced Parental Modifications," American Naturalist, 44:5, 1910. (X1)
R2. Barnett, S.A.; "Mice at -3°C," New Scientist, 27:678, 1965. (X2)

BMF11 Inheritance of the Effects of Rotation

Description. The appearance in progeny of behaviorisms and functional modifications that had been induced in parents by prolonged rotation. Breeding occurred after the parents' rotation, and the descendants did not undergo rotation.

Data Evaluation. To date, we have found only one report describing the rotation experiments that defined the subject phenomenon; and this was not authored by the researchers themselves. We need to know more about the experimenters, their institution, and the experimental details. Rating: 3.

Anomaly Evaluation. As with adaptations to cold (BMF10), a Lamarckian interpretation is possible for the rotation experiments described below. One would not expect mere physical motion---rotation here---to affect the genome. If no other interpretation is more likely, the rotation phenomenon supports the inheritance of acquired characters (Lamarckism) and is, therefore, an important challenge to the evolution paradigm. Rating: 1.

Possible Explanations. Essentially the same as in BMF10: Contrary to current thinking, acquired characteristics can be inherited. More specifically, environmental conditions can, in ways not yet appreciated, induce changes in the genome. It is also possible that genome changes are not involved at all but, rather, that some sort of maternal effect is operative, as suggested in BMF10-X2.

Similar and Related Phenomena. The possible inheritance of effects induced by a prolonged cold environment (BMF10). In the Series-B catalogs, check the Subject Indexes under: Lamarckism.

Entries

X1. Experiments in long-continued rotation. The research now recounted was apparently undertaken for military purposes during World War I by two psychologists, Bentley and Griffith.

Everyone is familiar with the sensation of dizziness that usually results from a rapid spinning upon one's heels, or an experience in the merry-go-round, or even with the revolving chair or turntable of the laboratory. Associated with this is a twitching back and forth of the eyes and oscillatory movements of the head to which we apply the term "nystagmus." Such responses are really compensatory adjustments, the object of which is to retain the same field of vision and original bodily position which the subject had prior to the application of the stimulus. Thus in a rat rotated clockwise or to its right, say ten turns in twenty seconds, on the turntable in a horizontal plane around a vertical axis, the two eyes make coordinated movements in a direction opposite to rotation during rotation, slowly moving to the left and snapping back to normal, while the head swings to the left---i.e., versus rotation. If the rotation is then suddenly arrested, the head swings to the right or in the direction of former rotation, while the eyes show the slow compensatory movement to the right with the quick return movement to the left---to which phenomenon we apply the term "after-nystagmus." ...Indeed, if the stimulus is intense, the bodily manifestations may be profound and involve pronounced muscular, glandular, respiratory, and vascular responses. This fact, that after-nystagmus persists for some seconds after rotation, makes it possible to measure the response to a given unit of stimulus in terms of time. (R1)

To explore the phenomenon of equilibration, an experiment was devised in which white rats were rotated over long periods of time. They were spun at 60, 90, and 120 revolutions per minute. Many rats accumulated millions of rotations. The animals adapted and learned to eat, sleep, reproduce, and generally lead normal lives in rotating nests. Upon removal from their spinning nests, the rats would often run or walk in directions parallel to their former rotation for several weeks. Two results followed:

(1) Such subjects showed increased muscular incoordination [sic], ocular movements became modified, they declined rapidly, and died, or

(2) They recovered after several weeks and appeared normal; but after several months deep-seated effects apparently cropped to the surface, and the subjects showed modified muscular and ocular movements, the necks and heads were twisted, and signs of labyrinthine or vestibular disturbances became apparent. (R1)

Rats that were removed from the rotating nests were bred among themselves and also with unrotated rats. The results of these matings defied conventional genetic conceptions in two ways:

(1) That individuals with a long history of rotation in their ascendants showed a peculiarly high incidence of disequilibrated progeny among the descendants, although the descendants were not rotated; and

(2) That the type of disequilibration in these descendants is specific in that it shows a one-to-one correspondence to the type of ancestral rotation. (R1)

The psychologist Griffith mentioned at the beginning of this entry was probably C.R. Griffith, who published a relevant report in Science in 1922. (R2)

References

R1. Detlefsen, J.A.; "Are the Effects of Long-Continued Rotation in Rats Inherited?" American Philosophical Society, Proceedings, 62:292, 1923. (X1)

R2. Griffith, C.R.; "Are Permanent Disturbances of Equilibrium Inherited?" Science, 56:676, 1922. (X1)

BMF12 Male Lactation

Description. The observation of lactation in a few species of healthy, male mammals, both wild and domesticated, including humans. Except for rare human cases, it is not known if this unexpected lactation ever serves any useful purpose.

Data Evaluation. Lactation in one species of fruit bat has been reported in the scientific literature, from which were derived several articles in popular publications. Only passing references to male lactation in domesticated mammals and humans have been seen, except for several very old cases in Gould and Pyle's Anomalies and Curiosities of Medicine. The phenomenon appears quite real in humans, though usually pathological; but more study is obviously needed, particularly with wild mammals. Rating: 2.

Anomaly Evaluation. Male mammals usually possess underdeveloped mammary glands. These can be induced to develop through the use of hormones and, occasionally, under pathological conditions. While male lactation is not normal, neither is it biologically impossible under certain conditions. We must, therefore, in most instances, label male lactation as a mere curiosity and search for specific causes. A bit more anomalous would be the demonstration that male lactation in a wild species is sometimes normal and used in rearing young. Rating: 3.

Possible Explanations. The consumption of wild food containing hormones that stimulate male lactation. Social or psychological pressures might encourage male lactation, as may occur rarely in humans. Mutation might initiate male lactation as a normal function.

Similar and Related Phenomena. The secretion of pigeon "milk" by male pigeons (BBF). Some fish also exude a nutritious fluid from skin glands for their young (BFF).

Entries

X1. General observations.

Dayak fruit bats. During a survey of the animals inhabiting the forest canopy in the Krau Game Reserve, Pahang, Malaysia, C.M. Francis et al netted male fruit bats (Dyacopterus spadiceus) that were capable of giving small quantities of milk. These scientists wrote in Nature:

> In July and August 1992, we captured 18 D. spadiceus in mist nets 8-30 m above the ground in the subcanopy of a lowland rainforest at Kuala Lompat in the game reserve. Of the 13 males that were captured, 10 were judged to be mature based on fully-ossified wing joints and descended testes. Each of the mature males also had functional mammary glands from which small amounts of milk were expressed. Among the five females that we captured, three were mature, but milk could be expressed from only one in response to manual palpation. (R4)

> The scientists do not yet know whether the males nurse young bats or otherwise put the milk to use. The amount of milk detected in the males, while clearly visible, was only about a tenth of the amount produced by the lactating female bats they captured. (R3)

When dissected, the lactating males were found to have normal testes and were in good health. Their mammary tissue, however, appeared very similar to that of the female breasts.

Attempting to explain male-bat lactation, one of the scientists, T. Kunz, speculated that, if these bats were monogamous, the males would gain an evolutionary advantage by wet-nursing their offspring. Unfortunately, the social habits of this species are poorly known; and this is only a guess.

Another possibility is that the male bats were eating leaves that contained high concentrations of phytoestrogens, which might stimulate breast development and even lactation. Generally, though, fruit bats stick to fruit. (R2, R3)

Domesticated mammals. Some inbred, domesticated male mammals, such as sheep and goats do, in rare cases, lactate. These cases may be due to mutations. In the wild, however, no males, except for the Dayak fruit bats, have been found lactating so far. (R3)

Humans. Human males, if given sufficent quantities of estrogen and progesterone, will grow larger breasts and possibly lactate. Some pathological conditions, such as liver disease can create the same effect. The scientific term for such male lactation is "gynaecomastia."

However, G.M. Gould and W.L. Pyle, in their compilation of human biological anomalies, offer several cases where healthy, unmedicated human males lactatated. We now quote:

> These instances of gynecomazia [sic] are particularly interesting when the individuals display ability to suckle infants. Hunter refers to a man of fifty who shared equally with his wife the suckling of their children. There is an instance of a sailor who, having lost his wife, took his son to his own breast to quiet him, and after three or four days was able to nourish him. Humboldt describes a South American peasant of thirty-two who, when his wife fell sick immediately after delivery, sustained the child with his own milk, which came soon after the application to the breast; for five months the child took no other nourishment. (R1)

So, possibly, some social and psychological situations can, in very rare situations, stimulate male lactation. Whether these observations are applicable to the Dayak fruit bats in unknown.

References

R1. Gould, George M., and Pyle, Walter L.; Anomalies and Curiosities of Medicine, New York, 1896. (X1)

R2. Fackelmann, K.A.; "Real Males That Lactate: A Batty Story," Science News, 145:148, 1994. (X1)

R3. Angier, Natalie; "Lactating Male Bats Found in Malaysia, Researchers Report," New York Times, February 24, 1994. Cr. J. Covey. (X1)

R4. Francis, Charles M., et al; "Lactation in Male Fruit Bats," Nature, 367:691, 1994. (X1)

BMF13 Asymmetry in the Function of Mammary Glands

Description. The ability of some mammals to produce two distinctly different types of milk---from different mammary glands---for offspring of different ages.

Data Evaluation. Our primary source is a popular book on Australian natural history. No mainstream scientific references have been found to date, but there are undoubtedly some. Rating: 2.

Anomaly Evaluation. Mammalian glands often alter their functions with the requirements of the animal, especially with advancing age. Usually, though, all glands of the same type work in concert, in particular the mammary glands. Nevertheless, there seems to be no law against paired or multiple glands functioning differently if they receive different signals. In this light, mammary glands functioning differently may be labelled as unusual, curious, and even remarkable, but not as especially anomalous. However, the signals involved and the details as to how milk production is changed and the evolution of same remain unelaborated. Rating: 3.

Possible Explanations. The different nursing habits of the in-pouch and out-of-pouch joeys might well stimulate the mammary glands to secrete different milks, as required.

Similar and Related Phenomena. The first milk of dairy cows and other mammals usually has a different composition (the colostrum) from later production. Non-lactating humans (females and, rarely, males) can sometimes be stimulated to lactate by suckling a child. Male lactation (BMF12)

Entries

X1. General observations. To date, only one mammal has been noted as exhibiting asymmetrical lactation.

Red kangaroos. Red kangaroos (Macropus rufus) are majestic marsupials. Balanced on their massive tails, the males are taller than the average man. The females, though, are not red, but blue grey, which accounts for their popular name "blue fliers."

> At any one time, blue fliers can have a joey at foot, another in the pouch and a dormant embryo in the uterus. Of the four teats, two are always in use; one for the joey developing inside the pouch, the other for the youngster finding its feet outside. And each teat provides different milk: the teat that feeds the pouch young is high on carbohydrates and low on fats, while the youngster at heel, which is burning up much more energy, receives milk that is very rich in fats. (R2)

C. Brown has provided a few details as to the compositions of the two types of milk:

> The red kangaroos, Megaleia rufa, can make two kinds of milk simultaneously: milk suitable for the newborn young in one gland and in the other gland milk suitable for a young kangaroo at heel. The two kinds differ considerably: that for the newborn contains, for instance, 51% palmitic acid and 15.6% oleic; whereas the other contains about 25% palmitic and 53% oleic. (R1)

Some taxonomists place the red kangaroo in a separate genus, Megaleia, which accounts for the conflicting generic names in the two quotations.

The females of other kangaroo species also must feed simultaneously both in-pouch and out-of-pouch young. It is probable that they, too, exhibit the same asymmetry.

References

R1. Brown, Colin; "The Monotremes," Creation Research Society Quarterly, 18:187, 1982. (X1)

R2. Vandenbeld, John; Nature of Australia, New York, 1988. (X1)

BMF14 Pressurized, Sealed Suckling Systems

Description. The existence in some mammals of special adaptations that allow their young to be pressure-fed milk when they cannot, for one reason or another, nurse in the usual fashion. Such adaptations include seals, extended tubes, and modified muscles. Such are best seen in the cetaceans, where underwater suckling is common.

Data Evaluation. All information presented here comes from science books on the popular level. Although we have not yet processed relevant scientific papers, we presume that the facts presented do have scientific foundation. Rating: 2.

Anomaly Evaluation. Here is still another example of "marvelous" adaptation engineered by evolution. In the cetaceans, especially, numerous biological changes in both mother and offspring had to be orchestrated in harmony to make underwater suckling possible. The "plumbing" between mother and young, as well as behavior patterns, have to be perfect---half a nipple cap is unacceptable! Most biologists just take it for granted that random mutation and natural selection can accomplish all the coordinated innovations. (What else is there?) We are not so sure and, as customary in this Catalog, decline to evaluate the claimed anomaly.

Possible Explanations. Random mutation plus natural selection are sufficient. If not, perhaps "adaptive mutation" might be invoked.

Similar and Related Phenomena. We ask the same questions of many biological developments. In the Series-B catalogs, see the Subject Indexes under: Adaptive evolution; Evolution.

Entries

X0. Introduction. Normal suckling and nursing in mammals involves suction and/or pressure on the mammary gland to force milk flow as well as mechanical sealing to minimize leakage. An infant mammal's lips and mouth usually perform these "engineering" functions with reasonable (but not perfect!) efficiency.

Two situations occur where significant modifications to normal suckling are required: (1) In marsupials, where the young are not sufficiently developed to nurse and the pouch environment makes good sealing a necessity; and (2) In the cetaceans (whales and dolphins), where the young cannot purse their lips and feeding occurs underwater. The latter condition also makes speedy feeding (under pressure) desirable, because if the young whale is nursing fully submerged it must return fairly quickly to the surface for air.

Nature has solved these engineering problems in different ways. Only in the case of the cetaceans do we find a need to seriously question the efficacy of the accepted evolutionary paradigm.

X1. Marsupials. Probably all marsupials force-feed their young, which at first are almost fused to their mothers' nipples. However, we have come across only the few specifics noted below.

Kangaroos in general.

> The new-born kangaroo is only an inch long and unable to suck. It seizes a teat, whose end swells at once so that the young can scarcely be pulled off. A sphincter muscle in the mouth of the young also helps it to hold its grip. Its mother has a special adaptation of the cremaster muscle as well, which enables her to squirt milk down its throat, past the larynx, otherwise the infant would drown in milk. (R2)

The joey's instinctive behavior after birth and the specially developed muscles are all necessary for this nursing stratagem to work.

Virginia opossum. L.L. Rue, III, (R3) states that in this species the young do not have to nurse, but are force-fed by the mother. Presumably, this is true of other possums and opossums.

X2. Cetaceans. The special suckling equipment evolved by the whales and dolphins is more elaborate than that seen in the marsupials. This is not surprising given the water environment.

Whales in general. D. Dewar expands on this as follows:

> Whale calves are born and suckled under water. This would be impossible if both mother and young were not specially adapted for this. In order that the baby whale can breathe while taking in milk and the adult breathe while taking water into the mouth, the epiglottis and the laryngeal cartilage have to be prolonged upwards to form a cone-shaped tube, and the soft palate has to be prolonged downwards so as tightly to embrace this tube. Then there must be a cap round the nipple of the mother into which the snout of the young one fits tightly. The mother also has to have a milk reservoir and apparatus for forcing milk into the mouth of her calf. If the whale evolved from a land ancestor all these adaptations must have been made before the sudden change from suckling the young in air to suckling under water. These adaptations are hardly noticed in the textbooks, which also slur over the locomotor difficulties. (R1)

Dewar was an early critic of evolution and wrote from that perspective, but his facts and doubts are echoed elsewhere.

R. Wesson, certainly not a creationist, also singled out underwater suckling as a case of complex, coordinated evolutionary innovation required before whales could suceed in a radically new environment.

> ...they had to become able to give birth in the water, a process that must have involved new instincts for both mother and calf, including suckling the calf by pumping milk into its mouth, having surrounded the nipple with a cap to keep out seawater. It is difficult to imagine how all this could have come about without a remarkable series of highly coordinated changes. (R5)

Sperm whales. These two sentences probably apply to all cetaceans.

> After the baby whales are born, special muscles at the mother's nipples will pump milk down the young whale's throat. This method is nescessary because whales cannot purse their lips and suckle. (R4)

To use a modern simile, underwater nursing is a lot like the aerial refueling of planes.

References

R1. Dewar, Douglas; The Transformist Illusion, Murfreesboro, 1957. (X2)
R2. Shute, Evan; Flaws in the Theory of Evolution, Philadelphia, 1961. (X1)
R3. Rue, Leonard Lee, III; Pictorial Guide to the Mammals of North America, New York, 1967. (X1)
R4. Thomas, Warren D., and Kaufman, Daniel; Dolphin Conferences, Elephant Midwives, and Other Astonishing Facts about Animals, Los Angeles, 1990. (X2)
R5. Wesson, Robert; Beyond Natural Selection, Cambridge, 1991. (X2)

BMF15 The Ability of One Mammal to Control the Sexual Functions of Another

Description. The ability of one mammal to influence another's sexual functions, including: sexual maturation, estrus, ovulation, and pregnancy. Such functions are closely related, as are the stimuli purported to control them.

Data Evaluation. The subject phenomenon has been recognized for years, particularly in laboratory mice. Our sources range from authoritative mammal guides to science magazines, but there is a corpus of references to articles in specialized journals that has not been checked. Rating: 2.

Anomaly Evaluation. While scientists have identified the obvious factors involved in the control of sexual functions (pheromone emission, bullying, etc.), many biochemical and psychochemical details have not been elucidated. This, however, is mostly only a matter of additional research and not paradigm-challenging. As for the evolution of sexual-function control, it is (as usual) easy to find superficial explanations in terms of maximizing the reproductive successes of a species and individuals of a particular species. The possible anomaly is in the complexity of the pheromone control system. Like the universe of odors and scents, the world of pheromones is hard for humans to appreciate given their dulled senses. We can marvel at the engineering of the vertebrate eye, but the complexity of the pheromone "language" and the organs that "listen" to it and act upon receipt of pheromone signals is probably greatly underestimated. Considerable biological innovation was required to convert the receipt of a specific pheromone into those signals needed to, say, terminate a mouse's pregnancy. In this catalog, we recognize that the established evolutionary paradigm always suffices for most biologists, but we suspect that it is really inadequate in many cases, including the phenomenon at hand. No anomaly rating is attempted in such situations.

Possible Explanations. Superficially, the combination of pheromones, visual cues, and bullying seem to comprise a reasonable explanation. If the evolution paradigm turns out to be insufficient, as it well may be for the chemicals and sensors required in the pheromone system, "adaptive evolution" is another possibility.

Similar and Related Pheomena. Synchrony of menstrual cycles in monkeys (BMF16) and humans (BHF15 in Humans II); the behaviors of eusocial and highly social mammals (BMB31 in Mammals I). See the Series-B Subject Indexes under: Complexity; Innovation; Evolution, adaptive.

Entries

X1. Sexual maturation. Some mammals can accelerate or delay the sexual maturation of younger members of the same species.

Laboratory mice. A young, prepubescent female mouse will, of course, eventually reach sexual maturity, but:

> ...put an adult male into the cage with her and she will reach puberty earlier. This intriguing phenomenon, known as the Vandenbergh effect, is produced by pheromones---chemicals that cause a behavioral response in other animals of the same species---in the male's urine. These pheromones, when detected by a sensing organ in the roof of the female's mouth, crank up her ovulatory machinery. (R4)

The converse also holds true. If the same female mouse is caged with a group of mature female mice, her sexual maturity will be delayed. If her pheromone-sensing organ in her mouth is blocked, the delay will not occur. (R4)

Orang-utans. Male orang-utans come in two varieties: (1) A large, muscular, dominant type, with thick long hair, a large muscular throat pouch, and fatty cheek flanges; and (2) A gracile, adolescent variety lacking those secondary sexual characteristics that announce sexual maturity. Age does not seem to be the factor controlling the full development of the gracile type. If the dominant male in an area is removed, one of the gracile orangs will quickly mature and assume adult characteristics. (R4) Obviously, there is some suppression factor at work here, probably pheromones.

Other mammals. Similar supressions of sexual maturity can be observed in young female baboons, several species of monkeys, mongooses, elephants, and others. (R3)

X2. Estrus (sexual receptivity). Except for humans and, perhaps, orang-utans, the sexual receptivity of female mammals is normally cyclic. In some species, though, it can be suppressed completely.

Bush dogs. The bush dog is a small carnivore of northern South America. Typically, the female bush dog does not exhibit any of the characteristics of estrus unless paired with a male, in which case the estrus cycle quickly manifests itself. (R2)

On the other hand, a dominant female bush dog in a family group will suppress estrus in her daughters. (R1) Presumably, pheromones are again at work.

Other mammals. Undoubtedly, this phenomenon is widespread, but when discussed it is usually merged with the distinctly different phenomena of suppression of sexual maturity (X1) and ovulation (X3)

X3. Ovulation. Obviously closely related to the estrus cycle of sexual receptivity is the key function of ovulation. We separate the two functions because in some mammals, such as cats and rabbits, estrus takes place without ovulation. If copulation does occur during estrus, only then will there be ovulation.

Marmosets. In a group of these New World monkeys, only one female gives birth.

> The dominant female actually makes her subordinates infertile: their ovaries shrivel and stop releasing eggs. After many years of research, biologist David Abbott has figured out how such dominance is enforced ---it's a combination of pheromones, visual cues, and simple bullying. (R5)

The phenomenon is usually termed "ovarian suppression." It is fairly common among mammals, especially the more social species.

Naked mole rats. These animals are "eusocial." They live in highly structured colonies similar to those of the social insects. (See BMB31-X1 in Mammals I for details.) Only the queen naked mole rat breeds, and she suppresses the fertility of her daughters through a combination of pheromones, sheer presence, bullying, and outright murder. Pheromones were originally believed to be the sole factor controlling the daughters' fertility, but further research proved that these other forces were also at work.

Other mammals. The list is long: prairie dogs, common African mole-rats, dwarf mongooses, mongooses, jackals, meercats, wolves, etc.

X4. Pregnancy.

Mice. The presence of a new, dominant male mouse in a colony not only accelerates the sexual maturity of young females (X1), but his pheromones will also terminate the pregnancies of those females that were fertilized by other males. (R3)

As in all of the foregoing aspects of sexual-function control, the details of what happens between the receipt of a pheromone signal and the resultant actions, say, pregnancy termination, are still unknown in detail.

References

R1. Eisenberg, John F.; Mammals of the Neotropics, vol. 1, Chicago, 1989. (X2)

R2. Nowak, Ronald M.; Walker's Mammals of the World, Baltimore, 1991. (X2)

R3. Wesson, Robert; Beyond Natural Selection, Cambridge, 1991. (X1, X4)

R4. Sapolsky, Robert; "Growing Up in a Hurry," Discover, 13:40, June 1992. (X1)

R5. Richardson, Sarah; "A Monoply on Maternity," Discover, 15:28, February 1994. (X3)

BMF16 Correlation of Primate Menstruation with Lunar Phase

Description. The synchrony of the menstrual cycles of some of the higher primates with the lunar cycle.

Data Evaluation. Our data come from secondary sources. One of these is a popular book and contains an obvious error. We are not too confident of the reality of the claimed phenomenon. Rating: 3.

Anomaly Evaluation. The synchronizing of monkey menstruation with lunar phase via chemical signals from the pineal gland appears to be a reasonable explanation, but scientific proof is still lacking. Another question concerns the survival value of this synchrony, if any. Is it just an accident of evolution? We have no basis for evaluation here.

Possible Explanations. See X1 below.

Similar and Related Phenomena. Associaton of the human menstrual cycle with lunar phase (BHF14 in Humans II).

Entries

X1. General observations. The similar lengths of the human menstrual cycle and the lunar cycle were remarked early in the history of humankind. However, it has been difficult to firmly establish a cause-and-effect connection. (See: BHF14 in Humans II.)

The only other mammals known to menstruate are some of the higher primates. Here, too, some scientists suspect a lunar effect.

Monkeys in general. E. Dewan, who studied the possibility that periodic light stimuli could effect human birth control (R1), also speculated on the influence of moonlight upon monkey menstruation.

> Dewan has suggested that the menstrual cycles of monkeys around the equator are synchronized because each cycle is locked in phase with the Moon. As the production by the pineal gland of a substance which inhibits the action of luteinizing hormone is suppressed by light, the continuous light of nights with a full Moon would facilitate ovulation across a group of monkeys and induce synchrony. (R2)

Guenon monkeys. P. Katzeff gives a more specific example in his popular book Moon Madness:

> A Dutch army surgeon apparently trying to make the most of his time during a hitch in Surinam, once a colony of the Netherlands in South America, made a similar observation. This surgeon, a fellow named Hill, noticed that the local guenon monkeys menstruated for three days at every new moon and also seemed to go into heat then. (R3)

The monkey species must be in error above, because guenon monkeys are Old World monkeys and are unknown in South America.

References

R1. Dewan, Edmond; "On the Possibility of a Perfect Method of Birth Control by Periodic Light Stimulation," American Journal of Obstetrics and Gynecology, 99:1016, 1967. (X1)

R2. McClintock, Martha K.; "Menstrual Synchrony and Suppression," Nature, 229:244, 1971. (X1)
R3. Katzeff, Paul; Moon Madness, Secaucus, 1981. (X1)

BMF17 The Delayed-Birth Phenomenon

Description. The ability of a very few inseminated female mammals to delay the births of their offspring by inserting delays in the processes occurring between mating and birth. We catalog three methods identified so far: (1) delayed implantation of the embryo; (2) delayed development of the implanted embryo; and (3) delayed fertilization of the ovum.

Data Evaluation. Delayed implantation and delayed fertilization are firmly established in the scientific literature, but delayed development of the implanted embryo has been tentatively demonstrated for only a single species. Our sources include books by scientific authorities and a couple articles from respected science magazines. Rating: 1.

Anomaly Evaluation. The varied aspects of the delayed-birth phenomenon engender several questions, as detailed in X4 below. Those questions associated merely with the elucidation of the control signals and biochemical mechanisms of the phenomenon will doubtless yield to further research. More serious are the anomalies we see related, on one hand, to the many appearances of delayed implantation sprinkled across many widely separated mammalian families and genera and, on the other hand, its appearance and absence in closely related species and even in different populations of the same species. These features seem difficult to account for using the established evolutionary paradigm. Was delayed implantation invented separately 100+ times, or did parallel evolution occur 100+ times? As for delayed development and delayed fertilization, these methods of inserting time delays seem confined to just a few species of bats and do not pose such serious problems. Rating: 1.

Possible Explanations. All mammalian genomes incorporate the instructions for introducing delayed implantation, but these orders are activated only when useful; that is, the potential for delayed implantation was evolved only once long ago. Another possibility is that the generally rejected theory of morphic resonance is at work.

Similar and Related Phenomena. None.

Entries

X0. Introduction. In about 97% of the earth's 4,400+ species of mammals, the fertilization of the egg and its implantation on the uterine wall occur within a few days of mating. The remaining 3% of the mammals have evolved biochemical schemes by which the time between mating and birth can be extended so that birth occurs at more propitious times. In other words, normal gestation times are sometimes too short, and births would occur at inconvenient, even fatal, times---as in the middle of the winter. Three different sorts of delayed-birth systems are considered here:

(1) Delayed implantation of the embryo. During the delay, the embryo, which usually consists of a hundred or so cells in a microscopic ball called a "blastocyte," ceases further development and floats freely in the uterus until a signal to implant is forthcoming.

(2) Delayed development. Here, the embryo is implanted on the uterine wall, but further growth is suspended, pending some sort of go-ahead signal.

(3) Delayed fertilzation. Sperm are stored until a go-ahead signal is received for ovulation and fertilization and implantation.

Of course, the time of birth could also be shifted forward or backward by changes in mating schedules. This probably has occurred and may still be occurring in nature, but it is hard to demonstrate it historically or paleontologically.

The potential advantages of delayed births are several:

(1) Births can be scheduled for times when food is abundant.

(2) Births can occur in the spring, giving infant mammals enough time to mature before the next winter sets in.

(3) Embryonic development can be delayed so that the female will not be overburdened during lean times of the year, when mobility and energy conservation are important to survival. For example, a female marten must not be hampered by a heavy embryo when hunt-during the winter months.

(4) Birth can be delayed until an earlier offspring has developed to a stage when it no longer needs its mother, as seen in some marsupials.

(5) Births can be synchronized in mammals that congregate annually in breeding colonies, as in some pinnipeds.

X1. Delayed implantation. Over a hundred species of mammals employ this phenomenon to improve their overall fitness, including both marsupials and placentals. Here, we will mention a few that may be of more than passing interest to anomalists.

Armadillos in general. The gestation periods of these neotropical mammals is prolonged by delayed implantation at the blastocyte stage. (R1) It is not immediately obvious why these warm-climate, non-migrating, terrestrial mammals benefit from delayed implantation.

Pinnipeds in general. In many, but far from all, pinnipeds (seals and sea lions) embryo implantation is delayed from 6 weeks to 5 months. (R4) Some research indicates that the delay may even stretch out to 10-11 months in the Australian sea lion. (R1)

Since many pinnipeds come ashore in colonies once a year to give birth and breed, some annual synchronization is a necessity. Usually, mating takes place within a few days of pupping, but the implantation of the blastocyte is delayed just the right length of time for each species so that births occur together at the next annual gathering of the breeding colony. (R1)

California sea lions. Curiously, not all pinnipeds, even closely related ones, employ delayed implantation. In fact, the California sea lions along California shores give birth from mid-May through late June and are probably synchronized through delayed implantation, but in the Galapagos the same species produces young throughout the year, except for April and May. No synchronization is needed there. (R1)

R.R. Reeves et al state that delayed implantation has not yet been demonstrated for the New Zealand seal lion (a very close relative of the Australian sea lion) nor for the leopard and northern elephant seals. (R4)

The mustelids in general. Delayed implantation is observed in many mustelids (otters, weasels, badgers, etc.).

Ermines. The ermine (stoat) breeds in the spring and early summer, but implantation waits until the following March---a rather long delay.

Badgers. Old World badgers mate from late winter into midsummer. The fertilized eggs stop developing at the blastocyte stage and may remain in that state for 10 months. The actual time of implantation seems to be associated with the amount of sunlight and the outside temperature. (R1) How do these external signals actually actuate the implantation process?

Fishers. In this species, the delay of implantation is about 10 months. Like many pinnipeds, the female fisher breeds again within a few days of birthing. The question arises: Why would the breeding season occur so soon, at a time when the female is burdened with young to feed and care for? Unlike the seals which disperse after their annual get-togethers, the fishers could wait until later. Experts are puzzled by this? (R2)

Spotted skunks. Another mustelid puzzle involves North America's eastern and western spotted skunks---look-alikes and very closely related. The eastern species does not delay implantation but the western species does. (R3)

Weasels. Long-tailed and least weasels look alike and have the same habits, yet the former delays birth for months, but the latter does not.

Roe deer. This species is the only deer (cervid) found to employ delayed implantation, but not all the roe deer take advantage of the phenomenon. Most females mate in July and August, with the blastocyte remaining floating in the uterus for about 4 months, so that birth occurs in the spring. A few females, though, delay mating until November and December. Their embryos are implanted almost immediately, and their fawns arrive in synchrony with the others. (R1)

Why does the phenomenon manifest itself only in some members of a species? Are their genomes that different?

Bears in general. At least three members of the bear family are known to use delayed implantation: black, grizzly, and polar bears---actually, all three are so closely related that the species barrier is fuzzy here. (BME8-X2) These bears mate in the spring and early summer, but implantation holds off until autumn. Birth is timed to occur in the spring during their so-called "hibernation." (BMF7) But if the female bear has not stored up enough fat during summer and fall to sustain her and her cubs, the blastocyte will not implant; there occurs a sort of "nutritional threshold" signal, the detailed nature of which is unknown. (R3)

Kangaroos and wallabies. As is usually the case, marsupials do things a bit differently. Female kangaroos and wallabies are essentially assembly lines for producing new kangaroos and wallabies as fast as the environmental conditions permit. Most females are attending, in one way or another, to three offspring: a joey that is well along in development and in and out of the pouch; a baby firmly attached to a teat in the pouch; and an embryo floating in the uterus that consists of some 80-100 cells. The latter is awaiting a signal to begin further development. This signal actually originates with the baby attached to the teat.

> Biologists agree that the baby's suckling keeps the embryo quiescent and prevents the development of the corpus luteum, a gland that secretes progesterone to prepare the uterus for pregnancy. But an anomaly occurs towards the end of the suckling. The corpus luteum and the embryo resume the process of development---despite the continued presence of young in the pouch. (R2)

Apparently, we still have much to learn about the biological signals involved in delayed implantation.

A bit of background information is appropriate here. Taxonomists separate marsupials from the "placental" mammals, but many marsupial embryos are connected to the uterine wall via a "yolk-sac" placenta. In some other marsupial species, a rudimentary placenta actually does develop. (R1)

The "assembly-line" approach of the kangaroos and wallabies seems to be a big advantage in Australia with its often harsh conditions. Under severe pressures, the infant attached to the teat may die, signalling the dormant embryo to begin developing to replace it. Meanwhile the female will mate again to keep the assembly line filled! (R1, R2)

X2. Delayed development. A few bats are somehow able to slow down the development of an implanted embryo. This achieves the same result as delayed implantation by inserting a time delay between mating and birthing.

California leaf-nosed bats. This bat, Macrotus californicus, one of the "big-eared bats," can slow down embryo development over the winter months. As spring approaches, some sort of signal causes development to accelerate in time for a spring birth---a time when food is more readily available, especially in the northern part of its range. (R1, R5) So far, this is the only mammal we have found using this approach.

X3. Delayed fertilization. Many insects store sperm for future fertilization of ova, but only a few mammals have availed themselves of this time-delay technique. (R1) As with the delayed-development approach (X2), it seems to be a trade secret of the bats.

> In many Plain-nosed and Horseshoe Bats the long delay between mating and birth is achieved by delaying fertilization. In these species, the female bats store sperm in their uteri for periods ranging from five days (Bamboo Bats) to 190 days (Little Brown Bats or Noctules). This pattern of sperm storage prevails among species of bats living in the temperate zones and also occurs in some tropical vespertilionids and thinolophids. The strategy seems well-suited to species that hibernate, for the period of storage coincides with hibernation. (R5)

But why would those tropical vespertilionids need sperm storage? One would not expect them to hibernate.

X4. Some puzzles and questions posed by delayed-birth phenomena.

(1) What are the chemical and neurological processes involved in the three types of delayed-birth scenarios? Of particular interest are the natures of the signals that start and stop the various steps. Are the signals environmental (length-of-day) or physiological (internal clocks and nutritional states)?

(2) Why have delayed-birth systems evolved in some species and not in very closely related species, or even in different populations of the same species?

(3) Given the apparent advantages of delayed births, why have so few mammals (100+ out of 4,400+) evolved the appropriate techniques? Perhaps the need is not great enough.

(4) Are the appearances of delayed births in so many distantly related species (marsupials, bats, pinnipeds, etc.) examples of widespread parallel evolution or multiple independent invention?

> Part of the answer probably lies in evolution. "There must be some ecological factor we don't know about, some historical component, that took place hundreds of thousands of years ago, which may explain why delayed implantation developed in some species and not in others," says [J.] Gittleman. (R3)

References

R1. Nowak, Ronald M.; Walker's Mammals of the World, Baltimore, 1991. (X1-X3)
R2. Anderson, Ian; "The Art of Avoiding a Crowded Pouch," New Scientist, p. 22, October 26, 1991. (X1)
R3. Verde, Thomas; "Mothers in Waiting," National Wildlife, 30:16, February/March 1992. (X0, X1, X4)

R4. Reeves, Randall R., et al; Seals and Sea Lions, San Francisco, 1992. (X1)
R5. Fenton, M. Brock; Bats, New York, 1992. (X2, X3)

BMF18 Polymorphic Sperm in Mammals

Description. The existence of several different varieties of mammalian sperm and their surprisingly sophisticated objectives beyond that of simple fertilization, such as forming copulatory plugs and seeking out and destroying sperm from other males. To accomplish such "extracurricular" tasks, mammals have had to evolve sperm possessing biochemical sensors, identification devices, and "weapons." Such concepts are part of the Kamikaze Sperm Hypothesis. In stark contrast to these belligerent proclivities, some of those sperm designed for fertilization seem to cooperate with one another.

Data Evaluation. Our chief sources of information are articles in well-known science magazines. The only science-journal article examined discounts the claimed phenomenon. Rating: 3.

Anomaly Evaluation. That mammalian sperm are polymorphic is not an issue. However, the claims that sperm are complex and sophisticated and designed to carry out quasi-military activities against alien sperm clash with the prevailing mainstream view of sperm as dedicated fertilizers. Kamikaze sperm and cooperative sperm are mildly anomalous in the sense they challenge current preconceptions. More serious is the question (so frequent in this catalog) that the evolutionary paradigm is inadequate to account for the complexity and innovation claimed for polymorphic sperm. Of course, the levels of complexity and innovation are lower than those required for the vertebrate eye.

Possible Explanations. Just as a mammal evolves eyes, immune system, and brain that promote its survival, so it competes at the gamete level. Such is to be expected. Here, too, if Darwinism proves insufficient to account for such complexity and innovation, one can consider "adaptive evolution" or some other evolution-accelerating mechanism.

Similar and Related Phenomena. See Series-B Subject Indexes under: Complexity; Evolution, adaptive; Innovation.

Entries

X0. Background. If we are to believe the popularizers of science, the only objective of each and every mammalian sperm is to proceed at top speed toward the waiting egg of the female and, once there, to dive into it, thus completing the fertilizing process. In virtually all cases, the number of sperm released is enormous---in the millions. Each one lashes its tail vigorously, striving to be the first to reach the egg. Obviously, sperms are macho entities: vigorous, competitive, and single-purpose.

Some recent research discredits this popular concept of the sperm: some sperm seem to have other agenda and no interest in the dash to the egg, and some that do are, frankly, whimps!

The sperm of all animals are polymorphic to some degree; that is, they come in different shapes and sizes. Some of them, particularly in the invertebrates, are manifestly unsuited for the fertilizing role and could have other objectives. Until recently, the "non-standard" sperm produced by mammals (about 20% of the average ejaculate) were simply regarded as defective, as errors made on the production line. Some have two heads or no head; others have no tails or coiled tails. They can have no part to play in the fertilization drama; they are useless throw-aways---according to some scientists. (R1)

Two sperm researchers, R.R. Baker and M.A. Bellis, believe otherwise. They hold that mammalian sperm do play nonfertilizing roles. In fact, they recognize four varieties of mammalian sperm:

- "Fertilizers," the egg-penetration specialists,
- "Blockers," the ones that construct copulatory plugs to prevent further insemination,
- "Search-and destroy sperm" that hunt down as kill "enemy" sperm from other sources,
- "Family-planning sperm" that kill all sperm. (R4)

One can liken this array of sperm types to polymorphic ant colonies with their castes of workers, soldiers, and queen. Baker and Bellis go further and suggest that the numbers of each sperm type are under the control (certainly not conscious control) of the males. For example, where promiscuity is observed, as is common in chimpanzee troops, the numbers of seek-and-destroy sperm are very high.

Other researchers concur that mammalian sperm do not fit the popular picture seen in elementary biology books. But, instead of aggressive, competitve sperm, some see "reluctant" and "co-operating"sperm! There seems to be no possibility of reconciling all of these divergent views.

We now expand on some of these thoughts.

X1. Fertilizing sperm. Assuming that there is indeed a special type of mammalian sperm dedicated to fertilization, would not this variety of sperm proceed aggressively and single-mindedly toward the waiting, passive egg? A radically different scenario occurs in the thinking of E. Martin, a Johns Hopkins anthropologist.

> A wastefully huge swarm of sperm weakly flops along, its members bumping into walls and flailing aimlessly through thick strands of mucus, eventually, through sheer odds of pinball-like bouncing more than anything else, a few sperm end up close to an egg. As they mill around, the egg selects one and reels it in, pinning it down in spite of its efforts to escape. It's no contest really. The gigantic, hardy egg yanks this tiny sperm inside, distills out the chromosomes, and sets out to become an embryo. (R2)

In Martin's view, the sperm are weak and bumbling, while the egg is assertive and dominant. Furthermore, the sperm actually try to escape the egg's clutches. Martin explains that sperm must be good escapers, because to reach the egg they must avoid all manner of obstacles. Perhaps Martin's scenario is a bit extreme, but it helps to correct the manifestly inaccurate popular concept of what goes on during fertilization. (R2)

X2. Kamikaze sperm. The other three varieties of sperm proposed by Baker and Bellis can rightfully be called kamikaze sperm, for their destiny is death, not union with an egg. Of special interest are the search-and-destroy and family-planning types. These must be of more sophisticated design. They should bristle with biochemical devices that find, identify, and destroy foreign sperm and, possibly, even defend themselves from attack.

Sperm are mobile extensions of the male mammal, which have had to evolve several different miniature fighting machines of surprisingly complexity, as well as the factory that produces them in huge quantities. Considerable biochemical innovation is implied here.

In order for a particular genome to project itself into the future (actually half of itself), evolution must occur at two levels: the genetic carrier (sperm) and the organism it represents. In the context of Dawkins' "selfish gene" hypothesis, we must ask which is the master?

X3. Cooperative sperm. The idea that sperm from the same male are fiercely competitive in the race to the egg is contradicted by two different sorts of observation.

R. Cone (Martin's husband) contributes the fact that sperm actually have a very difficult time in penetrating the thick mucus blocking the path to the egg. He remarks that they are really "like a team of bicyclists, they take turns up front parting the strands of mucus. So in a sense sperm are cooperative." (R2)

Opossum sperm cooperate in a different manner.

> Opossum sperm usually swim in pairs, neatly joined at the head like microscopic Siamese twins. More than a century after Victorian naturalists first noted this zoological curiosity, two biologists say that they have the explanation: teaming up in this way allows the sperm to force their way through the unusually thick, treacle-like mucus that lines the female opossum's reproductive tract. (R3)

As the paired sperm near the egg, they split and resume normal operations.

Opossum sperm usually swim in pairs and thus aid each other in forcing their way through thick mucus.

Such cooperative behavior, albeit a temporary thing, is remarkable in such simple biological entities. It must be an interesting exercise to chart a believable evolutionary scenario for the development of cooperative sperm.

A curious aside: only the sperm of New World opossums pair up. The Australian possums have solved the mucus problem with a highly effective, snake-like swimming motion that facilitates penetration of the mucus. (R3)

References

R1. Harcourt, A.H.; "Sperm Competition and the Evolution of Nonfertilizing Sperm in Mammals," Evolution, 45: 314, 1991. (X0)

R2. Freedman, David H.; "The Aggressive Egg," Discover, 13:61, June 1992. (X1, X3)

R3. Aldhous, Peter; "When Two Sperm Tails Beat as One," New Scientist,

p. 18, April 15, 1995. (X3)
R4. Sozou, Peter D.; "Mating Games," Scientific American, 274:102, January 1996. (X2)

BMF19 Pregnancy Rates Correlated with Lunar Phase

Description. The positive correlation of the pregnancy rates of some mammals and the lunar cycle.

Data Evaluation. The only report alleging this phenomenon comes from the scientific literature and presents the statistics from an extensive survey. Even so, the venue is geographically limited. Rating: 2.

Anomaly Evaluation. Since the observed phenomenon hinges upon earlier sexual activity, we look there for cause and effect. The lunar enhancement of sexual activity could be due to biochemical changes induced (in some mysterious way) by the lunar cycle or, more likely, by the effect of moonlight on the amount of nocturnal activity and/or the moonlight's enhancement of sexual displays. Since we do not know enough to even guess the mechanisms involved, an anomaly rating is impossible here.

Possible Explanations. See above discussion.

Similar and Related Phenomena. The correlation of mammalian sexual activity with the lunar cycle (BMB24 in Mammals 1); the correlation of the lunar cycle with human disturbed behavior (BHB4 in Humans I) and menstruation (BHF14 in Humans II).

Entries

X1. General observations. The direct observable here is the pregnancy rate of certain mammals. Of course this can be related to the times of conception and mating patterns. Instances where the latter are the direct observables are cataloged under BMB24 in Mammals I. The present entry is directed at the possibility that some other factors may be operative.

Malayan forest rats. In a 1952 issue of Nature, J.L. Harrison wrote:

> During the past four years, records have been kept of the state of pregnancy of a large number of rats and squirrels of various species collected

and killed in connexion with scrub-typhus investigations. While studying the relation between rainfall and breeding season, it was found that the rates of pregnancy of the nocturnal forest rats showed a bimonthly rhythm which appeared to be in phase with the moon, and which suggested that the greatest number of conceptions occurred near the time of full moon. (R1)

Harrison concluded that "the full moon has some stimulating effect on conception." (R1) Rather than some mysterious "stimulating effect," it is also possible that the rats' estrus cycles and/or their activity levels were entrained in the lunar cycle.

Reference

R1. Harrison, J.L.; "Moonlight and Pregnancy of Malayan Forest Rats," Nature, 170:73, 1952. (X1)

BMF20 Maternal Impressions in Mammals

Description. The appearance on a young mammal of marks or deformities that closely resemble an animal, an object, or a situation that had profoundly affected the animal's mother.

Data Evaluation. The ultimate source of the information reviewed below is a medical journal, which gives some small bit of credence to a most dubious phenomenon. Furthermore, more examples of the phenomenon have been collected for another mammal---humans. (BHF21 in Humans II) Bearing these things in mind, we feel obliged to add this phenomenon to the catalog. Rating: 3.

Anomaly Evaluation. There exists no scientifically reasonable way in which a mother animal's observations of specific objects or events can be transferred to a developing fetus. Rating: 1.

Possible Explanations. The only "acceptable" explanation for maternal impressions is that they are merely coincidences.

Similar and Related Phenomena. Maternal impressions in humans (BHF21 in Humans II). In the Series-P catalogs, there are recorded cases of hypnotically induced rashes, welt, spots, etc., some arranged in patterns suggested by the hypnotist.

Entries

X1. General observations.

Pigs. In a 1915 number of The Virginia Medical Semi-Monthly, W.B. Barham wrote about the curious effect of the sight of an elephant on a pregnant sow:

> ..."greatly frightened by a circus parade, in which several elephants were features. After seeing the elephants, the sow rushed in great alarm into a stable and hid persistently from the sight of the procession." When the litter of pigs was born, the head of one was curiously malformed. In contour it resembled an elephant: "from its forehead projected an appendage, closely resembling an elephant's trunk." (R1)

Reference

R1. McLaren, Anne; "'Maternal Impressions': an Old Wives' Tale Reconsidered," New Scientist. 22:97, 1964. (X1)

BMF21 Weeping in Mammals

Cross reference. The only mammals that shed tears are the marine mammals, elephants, and humans. The weeping function, like the presence of subcutaneous fat, links humans (and elephants) to the marine mammals and the Aquatic Ape Hypothesis. Details on this controversial hypothesis and weeping in mammals may be found in BHF30 in Humans II.

BMF22 Sleeplessness in Mammals

Description. The ability of some mammals to successfully perform their daily routines without any sleep at all or with just a few moments of deep relaxation. This ability contrasts starkly with humans and many other mammals who sleep substantial portions of the day.

Data Evaluation. Research on human sleep is an active area of science; other mammals are largely ignored in this respect. We have uncovered only one scientific report on sleeplessness in nonhuman mammals. Rating: 3.

Anomaly Evaluation. It is understandable how prey animals without access to burrows, dens, trees, or other relatively safe places might tend to evolve ever-alert senses and consciousness. Such animals would not know sleep as we know it. It is not clear to humans how sleepless mammals could cope successfully without the restorative value of sleep. (Cats and dogs sleep even more than humans!) Anyway, the apparent sleeplessness of sheep and cattle seems anomalous to us, but perhaps cattle would think it strange that humans need to sleep at all! In any case, some ruminants have a faculty most other mammals do not possess, and we do not understand exactly what it is. Rating: 2.

Possible Explanations. Mammals that require little if any sleep might have evolved a capacity that allows one half of their brain to sleep while the other half takes over and keeps the senses functioning. The roles of the brain hemispheres could then be reversed. This may be the case with some marine mammals. (BMF23)

Similar and Related Phenomena. The purpose of sleep in humans (BMF31 in Humans II); curious sleep patterns in nonhuman mammals (BMF23); REM sleep in nonhuman mammals (BMF24).

Entries

X1. General observations. Humans sleep about one-fourth of their life away. It seems an essential part of our existence. Nevertheless, despite considerable research on the subject of sleep, scientists have not found any biochemical value in sleep. Of course, psychological and performance tests demonstrate that sleeplessness has severe consequences. This subject is expanded upon in BHF31 in Humans II. The objective here is to discover if sleep is also essential to other mammals. Unfortunately, we have found little on sleeplessness in wild mammals and just a little more on domestic and laboratory mammals.

Seals. In their book Seals and Sirenians, R.R. Reeves et al include a passing comment to the effect that seals may not sleep at all while at sea. (R3) Such is, of course, difficult to verify.

While ashore and in captivity, they certainly *seem* to sleep. Captive elephant seals, for example, can be seen *apparently* sleeping on the bottoms of their pools while holding their breaths. (See BMF23.)

Ruminants. A good deal more is known about cattle and sheep at rest.

> During digestion experiments with cattle, it was observed that the animals never appeared to sleep and always used the same lying position. In recent years the behavior of cattle and sheep has been carefully studied by numerous workers, particularly under grazing conditions...In spite of this attention, the almost complete absence of reference to sleep is a striking feature of the reports. Brownlee could find no evidence that healthy cattle ever lost consciousness either by day or night. Similarly, Hancock found that it was debatable if cows ever sleep; even at times of total rest they kept their eyes open

except for very short periods---a few minutes at most---when they generally rested their heads on their flanks.

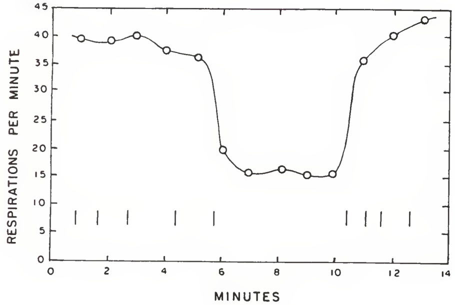
It is difficult to find an exact definition of sleep acceptable by all authorities; in the present work a search has been made for the marked relaxation and loss of consciousness (especially of vision) which are the more obvious manifestations of sleep in other animals. In the vast majority of cattle seen at night, their eyes were open and clearly watching the observer. In the few minutes where they were closed the movement of an ear would often betray consciousness, or slight noises such as rubbing together of the fingers would evoke an immediate reaction.

In order to confirm that the absence of mention of sleep from published reports did in fact mean that none was observed, I have communicated with a number of the observers. Their replies were in close agreement with observations here, namely, that sheep and cattle sleep little if at all, rarely closing their eyes and seeming even then not to lose consciousness. When lying, they keep the thorax upright and only very rarely and for short periods lie out flat. Observation and inquiry in zoos has confirmed that the apparent lack of sleep and the typical lying position are general characteristics of ruminants. (R1)

Guinea pigs. It has been found experimentally that guinea pigs can cope successfuly without sleep after portions of their midbrains have been destroyed. (R2)

References

R1. Balch, C.C.; "Sleep in Ruminants," Nature, 175:940, 1955. (X1)
R2. Curtis, Helena; Biology, New York, 1979. (X1)
R3. Reeves, Randall R., et al; Seals and Sirenians, San Francisco, 1992. (X1)



Short periods of slow breathing have been observed in cows. These seem to be the closest cows get to sleep as we know it. The vertical dashes indicate contractions of the reticulum (second stomach).

BMF23 Curious Types of Sleep

Description. A collection of observed sleep patterns or states that deviate markedly from those normally seen in mammals; specifically: underwater sleeping; episodic sleep; collective awakenings and restlessness; and half-brain sleep.

Data Evaluation. Most of the observations are casual and anecdotal and lack scientific rigor. Rating: 3.

Anomaly Evaluation. The only entry among the four recorded below that verges on the anomalous is the claim of half-brain sleep in dolphins (X4). This generally unrecognized talent of dolphins could represent a valuable evolutionary development in grazing mammals without safe refuges which must maintain eternal watchfulness. However, the dolphin's half-brain sleep would be easily accounted for by natural selection. In this light, we rate all four entries below as only curiosities. Rating: 3.

Possible Explanations. See above.

Similar and Related Phenomena. Apparent sleeplessness in ruminants (BMF22); correlation of the human sleep-wakefulness cycle with the lunar day rather than the solar day (BHF32 in Humans II); the absence of the corpus callosum connecting brain hemispheres in marsupials.

Entries

X1. Underwater sleep in mammals. On the surface this seems unlikely, but if a mammal can hold its breath for an extended period, it is certainly not impossible.

Elephant seals. These marine mammals are superb divers, reaching depths of almost a mile in underwater excursions lasting over an hour. (BMT7 in Mammals I)

> These seals also hold their breath while they sleep, a trick that slows their metabolism, thus conserving energy, and allows them to snooze underwater as well as on land. (R4)

People visiting marine research labs unaware of this habit are often shocked to see "dead" elephant seals snoozing on the bottoms of their tanks! (R4)

X2. Episodic sleep.

Marsupial moles. Although they are marsupials, these strange animals look and act much like placental moles. (BMA1-X1 in Mammals I) They also have the disconcerting habit of suddenly falling asleep while engaged in frenetic activity. We see this strange behavior in the following quote from Walker's Mammals of the World:

> Notorycytes is reported to be active, timorous, apparently solitary, and both diurnal and nocturnal. One captive proved to be extremely active and moved continuously about its enclosure in search of food. Its nose was always held downward. It fell asleep suddenly on several occasions and awoke just as suddenly to resume its feverish activity. Despite the appearance of being highly nervous, it did not seem to resent handling; it would even consume milk rapidly while being held and then would suddenly fall asleep again. (R3)

Placental moles are likewise extremely nervous; so much so that mere handling or even loud noises, such as thunderclaps, are apt to kill them. (R3)

X3. Nightly resurrections. The September 25, 1879, issue of Nature printed a charming letter from E. Bonavia. Here is the first paragraph:

> Yesterday, in the Pall Mall Budget of July 11, 1879, p. 22, in a review of Mr. Stevenson's---"Travels with a Donkey in the Cevennes," I read the following, which is an extract of Mr. Stevenson's book. It is a very interesting book. He slept a good deal under trees at night, and he says: "And there is one stirring hour unknown to those who dwell in houses, when a wakeful influence goes abroad, and all the out-door world (meaning animals and men who sleep in the open) are on their feet. It is then that the cock first crows...Cattle awake [?] in the meadows, sheep break their fast on dewy hill-sides, and change to a new lair among the ferns; and houseless men, who have lain down with the fowls, open their dim eyes and behold the beauty of the night...Even shepherds and old country folk, who are the deepest read in these arcana, have not a guess as to the means or purpose of this nightly resurrection. Towards two in the morning they declare the thing takes place, and neither know nor inquire further." (R1)

The rest of Bonavita's letter claims that this resurrection is communicated to him even inside his house and must be due to some "subtle influence," perhaps the earth's magnetic field. (R1)

X4. Half-brain sleep. Since sleep has a demonstrable restorative value to most mammals, a welcome evolutionary development would be the capability whereby one brain hemisphere sleeps while the other hemisphere maintains a sensory alert.

Dolphins.

> The brains of dolphins provide support for the notion that either hemisphere can take control of behavior. A Russian research group headed by L.M. Mukhametov discovered through electroencephalograms that in the bottle-nosed dolphin, hemispheres sleep one at a time. One of their animals spent 42.4 percent of his day alternating sleep between the hemispheres and only 0.8 percent of the time with both hemispheres asleep at once. While it is certain that human brain hemispheres never exhibit similar gross differences in activity, the demonstration that one mammalian brain can so readily switch dominance suggests that humans may also shift control of behavior from one hemisphere to the other. (R2)

References

R1. Bonavia, E.; "A 'Nightly Resurrection'," Nature, 20:505, 1879. (X3)
R2. Finn, Robert; "New Split-Brain Research Divides Scientists," Science Digest, 91:54, September 1983. (X4)
R3. Nowak, Ronald M.; Walker's Mammals of the World, Baltimore, 1991. (X2)
R4. Anonymous; "SIDS and Seals," Discover, 13:7, February 1992. (X1)

BMF24 REM Sleep in Mammals

Description. The existence of REM-sleep stages in all examined mammalian species except the echidnas. REM sleep is considered by some to be a notable evolutionary adavnce in the information-processing capability of the brain.

Data Evaluation. At hand is only one article dealing with this subject, and it is from a science magazine rather than a mainstream journal. The importance of the phenomenon depends upon the accuracy of the generalizations that: (1) Only mammals display REM sleep; and (2) REM sleep is, in part, a form of off-line data processing. No comprehensive surveys of REM sleep in mammals have been located, nor does the utility of REM sleep in subconscious data-processing seem to be strongly supported. Our incomplete literature search may be at fault here. Rating: 3.

Anomaly Evaluation. Assuming that: (1) REM sleep is actually employed for off-line (subconscious) information processing; and (2) REM sleep is to be found only in the "higher" mammals; then, how did such a sophisticated evolutionary advance ever arise? This question evokes many subsidiary questions: How and where are data acquired during waking hours stored and later accessed? How could an entirely new level of brain activity be created in small steps? Continuing the computer analogy, a new program will not run properly unless it is perfect and complete! It's the old "what-good-is-half-a-wing" complaint in more modern guise. On top of this are the factors of complexity and innovation---factors that we see so prominent in the celebrated vertebrate eye. (BMO1) Is Darwinism (or perhaps its more recent incarnation, self-organization) really up to such tasks? We have no idea; and we are not inclined to accept all those passionate assurances that it is until we see more detailed evolutionary scenarios! There may be much more to the evolution story; that is, scientifically acceptable improvements may exist.

Possible Explanations. If there are no other "scientific" theories of evolution other than Darwinism, then Darwinism, or spontaneous organization, may be incomplete paradigms, just like Newtonian physics.

Similar and Related Phenomena. Sleeplessness in mammals (BMF22); the frequently stated subjective impression that "sleeping on a problem" may lead to its solution. The absence of REM sleep in echidnas (BMO11).

Entries

X0. Background. REM (Rapid Eye Movement) sleep is a rather mysterious stage of sleep found only in mammals as far as we know. This stage is readily seen in human electroencephalograms (EEGs).

> Every 80 to 120 minutes, there occurs a period of rapid, low-voltage activity similar to that seen in alert persons. This is also called paradoxical sleep and it is associated with rapid eye movements (REMs), in which the eyeballs move jerkily as if the sleeper were watching some scene of intense activity. (R1)

It has been suggested that REM sleep indicates a period during which the sleeping animal processes and stores information acquired while awake. Supporting this interpretation is the observation that animals deprived of REM sleep forget tasks they had just learned while awake. In a sense, REM sleep is analogous to "off-line" data processing. The brain thus works during sleep freeing the waking brain for other tasks. REM sleep makes the brain more efficent ---assuming the correctness of the foregoing interpretation.

X1. General observations. Two important observations are embedded in the quotation that follows. First, only mammals are blessed with REM sleep as far as we know. Second, the echidna is the only known exception. Our underlining is intended to emphasize the tentative nature of these generalizations.

In the July 1992 issue of Discover, J. Kinoshita wrote:

> REM sleep appears late in evolutionary history. Only mammals have it, and, with one documented exception, every terrestrial mammal has it. The curious exception is the echidna, or spiny anteater. This small Australian animal, which looks like an overfed hedgehog with a beak, is monotreme, the most primitive kind of mammal---so primitive that it lays eggs, like a reptile. In addition to lacking REM sleep, the echidna is exceptional in one other respect. Its prefrontal cortex is huge, larger relative to the rest of the brain that any other mammal, humans included. (R2)

In the paragraphs that follow, Kinoshita says essentially that the more advanced mammals developed more information processing capacity by adopting off-line processing (REM sleep) rather than trying to further enlarge the prefrontal cortex, where such operations are believed to occur. In this sense, the echidna's brain took a less efficient evolutionary road---at least a far as data processing is concerned.

It should be added that the echidnas (there are actually two species) sport electrosensitive noses, which are not exactly "primitive" biological accomplishments! See BMO8. It is even possible that its prefrontal cortex is actually enlarged to process signals from this unusual sensor.

Ruminants. If mammalian ruminants are really sleepless, how can they exhibit REM sleep? (BMF22)

References

R1. Curtis, Helena; Biology, New York, 1979. (X0)

R2. Kinoshita, June; "Dreams of a Rat," Discover, 13:34, July 1992. (X1)

BMF25 Big-Bang Reproduction (Semelparity) in Mammals

Description. In a few species of small mammals, mostly marsupials, the concentration of all reproductive activity in a single short period of time, synchronized for each population, after which all males shortly die. Most females expire, too, after weaning their young. Technically, this phenomenon is termed "semelparity." More popularly, it is "big-bang" reproduction.

Data Evaluation. Big-bang reproduction has been studied in depth in one species of Australian marsupial "mice." The phenomenon also occurs in a very few other species, but few details are known for them. The phenomenon is well-established in the scientific literature and a few science magazines as well. Rating: 1.

Anomaly Evaluation. Big-bang reproduction may confer several advantages on small mammals that are targets of intense predation and with normally short lifetimes. Some of these possible pluses are presented in X3 below, but they do not appear particularly strong. Two questions seem appropriate here; (1) If semelparity really has significant survival value for small mammals, why has it evolved in just a small handful out of many hundreds of similar mammals coping with similar environmental pressures; e.g., many rodents? (2) If big-bang reproduction results in only slightly increased survival value, how did the manifold biophysical and behavioral characteristics required for this major new reproductive strategy ever get selected for, coordinated, and encoded in the genomes of a few diverse and geographically separated species? Semelparity thus presents a minor conflict for evolutionists to puzzle out. Rating: 3.

Possible Explanations. See X3 below.

Similar and Related Phenomena. Big-bang reproduction in plants (annuals); fish (some salmon); invertebrates (some squid). Menopause in humans (BHF18 in Humans II).

Entries

X0. Background. Big-bang reproduction in some species of salmon is a familiar subject in some TV documentaries. These fish breed but once during their lifetime and then die, littering the stream banks with their bodies, much to the delight of scavengers. This type of reproduction is termed "semelparity," named after Semele, one of the human lovers of Zeus, who was incinerated when Zeus appeared, as he often did, as a thunderbolt! (R4) Many plants, too, flower and set seed only once. Among the mammals, though, repeated breeding (iteroparity) is the general rule and continues until stopped by death or menopause.

It is not immediately obvious why big-bang reproduction would benefit mammals, and its existence among them was long doubted. Only in 1966 was the first semelparous species discovered among the Australian marsupial "mice." (They really look more like shrews.) Several other small Australian mammals are now also known to be big-bang reproducers; so is one New World opossum. Our literature survey has also identified a genus of African grass mice---placental mammals---that seem to be essentially semelparous.

X1. Survey of big-bang reproduction in mammals. The phenomenon of semelparity was first noticed in mammals when an Australian scientist was studying marsupial "mice." He found that at a certain time of the year, he trapped only pregnant females. All of the males in certain species had apparently expired. In Walker's Mammals of the World, R.M. Nowak wrote in reference to the genus Antechinus (the broad-footed marsupial "mice"):

> A remarkable feature of the biology of Antechinus is the abrupt and total mortality of males following mating, when they are 11-12 months old. Although the period of mortality varies geographically, it occurs at the same time each year in any given population. The phenomenon is known in five species---A. flavipes, A. stuartii, A. bellus, A. swainsonii, and A. minimus---but is best understood and is especially sudden in A. stuartii (R5)

During the brief mating period, the male marsupial "mice" in this genus become very aggressive and nervous, as described by J. Vandenbeld:

> Toward the end of winter, activity among Antechinus males becomes even more frantic; but the search for

mates is even more important than the hunt for food. They have only one season to mate and pass on their genes. So urgent is their drive that the mating itself takes up to six hours. Males are 'programmed' to put all their effort into reproduction: they hardly eat, and expend a great deal of energy fighting to secure females. Stress hormones rise to such high levels that they suppress the animals' immune systems and cause gastric ulcers. By the end of the season, all the males are dead. (R3)

The Antechinus reproductive cycle is remarkable for its synchronicity. All females come into estrus in early August; all males die by the end of August; all births occur during a two-week period in September. A very few females may survive to breed again---perhaps with their sons---but most die. In one species, A. minimus, all of the females do die after weaning their litters. (R1, R2)

We have dwelt on these particular marsupial "mice" because they have been much studied and, with some variations, the preceeding discussion of big-bang reproduction applies to the several other species now mentioned.

Brush-tailed marsupial "mice" (tuans). Genus Phascogale. The wild males of the two species in this genus also expire after mating toward the end of their first year. However, captive males have lived for over three years but cannot reproduce after the first year. This seems to indicate that their reproduction system is programmed to deteriorate after the first year. (R5)

Genus Parantechinus. These mouse-like marsupials of southwest Australia are also semelparous. (R6)

Native cats (quolls). The species Dasyurus hallucatus, a cat-like marsupial of Australia, has also been found to be semelparous. (R6) This animal is much larger than the marsupial "mice," implying that small size is not a universal requirement for appearance of the phenomenon.

Eastern short-tailed opossum. This is a South American marsupial. The males die shortly after mating, and the females do not survive to breed a second time. (R5, R7) Again. this animal is much larger than the marsupial "mice" and, in addition, lives in an entirely different environment.

Striped grass mice. Genus Lemniscomys. There are eight species of these placental mammals in Africa. Nearly all adults of both sexes die after breeding. Total population turnovers occur twice a year. (R5) Apparently, semelparity is not a marsupial exclusive.

X2. Male pathology leading to death. To inquire into the evolution of big-bang reproduction, it is useful to learn more precisely why the males die. A. Cockburn and A.K. Lee have done this in their article in Natural History.

> Two consistent conditions are gastrointestinal ulcers and evidence of a suppressed immune system, both commonly associated with stress. Measurements showed that glucocorticoids (stress hormones) reach extreme levels in males during the mating season, even in animals isolated in the laboratory. However, laboratory males live longer than their compatriots in nature. Perhaps the rigors of the mating season push the stress response of wild males to pathological levels. Males may benefit from higher levels of glucocorticoids, which convert body protein to glucose that provides males with a ready supply of energy to sustain their vigil at the mating arenas. But after mating, males pay the ultimate price. (R4)

Once again, captive males exhibit some degree of programming that must be explained in evolutionary terms.

X3. Possible explanations for the evolution of semelparity. The main questions posed by big-bang reproduction are: (1) Why would an individual animal place all bets on a single mating period? (2) Why would an entire population do the same thing? (3) Why do not more small mammals utilize semelparity, assuming it is advantageous to such animals? J.M. Diamond has advanced several suggestions.

•Synchronism in entire populations allows all young to be born when food supplies are best and weather most favorable for survival of the young. This is especially pertinent in Australia with its wild environmental swings.

•By dying off right after mating, the large males remove themselves from competition for food with the developing young.

•Small mammals have very low life expectancies in the wild, and survival to a second breeding season is unlikely. The best strategy is to bet everything on a single, all-out effort at reproduction. (R1)

In reality, this last suggestion is applicable to hundreds of small animals, rodents in particular.

In sum, it is possible to partially rationalize big-bang reproduction in terms of maximizing reproductive success. While such rationalizations are at the core of many evolutionary explanations, it is much harder to see exactly how strategies as complex as semelparity are encoded in the genes ("programs") given such rather vague environmental forces.

References

R1. Diamond, Jared M.; "Big-Bang Reproduction and Ageing in Male Marsupial Mice," Nature, 298:115, 1982. (X0-X3)

R2. Diamond, Jared; "Big-Bang Reproduction," Discover, 5:52, October 1984. (X0-X3)

R3. Vandenbeld, John; Nature of Australia, New York, 1988. (X1)

R4. Cockburn, Andrew, and Lee, Anthony K.; "Marsupial Femmes Fatales," Natural History, 97:40, March 1988. (X2)

R5. Nowak, Ronald M.; Walker's Mammals of the World, Baltimore, 1991. (X1)

R6. Dickman, C.R., and Braithwaite, R.W.; "Postmating Mortality of Males in the Dasyurid Marsupials, Dasyurus and Parantechinus," Journal of Mammalogy, 73:143, 1992. (X1)

R7. Redford, Kent H., and Eisenberg, John F.; Mammals of the Neotropics, vol. 2, Chicago, 1992. (X1)

BMF26 Unusual Deaths of Mammals

Description. Observations of dead mammals and mammals seen to die under rare and unusual circumstances. No common thread ties these curious phenomena together. They are so strange as to warrant inclusion in this catalog.

Data Evaluation. Our sources are varied: a mammal catalog, a science journal, and two respected newspapers. Rating: 2.

Anomaly Evaluation. Although on the bizarre side, most of the phenomena cataloged here have rather mundane natural explanations. Rating: 4.

Possible Explanations. Accidents and such natural forces as lightning and thunder.

Similar and Related Phenomena. Falls in general (GWF in Tornados, Dark Days, etc.)

Entries

X1. Falls. Falls from the sky of organic matter and even living animals, such as fish and frogs, are typical Fortean phenomena. Most of these unexpected forms of precipitation can usually be explained in meteorological terms---whirlwinds, waterspouts, tornados, etc. They do not deserve the derision accorded them by mainstream science. The Catalog of Anomalies, in fact, devotes an entire chapter to such "falls." (GWF in Tornados, Dark Days, etc.) When this volume was compiled, we had no good records of falls of mammals. Now, 13 years later, we do have a couple cases of mammal falls, although meteorological explanations may not be adequate in these instances.

Small mammals. In this entry, the actual "fall" was not observed but was inferred from the evidence.

> On 16 May 1961, three species of small mammals were found at the base of a cliff in Giant City State Park, Jackson County, Illinois. Along some 1,000 feet of path, at the base of a vertical sandstone bluff between 80 and 100 feet high, a total of 15 Pitymys pinetorum [voles], one Microtus ochragaster [another vole] and one Blarina brevicauda [a shrew] were picked up. These small mammals were spread along the path, not all at one location except at the point of the highest bluff where 5 pine voles were found within a distance of 6 feet. (R1)

All of the mammals showed lung congestion attributable to falls from the cliff. Otherwise, they were all healthy and in fresh condition. The area in which the animals were found was not their normal habitat. (R1)

Bats (species unknown). Bats are not usually aloft during daylight hours. So this bat fall observed in Fort Worth, Texas, on September 6, 1989, by many townspeople is definitely highly unusual. This appeared in the Fort Worth Telegraph:

> Pedestrians dodged hundreds of bats that fell onto downtown sidewalks yesterday afternoon. The winged mammals were sick and dying, and no one knows why.
>
> "I have never seen bats on the sidewalk at 4 o'clock in the afternoon before," said restauranteur Chris Farkas after encountering the bats in the 600 block of Main Street. "About half of them were crawling on the ground. There were about 50 in the air flying around." (R3)

Many of the bats subsequently died. Two possible causes advanced were heatstroke and building fumigation. Neither could be shown to be correct.

X2. Lethal lightning. Small groups of domestic cattle sheltering under a tree during a thunderstorm are occasionally electrocuted by current from a nearby lightning strike passing through the earth beneath their feet. It is very rare, however, to find large numbers of wild animals in the open similarly electrocuted. But 53 Alaskan caribou apparently met their demise in this way. They were strewn out in a clearing in a strange circular cluster. (R2) For details on this event, see BMB26-X3 in Mammals I.

X3. Lethal thunder. Shrews are extremely nervous animals. Loud noises, even thunder, will sometimes kill them. (R4)

References

R1. Stains, Howard J., and Calvert,

Larry; "Unusual Death of Small Mammals," Journal of Mammalogy, 43:422, 1962. (X1)

R2. Anonymous; "Anomalous Electrical Phenomenon," New York Times, July 31, 1972. (X2)

R3. Gilberto, Julie; "Scores of Bats Rain on Downtown," Fort Worth Telegram, September 7, 1989. (X1)

R4. Nowak, Ronald M.; Walker's Mammals of the World, Baltimore, 1991. (X3)

BMF27 Longevity Increased by Radiation and Hunger

Description. The extension of life span through exposure to low-level radiation and/or hunger.

Data Evaluation. This entry is based upon a short letter to a science magazine, which implies that the phenomenon is well-known. However, without specific references to the scientific literature, we cannot assign a high rating here. Rating: 3.

Anomaly Evaluation. Both low-level radiation and hunger are popularly thought to be inimical to long life. Consequently, this phenomenon is contrary to general expectations. The importance of the phenomenon is heightened by the absence of any reasonable scientific explanation for the claimed phenomenon. Rating: 2.

Possible Explanations. None offered.

Similar and Related Phenomena. None.

Entries

X1. Casual mention. In a letter to New Scientist, R. Erck linked increased longevity to hunger and radiation exposure.

> It has been known for many years that mice live slightly longer when subjected to low-level radiation. No satisfactory explanation of this phenomenon has been offered. Recently it has also been observed that hungry mice live 20 to 50 per cent longer than well-fed mice. Could there be a connection between the two?
>
> Could low levels of radiation cause the mice to lose their appetite, eat less food, and live longer as a result? (R1)

Reference

R1. Erck, Robert; "Long-Lived Mice," New Scientist, p. 49, April 11, 1992. (X1)

BMG GENETICS

Key to Phenomena

BMG0 Introduction

The "genetics" anomalies of nonhuman mammals closely parallel those recorded for humans (BHG in Humans III), as one should expect from the close evolutionary relationships. In particular, four popular biological assumptions are challenged in this chapter.

(1) Accurate evolutionary family trees can be constructed from the comparison of visible traits (morphology) and/or molecular sequences, especially DNA.

(2) Genome mutations occur at constant speeds and are compatible with rates of evolution seen in the fossil record.

(3) Identical twins, quadruplets, etc. are truly identical.

(4) Mitochondrial DNA (mtDNA) is inherited exclusively from the mother.

BMG1 Discordances between Phylogenies Established from Visible Traits and Biochemistry

Description. Large differences in the phylogenies (family trees) drawn from comparisons of morphologies (visible traits) and biochemistry (DNA, molecular sequences, etc.). Also included are those phyletic discordances found when different molecular sequences are employed; that is, when different molecular sequences lead to different phylogenies.

Data Evaluation. Biochemical comparisons are very common today, often being regarded as the final solutions to taxonomic paradoxes. The scientific journals and magazines yield an abundance of high quality data on this phenomenon. However, molecular phylogenies, even when published in the top journals, are subject to the many assumptions that are routinely made in biochemical analysis. There are, in addition, the several technical reservations mentioned in X0 below. Rating: 2.

Anomaly Evaluation. The implications of the claimed discordances are sometimes profound: (1) Visible traits (morphologies) are not always good indicators of evolutionary relationships; (2) Neither are biochemical (molecular) data; and (3) Evolution is not completely determined by genomes. Hybridization, endosymbionts, and other extragenetic factors are at work. Of course, it is not necessary to postulate any supernatural forces here. Rather, these discordances are just warnings that there is much left to learn, and rash claims that biochemistry is the final word in charting evolution's progress should not be made. Rating: 1.

Possible Explanations. Extragenetic factors very likely exist, perhaps as seen in so-called "adaptive evolution."

Similar and Related Phenomena. The evolutionary relationship of the two pandas (BMA1-X7 in Mammals 1); uncertainties about whale evolution (BME1-X4); the possible dual origin of bats (BMA1-X9, BMA2-X3, BMA41 in Mammals 1); the discordances between human/ape phenotypes and genotypes (BHG11 in Humans 111).

Entries

X0. Introduction. A relatively recent and very popular way of constructing evolutionary family trees (phylogenies) is based upon the comparison of chromosomes, genes, and sequences of DNA, RNA, proteins, and other molecules. The basic hope is that "molecules" are better indicators of evolutionary relationships than visible characteristics, such as teeth, number of toes, general appearance, etc. New, molecular phylogenies have been built up embracing all the biological kingdoms. Some new insights have resulted, but there are also many serious conflicts between traditional (visible-trait) and molecular phylogenies.

The purpose of this section is, as any anomalist would expect, the highlighting of taxonomic conflicts. In many places in the Series-B catalogs we take pains to point out instances where visible traits do not concord with accepted evolutionary family trees, even though traditional phylogenies are still founded mainly on visible traits. Here, we will see that molecular phylogeny, too, has its share of problems.

To begin, molecular phylogeny is based on several assumptions. L. Margulis and R. Guerrero have stated these succinctly.

Like any other procedure, the molecular approach rests on a series of assumptions. First, it assumes that homologous genes---that is, genes that produce RNA molecules or proteins whose functions have not diverged in different organisms---can be unambiguously identified. A comparison of nonhomologous genes will obviously give a spurious result. Secondly it assumed that the branches of the phylogenetic tree only diverge with time and never reunite. In other words, as two organisms become increasingly distinct, the sequences of all pairs of homologous genes in the two organisms drift further and further apart and the trend never reverses. Finally, it assumes that the major, or indeed only, source of evolutionary innovation is the gradual accumulation of gene mutations. All three propositions are questionable. (R19)

Beyond their reservations about assumptions, Margulis and Guerrero worry about several other problems.

- Small molecular changes may result in large evolutionary divergences, while large changes might be barely noticeable in the visible traits.

- It is hard to determine whether the molecules and sequences chosen for comparison are really representative of a species, particularly when these molecules and sequences may vary during a species' life cycle.

- Do different molecular and sequences yield different phylogenies? We shall see below that the answer here is "yes."

Manifestly, the construction of molecule-based phylogenies is fraught with assumptions and problems, but so is the building of traditional family-trees based upon visible traits. We will probably never have completely accurate phylogenies that reveal precisely what happened during life's evolution. Pronoucements to the contrary must be viewed with suspicion.

X1. Cetaceans (whales and dolphins). In the traditional exposition of cetacean evolution, the toothed and baleen whales split from their common ancestors, the Archaeocetes, about 45 million years ago. The toothed whales all developed echolocation capability, but the baleen whales did not. Instead, the baleen whales, such as the humpback, lost their ancestral teeth and replaced them with plates of baleen. Next, the toothed whales split three ways into the sperm whales, the beaked whales, and the "other" toothed whales, including the dolphins. This family tree seemed eminently reasonable from a morphological point of view. One would certainly not place toothed and baleen whales in the same line of evolution---they are so radically different in structure. (See BME1-X4)

A cautionary aside is appropriate here: It is all too easy to say that the baleen whales "lost" their teeth and "replaced" them with baleen. It's a good story that neglects many extensive structural and behavioral modifications as well as remarkable innovations, such as baleen itself and its incorporation into huge arrays of plates. Most of the details in these evolutionary "stories" remain unelaborated. All anomalists should be wary of them.

DNA analysis. Assuming that DNA is the major source of heriditary information, one would expect that the large morphological changes just indicated would be mirrored when the DNAs from the various whale groups are compared. M. Milinkovitch and colleagues reported on such systematic comparisons in a 1993 report in Nature. (R15) Essentially, they said that, from the standpoint of DNA comparisons, the traditional picture of cetacean evolution is all wrong.

> The researchers studied 16 cetacean species. They determined the DNA sequences of the genes that coded for the mitochondrial 12S and 16S ribosomal RNA, and compared them with the aid of a computer. They found that the DNA sequence of the sperm whale and pygmy sperm whale were more closely related to the baleen whales than to the other toothed whales and dolphins. The study also showed that the beaked whale (which has only a few teeth) is only distantly related to any other whale or dolphin. (R16)

In commenting on the Nature paper by Milinkovitch et al, M. Novacek, a scientist at the American Museum of Natural History, wrote:

> The sperm whale/baleen whale grouping thus represents a major anomaly in a case where morphology and molecular data otherwise agree. (R18)

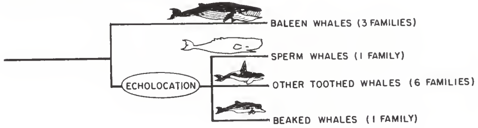
A new whale family tree based upon DNA comparisons is shown in the accompanying figure. Quite obviously, DNA sequences are not good mirrors of the whales' actual physical morphologies.

The Milinkovitch group also compared the DNA sequences of another biological molecule, myoglobin. These comparisons confirmed the other DNA tests and the new whale evolution sequence. (R16, R17) But one should not assume that this "molecular" phylogeny is the final word on this subject!

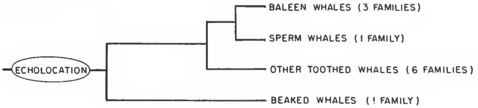
The implications of the revised family tree.

Echolocation. There are two possibilities: (1) Ancestral whales had developed echolocation capability before the toothed-baleen split, but the baleen whales, having little need for it, subsequently lost it, as shown on the figure; or, (2) Echolocation was evolved after the split, but only in the sperm, beaked, and "other" toothed whales---possibly independently three times. Multiple inventions of the same feature are awkward to explain for evolutionists, and it is far easier to believe that the baleen whales jettisoned their inherited echolocation apparatus (Bottom part of the figure). After all, they no longer needed it, and they also had to make room in their skulls for all that baleen.

TRADITIONAL CLASSIFICATION



DNA ANALYSIS



Traditional whale classification (top) compared to that suggested by DNA analyses (bottom). Note especially, the shift of the sperm whales from the toothed-whale group to the baleen-whale group.

(R17) Of course, tooth loss, skull modification, baleen invention, and echolocation loss all had to be properly orchestrated or the transitional whales would not be able to make a living!

Teeth. It is usually assumed that the sperm, beaked, and "other" toothed whales simply retained and activated the teeth-making genes of Archaeocetes. Tempting though this approach is, the tooth-bearing jaws of these three groups differ radically, so that independent invention remains a possibility. The male beaked whales usually possess only two ineffective teeth and the females, none. (BMA35-X4 in Mammals 1). The lower jaw of the sperm whale contains about two dozen functional conical teeth that fit into sockets in the upper jaw, which has few teeth. In contrast, the "other" toothed whales have many teeth in both jaws. So, the whale dentitions differ so widely that they could well have had different evolutionary origins, although this possibility is always discounted by mainstream science.

Loose-ends and other conflicts. The DNA work of Milinkovitch et al also suggests that sperm whales split from baleen whales only 10-13 milllion years ago, as measured by molecular clocks. These dates are in direct conflict with the fossil record. Fossils of both sperm and baleen whales have been found in strata 23 million years old in South America. (R18)

Another conflict can be seen in whale family trees drawn by M. Landau, based on sequences from myoglobin and cytochrome. (Not reproduced here) The trees are substantially different. (R2)

Biochemical (or "molecular") data are, therefore, hardly the final answer in guiding the construction of evolutionary family trees.

X2. Bats. Like the whales, some but not all bats possess echolocation apparatus; but, unlike the whales, they are quite similar morphologically---at least they look alike superficially.

Morphological comparisons. The large, Old World fruit bats (the megabats) seem to have come from the same mold as the small, echolocating, largely insectivorous microbats. Those grotesquely long fingers connected by membranes to make wings and all the muscular and neurological infrastructure that confer the power of flight could never have evolved twice. Cranial vascular features and fetal membranes, too, are so much alike (R13) that bats must be monophyletic---that is, on the same branch of the Tree of Life. But are they really?

Beneath the external morphological similarities of bats lurk some rather profound differences. These are well known to the monophyleticists but are usually discounted by them. Here are a few of the dissimilarities.

- The dentition of the megabats is distinct from that of the microbats. The latter's teeth "could not have been derived from their insectivore-like teeth." (R10) (See BMA1-X9 in Mammals 1 for more on this subject.)

- The glans penis is present only in the megabats, flying lemurs (Dermoptera) and the primates. (R13)

- The above association of the megabats with the primates was accentuated in 1984 when J.D. Pettigrew wrote in Science that the megabats possess a primate-type connection between their eyes and midbrain. (R5) The microbats do not boast this "advanced" neural circuitry. Interestingly enough, the flying lemurs do. (R13) In fact, some taxonomists maintain that brain-visual traits are more likely to indicate true evolutionary relationships than such adaptive features as wings. (R12) See BM16 for more on bat neurologies.

What does all this mean? The majority of those scientists interested in such arcana favor the traditional taxonomic relationship; that is, monophyleticity. Even so, the differences between the mega- and microbats, while not as obvious as wings, were still troubling. Then, along came DNA analysis---the White Knight of taxonomy or, more properly, phylogeny. (Pure taxonomy does not purport to show evolutionary relatioships; it's just a way or systematizing life forms.)

The DNA evidence. W.J. Bailey et al, all at Wayne State University School of Medicine, used a 1.2-kilobase region of nuclear DNA from 17 species, including

11 primates, both bats suborders, the flying lemur, a tree shrew, and even a rabbit and goat. The family tree they drew up from their comparisons placed the mega- and microbats squarely in the same taxonomic order and, at the same time, some distance from the primates. (R13) The work of Bailey et al involved the epsilon-globulin gene and echoed previous comparisons of bat mitochondrial genes by other workers. (R14) All of the biochemical evidence so far supports the conventional view that all bats belong to the Order Chiroptera, which is distinct and far distant from the Order Primates.

Loose ends. Taxonomists doubtless breathed a sigh of relief when biochemistry assured them that bat flight did not evolve twice. However, this determination means that unique eye-brain neural circuitry and glans penis found in the megabats, flying lemur, and primates were invented and evolved thrice---in three different orders of mammals. It is not obvious that this is easier to believe than the double invention and evolution of wings and flight.

X3. Pandas. The giant panda and lesser or red panda share many anatomical and behavioral characteristics. They both live in Asia and dote on bamboo. (These similarities are discussed in more detail in BMA1-X7 in Mammals 1.) Here, the following sentence from Science News will suffice:

> The giant and lesser pandas have been grouped together because they share characteristics of tooth structure, skull architecture, penis shape and fur color pattern. (R4)

With all these morphological similarities, one would expect them to be closely related, and some taxonomists have thought so, too. But the giant panda does look a lot like a bear, even though it does not hibernate and bleats instead of growling. And the lesser panda hints at a raccoon connection. So, other taxonomists insist they are actually not closely related. Surely, this is a controversy that biochemistry can lay to rest.

One such analysis, by S.J. O'Brien et al, examined DNA and protein sequences. The result was a phylogeny that showed clearly that the giant panda is really a bear, and the lesser panda, a raccoon. Furthermore, their lineages split 30-50 millions years ago. O'Brien ventured that all the similarities are: "...probably the result of parallel retention of ancestral characters that may have been lost (for example, in the bear) after their divergence from the main line." (R4)

Complicating the picture are the mitochondrial-DNA analyses of Y. Zhang and L. Shi, who came up with a conflicting phylogentic tree.

> In our phylogenetic tree, the giant panda is more closely related to the lesser panda than to the bears. (R9)

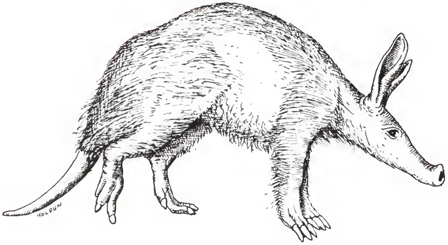
Therefore, biochemistry does not always tell the same story. It seems to depend upon which molecules are used. Even more certainly, it sometimes cannot confirm family trees established from visible traits; that is, morphology.

X4. Some lesser discordances between external morphology and biochemistry.

Guinea pigs. Familiar to everyone, the domestic guinea pig (and all its wild relatives) looks like a rodent minus the long tail. Once again, external appearances are deceiving. For example, the guinea pig's insulin differs markedly from that of other mammals. In fact, amino-acid-sequence data have convinced some taxonomists that guinea pigs are so different that they should be placed in a new order that is separate and distinct from Rodentia. (R8) and BMC6-X1.

Aardvarks. Besides being the first mammal in the dictionary, the aardvark is unusual in having an entire taxonomic order to itself: Tubulidentata. The animal looks a bit like a pig but operates as if it were an anteater, using its long, sticky tongue in the approved anteater manner. But the aardvark is neither a pig nor an anteater; in fact, it is hard to decide just where it belongs on the mammalian family tree. Can biochemistry aid the taxonomist here?

In 1981, W.W. de Jong et al published in Nature the results of their



Closely related to neither pigs nor anteaters, some of the aardvark's proteins suggest a close relationship to elephants and manatees---animals that are quite different morphologically.

comparison of an eye-lens protein from the aardvark and 15 other orders of mammals. The aardvark turned out to be most closely related to the paenungulates (elephants, manatees, hyraxes). (R1) There is obviously little hint of this relationship in external appearances. When the aardvark teeth are examined, however, it is found that those nearest the front of the jaw develop first, only to fall out as maturity is reached. These are succeeded by others farther back. (R7) Readers of Mammals I will recall that the "marching teeth" of manatees and elephants link them taxonomically despite their present diverse life styles. (BMA31) The aardvark's teeth do not really "march", but the front ones do fall out as with elephants and manatees. So, there is a morphological connection of sorts.

Hyraxes. Many, but not all, morphologists place the hyraxes and perissodactyls (horses, rhinos, tapirs) very close on the evolutionary family tree. Protein-sequence data, though, link the hyraxes more closely to the sirenians (manatees, dugongs) and elephants. (R12)

Rabbits and rodents. In his 1992 survey of the impact of molecular data on taxonomy, M.J. Novacek wrote:

> There are also some marked discrepancies between molecular and morphological results. Perhaps most notable among these concerns the Cohort Glires, which includes lagomorphs [rabbits and hares] and rodents. Glires was promoted in early

According to protein-sequence data, the hyrax may be more closely related to the sirenians (manatees, etc.) than their usual neighbors on the evolutionary family tree, the perissodactyls (horses, etc.)

studies, preserved in [G.G.] Simpson's classification and strongly supported in many modern investigations of skull structure, architecture of the ankle joint, fetal membranes and tooth development. Such results starkly contradict immunological comparisons and fail to find clear affirmation in protein sequence as well as gene sequence studies. (R12)

Mammals in general. Taxonomists always line up monotremes as most "primitive," marsupials follow as being a bit more "advanced," and the placental mammals come last as being the most "advanced" of all. Do DNA comparisons bear out this rather subjectively designed sequence?

> Recently there has been much work done on molecular biology with the idea of tracing relationships thereby. It is interesting, then, to note from this that the DNA complement of monotremes is from 93% to 98% of that of the placental mammals. The corresponding figures for such marsupials range from 81% to 94%. Is anyone then ready on this basis to say that the monotremes are more closely related to the placental mammals than are the marsupials? There are also other cytological correspondences between monotremes and placental mammals. (R3)

On this matter, unfortunately, we have found neither the desired details nor a reference from the mainstream scientific literature.

References

R1. de Jong, Wilfried W., et al; "Relationship of Aardvark to Elephants, Hyraxes and Sea Cows from Alpha-Crystallin Sequences," Nature, 292:538, 1981. (X4)

R2. Landau, Matthew; "Whales: Can Evolution Account for them," Creation/Evolution, 3:14, Fall 1982. (X1)

R3. Brown, C.; "The Monotremes," Creation Science Movement, Pamphlet #235, July 1983. (X4)

R4. Anonymous; "Panda Pedigree: Giant and Lesser," Science News, 128:216, 1985. (X3)

R5. Pettigrew, John D.; "Flying Primates? Megabats Have the Advanced Pathway from Eye to Midbrain," Science, 231:1304, 1986. (X2)

R6. Martin, R.D.; "Are Fruit Bats Primates?" Nature, 320:482, 1986. (X2)

R7. Nowak, Ronald M.; Walker's Mammals of the World, Baltimore, 1991. (X4)

R8. Graur, Dan, et al; "Is the Guinea-Pig a Rodent?" Nature, 351, 1991. (X4)

R9. Zhang, Ya-Ping, and Shi, Li-Ming; "Riddle of the Giant Panda," Nature, 352:573, 1991. (X3)

R10. Wesson, Robert; Beyond Natural Selection, Cambridge, 1991. (X2)

R11. Anonymous; "Is It a Bat or Is It a Monkey?" New Scientist, p. 9, April 11, 1992. (X2)

R12. Novacek, Michael J.; "Mammalian Phylogeny: Shaking the Tree," Nature, 356:121, 1992. (X2, X4)

R13. Bailey, Wendy J., et al; "Rejection of the 'Flying Primate' Hypothesis by Phylogenetic Evidence from the Epsilon-Globin Gene," Science, 256:86, 1992. (X2)

R14. Gibbons, Ann; "Is 'Flying Primate' Hypothesis Headed for Crash Landing?" Science, 256:34, 1991. (X2)

R15. Milinkovitch, Michael C., et al; "Revised Phylogeny of Whales Suggested by Mitochondrial Ribosomal DNA Sequences," Nature, 361:346, 1993. (X1)

R16. De Smet, Koen; "Baleen Whale's Genes Capture Echoes of Past," New Scientist, p. 15, February 20, 1993. (X1)

R17. Anonymous; "Whale of a Change for Cetacean History," Science News, 143:127, 1993. (X1)

R18. Novacek, Michael; "Genes Tell a New Whale Tale," Nature, 361:298, 1993. (X1)

R19. Margulis, Lynn, and Guerrero, Ricardo; "Kingdoms in Turmoil," New Scientist, p. 46, March 23, 1991. (X0)

BMG2 Closely Related Mammals with Different Chromosome Numbers

Description. The presence of different numbers of chromosomes in mammals that look very much alike and are generally acknowledged to be closely related. Males and females of the same species with different chromosome numbers are also included here.

Data Evaluation. The information sources here are a book and science-magazine article by a widely respected biologist and a technical guide to neotropical mammals. The phenomenon is considered well-established. Rating: 1.

Anomaly Evaluation. Chromosome-number differences between males and females of the same species (sex-chromosome mosiacism) is not considered anomalous, for it seems to have no evolutionary significance. Gross differences in chromosome numbers between closely related species, as in the case of the horses, may signify that a type of macromutation called "chromosomal speciation" has occurred. For reasons unknown, one or more chromosomes, in sperm or egg, will very rarely spontaneously fission or fuse, resulting in morophological changes that may ultimately lead to a new species. This sort of random speciation is consistent with the evolutionary paradigm and cannot be considered anomalous. We do, however, consider it curious enough to catalog. Rating: 3.

Possible Explanations. It does seem incongruous when closely related species have widely divergent chromosome numbers. Somehow, the cell machinery finds and uses just the genetic information it needs regardless of how it is packed into chromosomes or mixed up with "junk" DNA (introns). This is obviously not an explanation, but it does defer the question of "how" to the separate catalog volume on genetics (BG).

Similar and Related Phenomena. Genetic anomalies (BG). The many human chromosome aberrations leading to various pathologies of body and behavior.

Entries

X1. Species that look alike. Rather surprisingly, some mammals that are very much alike in form and behavior display marked differences in the numbers and shapes of their chromosomes. (R1)

Horses. Modern horses are very similar in general appearance. Even the gaudy stripes of the zebras cannot conceal the fact that they belong to the horse family. But when one begins to count horse chromosomes, the picture is startlingly different.

> All zebras, and only zebras, have fewer than fifty pairs of chromosomes (thirty-two in Hartmann's zebra to forty-six in Grevy's zebra). All other horses have more than fifty (from fifty-six in Equus hemionus [onager] to sixty-six in Przewalski's horse). (R2)

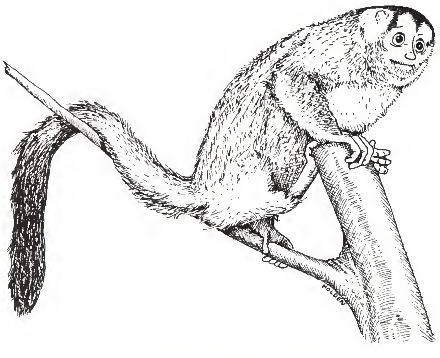
S.J. Gould, author of the above quotation, remarks that the fission and fusion of chromosomes may be a major mechanism of mammalian speciation---a way of introducing variety. (R2) It is theoretically possible for a single male, in whom chromosomal fusion or fission has occurred, to introduce the chromosomal change into a normal population under certain circumstances. First, of course, the chromosomal change must be advantageous to the species. Second, some types of social structure can accelerate the introduction of the change. For example, small kin groups that breed almost exclusively among themselves, with harems belonging to a dominant male, will favor a type of evolution called "chromosomal speciation." (R1)

Humans and chimpanzees. One writer, J. Diamond, labels humans "the third chimpanzees." There are, of course, many obvious similarities in morphology and behavior. The supposed close kinship between humans and chimpanzees is supported further by claims that their DNAs differ by only 2%. Even so, humans possess only 46 chromosomes, while chimpanzees (and gorillas and orangs) have 48. For elaboration, see BHG5 and BHG11 in Humans III.

X2. Different sexes of the same species. In our literature survey, we have found two mammals where the males and females have different numbers of chromosomes. There may be more.

Dromiciops australis. This little marsupial of northern Argentina and Chile is locally called "colocolo" or "monito del monte" (little monkey of the mountain). It is only about 10 inches long, half of which is tail, and not a monkey at all. The colocolo is considered to bring bad luck. Natives who see it around their houses sometimes burn their houses down! Unrelated to this superstition is the fact that the males possess only 13 chromosomes to the female's 14. Males of this species exhibit what is called "sex-chromosome mosaicism." (R3) This seems to be only an aberration with no evolutionary significance.

Aotus azarae (night monkey). Inhabiting the same general area as the monito del monte is this small primate---a placental mammal obviously. In this case, the males possess 49 chromosomes and the females, 50. (R3) This is probably another example of sex-chromosome



Weighing less than a kilogram, this "night monkey" (Aotus azarae) inhabits southern South America. The females have one more chromosome than the males.

mosiacism.

References

R1. Gould, Stephen Jay; "The Chance That Shapes Our Ends," New Scientist, 89:347, 1981. (X1)

R2. Gould, Stephen Jay; Hen's Teeth and Horse's Toes, New York, 1983. (X1)

R3. Redford, Kent H., and Eisenberg, John F.; Mammals of the Neotropics, vol. 2, Chicago, 1992. (X2)

BMG3 Evolution Rates That Are Much Higher Than Predicted from Genetics

Description. Discordances between the rates of evolution inferred from the fossil record and those deemed possible using accepted evolutionary mechanisms.

Data Evaluation. The rate of evolution of a species is theoretically calculable from fossil evidence. One needs, first, accurate radiometric clocks. These have a relatively sound scientific foundation. On the other hand, measuring the rate of evolution of a species from the fossil record is highly subjective. Some important visible traits are not even fossilizable. And just what is a "unit" of morphological change? Likewise, most estimates of rates of genetic change must be labelled speculative, especially during episodes of macroevolution, where no one really knows what is happening in the genome or at the morphological (visible-trait) level. Seeing all these imponderables, we do not consider this phenomenon firmly established. Rating: 3.

Anomaly Evaluation. The claimed incompatibility of rates is a major challenge to either the accuracy of the fossil record, or the accuracy of predictions of rates of genetic change, or both. Rating: 1.

Possible Explanations. No one really yet has a handle on many of the parameters that make up this phenomenon. Radiometric dating may be the exception. Further research may eliminate the claimed phenomenon.

Similar and Related Phenomena. The fossil record of whales (BME1-X4).

Entries

X1. Whale evolution. Despite the reservations expressed above, R. Wesson has stated that the claimed phenomenon is seen in whale evolution.

Genetic considerations also point up

the difficulty of the whale's rapid evolution. By Mayr's calculation, in a rapidly evolving line an organ may enlarge about 1 to 10 percent per million years, but organs of the whale-in-becoming must have grown about ten times more rapidly over 10 million years. Perhaps 300 generations are required for a gene substitution. Moreover, mutations need to occur many times, even with considerable selective advantage, in order to have a good chance of becoming fixed. Considering the length of whale generations, the rarity with which the needed mutations are likely to appear, and the multitude of mutations needed to convert a land animal into a whale, it is easy to conclude that gradualist natural selection cannot account for this animal. (R1)

Reference

R1. Wesson, Robert; Beyond Natural Selection, Cambridge, 1991. (X1)

All whales, including this right whale, seem to have evolved too rapidly.

BMG4 Unexplained Rapid Evolution of Inbred Mice

Description. Unexplained, unexpectedly rapid genetic divergence (that is, "evolution) in strains of inbred laboratory mice.

Data Evaluation. Our entry is based on a single study reported in Science. As always the case, replication and confirmation are desirable. Rating: 2.

Anomaly Evaluation. Some low rate of genetic divergence is not only expected but thought to be impossible to avoid in all life forms. The question arising here is why this "genetic drift" should be accelerated by several orders of magnitude in inbred laboratory mice. This phenomenon challenges our understanding of how and why mutations occur. Rating: 1.

Possible Explanations. Undetected contamination of the strains of mice. Or, perhaps natural rates of genetic divergence are really much higher than we think, but natural selection exerts a much stronger damping force than expected.

Similar and Related Phenomena. Chromosomal speciation in small, inbreeding groups of wild animals (BMG2-X1).

Entries

X1. A study of genetic variation. Using ten strains of inbred laboratory mice, W.M. Fitch and W.R. Atchley, University of Wisconsin, determined the variation at 97 loci of their genes. They were astounded to find that the changes they observed were many times more frequent than they could account for using simple, established mechanisms of genetic change. In fact, the rate was several orders of magnitude higher than those seen in wild populations. Fitch and Atchley looked for possible causes of their unexpected results, such as contamination of the mouse strains, but could find none. They concluded that they had seen unusually rapid mutation in the special case of an inbred group. (R1, R2)

X2. Rapid morphological changes observed in inbred mice. Some biologists have reported seeing unexpectedly rapid changes in the jaw shape and other visible traits in inbred strains. (R1, R2) Evidently, there are no systematic studies of rapid mutation at the phenotype level; that is, visible morphology.

X3. Implications of the phenomenon. The results of the observations made by Fitch and Atchley could be far-reaching. R. Lewin explains:

> Whatever the mechanism, it will be of interest in the context of origin of the species, specifically the rate at which such events might occur. Few would wish to extrapolate without restraint between the highly artificial breeding of an inbred strain and conditions that apply in nature, but the greatly accelerated rate of the fixation of variants in what is effectively a small, isolated population bears taking note, especially as it is in the apparent absence of selection. (R1)

In BMG2-X1, we see how "chromosomal speciation" may also be favored in small, isolated, wild, inbreeding populations.

References

R1. Lewin, Roger; "Why Do Inbred Mice Evolve So Quickly?" Science, 228: 1187, 1985. (X1-X3)

R2. Fitch, Walter M., and Atchley, William R.; "Evolution in Inbred Strains of Mice Appears Rapid," Science, 228:1169, 1985. (X1, X2)

BMG5 Species with Cells Containing "Alien" Mitochondria

Description. The existence of species harboring the mitochondria typical of another species rather than its own. Usually the species involved are closely related but easy to distinguish by their differing nuclear DNAs and visible traits.

Data Evaluation. So far, the phenomenon has been noted in only two species of European mice. Our source is a commentary in Science on a paper that originally appeared in the Proceedings the National Academy of Sciences (80:2290, 1983). It is likely that the phenomenon is more complex and widespread than indicated below, but we have so far seen nothing else on it. Rating: 2.

Anomaly Evaluation. The creation of "double-species" seems well within the explanatory capability of present biological theory. What is actually at risk is the concept of species. Does the presence of "alien" mitochondria require taxonomists to split the species: one with "normal" mitochondria, the other with "alien" mitochondria? Would other types of endosymbionts become involved in species definition? The species concept continues to be very useful, but it is also highly artificial and rather flimsy. But, all biologists recognize this already, and one more challenge to the species concept is not very anomalous in this context. Rating: 3.

Possible Explanations. See X1 below.

Similar and Related Phenomena. Hybrid mammals (BMA4 in Mammals I); mammalian mosaics (BMA4 in Mammals I); blood chimeras in humans BHC15 in Humans II).

Entries

X1. Observations of European mice. In Western Europe, homes are invaded by the mouse Mus domesticus. In the east, a very close relative, Mus musculus, fills this niche. The nuclear genes of these two recognized species differ by a significant 5%. At the morphological level, these genome differences manifest themselves in terms of small, but diagnostic differences in visible traits. All this is as a biologist would expect.

But when the animals' mitochondrial DNA (mtDNA) is examined, a remarkable situation arises. The mice in northern Denmark and northward into Scandanavia are Mus musculus according to their nuclear DNA and visible traits, but Mus domesticus in terms of their mitochondrial DNA. In effect, we have a double-species, a genetic chimera; part one species, part another.

A few words about mitochondria are in order. Mitochondria are widely believed to have originated when ancient bacteria invaded animal cells and were assimilated to become the energizers of cells. They have their own DNA and evolutionary history. Each cell incorporates thousands of mitochondria, but only one nucleus. Mitochondrial DNA is much simpler than nuclear DNA and evolves much faster. Mitochondrial DNA is inherited almost exclusively from the mother. (See BMG6.) Mitochondria are not passive and will compete with other "species" of mitochondria given the chance.

Such opportunities occur where Mus domesticus and Mus musculus overlap in Europe. The hybrids that sometimes occur are usually subfertile. Nevertheless, the "double-species" are believed to originate during such hybridization, when a "founder" female Mus domesticus introduces her "alien" mitochondria into a normal Mus musculus population.

At issue is not so much the exact way in which "double-species" are created, but what it all means to the definition of a species. Will it now be necessary to define species in terms of the types of nuclear and mitochondrial DNA it carries? Who knows how many "double-species" exist. Since mitochondria are so ancient in evolutionary terms, some of them are probably more successful than others at disposing of rival mitochondria when encountered within the same cell! Species-within- species implies evolution-within-evolution.

Reference

R1. Lewin, Roger; "Invasion by Alien Genes," Science, 220:811, 1983. (X1)

BMG6 Paternal Mitochondrial DNA Can Be Inherited in Mammals

Cross Reference. Contrary to widely promulgated assertions that mitochondrial DNA (mtDNA) can be inherited only maternally, experiments by U. Gyllensten and colleagues, at the University of Uppsala, have demonstrated that, in laboratory mice, approximately one mitochondrion in every thousand is actually paternal. (R1) This subject and its possible impact upon theories of human origin (African Eve hypothesis) are covered in BMH14 in Humans III.

Reference

R1. Ross, Philip E.; "Crossed Lines," Scientific American, 265:30, October 1991.

BMG7 Functions of "Knocked-Out" Genes Not Completely Lost

Description. The discovery that when a specific gene is "knocked out" or eliminated from a genome, its functions may be assumed, at least in part, by the remaining genes.

Data Evaluation. The sole basis for this entry is a newspaper report on a series of "knock-out" experiments with mice. No professional-level reports have been found as yet. Rating: 3.

Anomaly Evaluation. The "knock-out" gene experiments imply that genes are more than information-storage devices analogous to magnetic tapes. Instead, it seems that genetic information may be spread holistically throughout the genome, so that the damage or destruction of one gene is not catastrophic. Lost information may, in the holistic model, be recovered in part from the remaining genome. The idea of holistic genomes in not new, but it clashes strongly with current reductionism in genetics. Rating: 1.

Possible Explanations. See X2 below.

Similar and Related Phenomena. Apparent lack of memory traces in brains (BHO23 in Humans II); the surprising capabilities of damaged brains (BHO20 in Humans II).

Entries

X1. Mice with knocked-out genes. At the University of Utah, M. Capecchi and colleagues create what they call "knock-out mice" by knocking out or excising genes known to be associated with certain functions. Suprisingly, when a gene is knocked out, other genes seem to possess some of the information and the capacity required to complete the function that was supposedly destroyed---at least to some degree. Consider, for example, what happened when Capecchi et al knocked out a gene known to be concerned with the formation of the ears in embryonic mice. More specifically, the knocked-out gene controls the production of a stimulator protein called "fibroblast growth factor 3." When the mice lacking the gene matured, a surprising spectrum of ears was observed despite the gene excision.

> In some cases, the genetic program compensated for the defect by building one normal left ear but neglectting the right ear, leaving the animal with a useless hole where the right ear should be. In other cases, the genetic program opted to build a good right ear, and the left ear came out defective. About 15 percent of the time, the entire attempt failed, and the mice were born with no ears at all, while more rarely the DNA pulled off a near-miracle and constructed two healthy ears. (R1)

X2. Implications of the phenomenon. The above experimental results lead inevitably to speculations as to just how genetic instructions are stored and executed in life forms. We now present a few of these musings.

- Genetic information and instructions are spread throughout the genome and are probably repeated often. Holism and redundancy are implied here---properties useful in complex systems. However, holistic genomes are not yet part of mainstream biological thinking.

•Genomes are more than information-storage devices. They can improvise and innovate when errors and missing information are encountered. (If genes can be "selfish." perhaps they can also be "intelligent" or at least "adaptive"!) This interpretation is the antithesis of clockwork reductionism. The variability of the above-described experimental results suggest that genomes, even from the same species, are not equally successful in coping with problems.

•Our single source does not say if the ear-making gene was knocked out in all of the cells in the mouse embryo. If this did not happen, the information required for ear development might be obtained from unaffected cells in some unrecognized manner. (R. Sheldrake's widely rejected idea of morphic resonance suggests itself here!)

•If the procedure of knocking-out a gene leaves genetic debris behind, the information content of this debris might be "read" and acted upon by surviving genes.

•Some of the information needed for ear-building might be extragenetic; that is, stored in other parts of the cells.

It is amazing how many provocative thoughts one experiment can engender. But the bottom line is that the genome may well transcend the popular concept that it is just strings of coded information; that is, merely a biological data-storage device.

Reference

R1. Angier, Natalie; "When a Vital Gene Is Missing, Understudies Fill In," New York Times, September 7, 1993. Cr. P. Gunkel. (X1)

BMG8 Armadillo "Identical" Quadruplets Are Not

Description. Substantial differences observed in the morphological and biochemical traits of nonhuman mammals thought to be genetically "identical." Such "identical" offspring (twins, quadruplets, etc.) are created when an ovum splits and each part develops into a separate embryo, each supposedly containing the same genome.

Data Evaluation. While we have found several reports dealing with the nonidentity of human identical twins (BHA8 in Humans 1), our files contain only one item concerned with nonhuman mammals (armadillos, in this case). This item is from a science magazine dated 1968. Our data base is very likely incomplete and dated as well. Nevertheless, the phenomenon is well worth recording, even if incompletely described. Rating: 3.

Anomaly Evaluation. The paradigm at risk here is the assertion, frequently made, that the genome carries all the information required for the development of the embryo and resulting offspring. It is now widely recognized that the womb's environment will differ for each embryo and, therefore, result in differences in the end products. In this context, the paradigm is already weakened a bit. But the extragenetic factors considered here, such as unequal division of cytoplasm, are more hazardous to the-genome-is-everything paradigm. Rating: 2.

Possible Explanations. Ova do not split evenly, allowing cells to receive different inventories of cytoplasm and the extragenetic factors it may contain. Even some genetic material (DNA) may be split unequally, resulting in human "identical" twins of opposite sex (BHA8 in Humans 1).

Similar and Related Phenomena. Discordances between human identical twins (BHA8 in Humans 1); the observation in simple life forms that some DNA resides outside the nucleus (BLG).

Entries

X0. Background and cross reference. Human identical twins often look very much alike and possess similar behavioral traits. Even identical twins reared apart are discovered, when reunited, to have habits and life histories that are eerily alike. Yet, these twins, supposedly carrying identical genomes, also exhibit some significant morphological and behavioral differences. These discordances make biologists wonder what extragenetic factors might be at work. Such possiblities among humans are explored in BHA8 in Humans 1.

Much less is known about differences in "identical" nonhuman mammals. In fact, we have so far acquired only one report upon which to base this entry, and it is focussed on the nine-banded armadillo. In this armadillo (and probably other armadillo species) the female's egg almost always divides into four parts all carrying identical genetic information. The result is "identical" quadruplets---almost every time. But like the human identical twins, the armadillo quadruplets are not really identical.

To casual human observers, the armadillo quadruplets may look the same as far as visible traits are concerned, but studies of their organs and biochemistry reveal otherwise.

X1. Studies of armadillo quadruplets. In 1951, after biochemist R.J. Williams detected significant changes in the urine of rats that had been inbred for 101 generations, it was obvious to him that these rats, possessing essentially the same genomes, were far from identical biochemically. He then decided to explore further the question of extragenetic factors in the development of animals.

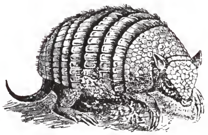
> Dr. Williams, working with Dr. Eleanor Storrs Burchfield, collected 62 adult female armadillos who produced 249 infants---61 quadruplet sets and one litter with a fifth wheel---of which 16 sets of four were used.
>
> The 64 were sacrificed at birth and tested for 20 parameters including body weight, organ weight (including adrenals, brain, heart, kidney and liver) and levels of various chemicals present in these organs. Each animal was compared to his litter mates.
>
> The ostensibly identical quadruplets showed differences ranging from 2- to 140-fold.
>
> Although the interuterine enivronment may be partially responsible for the differences, these variations are too marked to be attributed to such factors as position in the uterus or the amount of blood supplied to the fetus, Dr. Williams says. The explanation, he believes, can be more accurately attributed to something in the cytoplasm, the fluid surrounding the nucleus of the egg cell from which the animals developed. (R1)

Williams pointed out that before splitting the armadillo egg is asymmetrical. When it does split into four parts, the new cells are not all of equal size---some are shortchanged in the division of the cytoplasm. The constituents of the cytoplasm may affect the ability of a cell's genes to express themselves. For example, Williams ventured, the divided cells may have received unequal numbers of mitochondria, those organelles that energize cells. Such extragenetic inequalities could well account for the rather large internal and biochemical differences seen in "identical" armadillo quadruplets. (R1)

In BMG5, the presence of "alien" mitochondria is seen to affect visible traits in populations of wild mice.

Reference

R1. Culliton, Barbara J.; "64 Armadillos Threaten a Theory," Science News, 94:555, 1968. (X1)



Armadillos are usually born as quadruplets, all from the same egg. Even so, they may differ substantially from their "identical" brothers or sisters.

BMI INTERNAL SYSTEMS AND STRUCTURES

Key to Phenomena

BMI0 Introduction

After the externally discerned anomalies of mammals have been discussed (BMA in Mammals I) and their organs assessed for still more anomalies (BMO in the present volume, there remain several vital internal structures and systems that support and protect the body and unite its subsystems. These systems are unusually complex and sophisticated, especially the immune and nervous systems. It is a major theme of this book that the evolution of such systems, using only Darwinistic mechanisms (mainly random mutation and natural selection) must be regarded with suspicion. Beyond this heresy, which is bad enough, the specter of Lamarckism is raised again, this time in connection with claims for acquired immunological tolerance.

BMI1 Inheritance of Acquired Immunological Tolerance

Description. Laboratory experiments demonstrating that a mammal's acquired immunological tolerance can be inherited by its progeny. In simpler terms, a mammal's immune system at first acts to reject alien cells but in time acquires some degree of tolerance for them. An anomaly exists if this acquired tolerance can be passed on to its offspring.

Data Evaluation. Experiments reported by Gorczynski and Steele in 1981 seemed to prove the reality of the claimed phenomenon, but several attempts at replication by other groups failed to support the Gorczynski-Steele claim. At present, the scientific consensus is that acquired immunological tolerance cannot be passed from one generation to the next. Steele, however, has recently claimed further evidence for the reality of the phenomenon. Rating: 3½.

Anomaly Evaluation. The proof that acquired immunological tolerance can indeed be inherited would support Lamarckism (the doctrine of the inheritance of acquired traits), long considered to be thoroughly discredited. Given the passionate denial of Lamarckism by virtually all biologists and biological textbooks, the phenomenon at hand must be rated as highly anomalous. Rating: 1.

Possible Explanations. "Bad science" is the generally accepted explanation of the Gorczynski-Steele experiments. Despite all the controversy, it is theoretically possible that retroviruses can carry genetic data from modified somatic (body) cells to germ cells (sperm and ova) and thence to offspring.

Similar and Related Phenomena. See the Subject Indexes of the Series-B catalogs under: Lamarckism.

Entries

X0. Background. In 1980-1981, R.M. Gorczynski and E.J. (Ted) Steele published in quick succession two papers in highly respected science journals. (R1, R2) Their work seemed to support J.B. Lamarck's two-century-old theory that traits acquired during an organism's lifetime could somehow be passed on to its progeny. The papers ignited a firestorm among biologists, because it was (and still is) dogma that Lamarckism has never been proved and had long ago succumbed to Darwinism.

Although Gorczynski was the first author on both papers, it was Steele who pushed the inheritability of acquired immunological tolerance and, in consequence, became the central figure in the controversy that erupted. This young Australian immunologist did his original research on the subject in Canada and was then invited to England to pursue his ideas further. After about 15 months of intemperate jousting with English Darwinists, Steele returned to Australia where he has continued to look to evidence of Lamarckism.

Although Darwinism is popularly said to have vanquished Lamarckism, Darwinism does not really preclude Lamarckism. The former actually deals with the action of natural selection upon traits acquired by any mechanism---even Lamarckism. It was in 1885 that the German biologist A. Weismann formally declared that Lamarckism was impossible. There is, Weismann said, an impenetrable barrier between an organism's germ cells (eggs and sperm) and its somatic cells (rest of the body). Therefore, any traits acquired by the body cannot be communicated to the germ cells. While more than a century of experience has confirmed Weismann's hypothesis, it remains a hypothesis, and perhaps one with a slight crack. (R5)

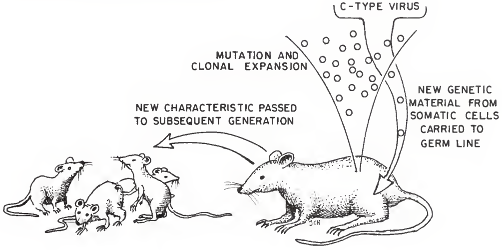
Weismann's impenetrable barrier can be breached in principle by retroviruses that have been shown to carry DNA fragments from somatic cells to the germ cells and insert them there. If the DNA of the somatic cells has mutated, this information might be incorporated in the germ cells and passed on to progeny. Interestingly enough, the first paper by Gorczynski and Steele (R1) was submitted to the U.S. National Academy of Sciences by H.M. Temin, who had received a Nobel prize for research on the suspect retroviruses. (R7)

Steele's attitude toward Darwinism bears strongly on his zeal in exploring Lamarckian ideas. The following paragraph characterizes his outlook.

> "Although Darwinism may account to some extent for the diversity and abundance of cells or organisms," writes Steele, "there remains a suspicion that it provides no satisfactory explanation for our intuitive belief that there appears to be an element of 'directional' progress in the complexity and sophistication of adapted living things.' Steele sees "an undercurrent of Lamarckian modes of inheritance" as providing the directional element he seeks in evolution. Steele is also in search of, as he sees it, a better explanation of the speed with which evolution can advance and of the large coordinated changes that appear to be demanded. (R5)

Steele states that he does not reject Darwinism, he only wishes to improve it. His words, though, seem like those of a committed iconoclast.

X1. The Gorczynski-Steele experiments. The hypothesis that Gorczynski and Steele set out to test can be stated simply: Retroviruses can carry genetic information from somatic cells to germ cells and thus pass along to future generations genetic adaptations that had occurred in the somatic cells---Lamarckism pure and simple. In their first experiments, Gorczynski and Steele measured



E.J. Steele proposes that a mutant somatic cell favored by the environment will undergo clonal expansion. The modified genetic material from these cells may be passed on to the next generation via C-type viruses.

the vigor with which the spleen cells of laboratory mice attacked "alien" cells that had been injected into them. This reaction of the immune system is, of course, expected. Eventually, the mice became more tolerant of the injected "alien" cells. But could they pass this acquired tolerance on to their progeny? Gorczynski and Steele found that they could. In fact, 50-60% of the first generation exhibited such tolerance, an effect that waned to 20-40% in the second generation. (R5)

These results were duly published in prestigious journals. (R1, R2) Given their Lamarckian implications, the two papers attracted more than the usual attention.

X2. Failures to replicate. The Gorczynski-Steele experiments were a bombshell in the biological community. Other researchers quickly tried to replicate them. In one set of experiments, L. Brent et al applied skin grafts to lab mice instead of actually injecting alien cells---a common technique in immunology. Brent et al found no evidence at all of inheritance of immunological tolerance. (R3) R.N. Smith utilized cell-injection, as had Gorczynski and Steele, but chose laboratory rats over mice. He could not detect the claimed inheritance effect either. (R4) Other experimenters reached similar conclusions.

Steele, now the major protagonist, was quick to defend the work he and Gorczynski had done, asserting that the research of Brent et al actually confirmed their results! He wrote:

> So in contrast to the negative conclusions reported by Brent and coworkers I find the results of their extensive and serious study very encouraging. They report positive effects in the direction predicted by my theory: paternal transmission of an acquired state of lowered immune responsiveness. Like many other important conflicts in the history of science, this one has been resolved by intensive experimentation to refute a hypothesis, and the resulting data have been interpreted in the light of that hypothesis. (R8)

Brent and his colleagues responded (rather passionately) that Steele had: "...examined our data with scant regard for accuracy or scientific method." They forcefully reiterated that their results did not in the slightest degree support the inheritance of immunological tolerance. (R9)

X3. New experiments in Australia. Disheartened by the reception of his ideas in Britain, Steele returned to Australia. Fifteen years after his original work with Gorczynski, Steele appeared as one of the authors of another paper claiming to show that mutations acquired by somatic cells can be passed on to the next generation. (R11) (This title of this reference is virtually an abstract of the paper!) This new work was greeted with the same doubts and emotions as the earlier Gorczynski-Steele research. (R10)

We have not yet found any published refutations of Steele's latest Lamarckian claims, but it is safe to say that mainstream biologists are not even close to admitting Lamarckism to the fold.

References

R1. Gorczynski, R.M., and Steele, E.J.; "Inheritance of Acquired Immunological Tolerance to Foreign Histocompatibility Antigens in Mice," National Academy of Sciences, Proceedings, 77:2871, 1980. (X1)

R2. Gorczynski, R.M., and Steele, E.J.; "Simultaneous Yet Independent Inheritance of Somatically Acquired Tolerance to Two Distinct H-2 Antigenic Haplotype Determinants in Mice," Nature, 289:678, 1981. (X1)

R3. Brent, L., et al; "Supposed Lamarckian Inheritance of Immunological Tolerance," Nature, 290:508, 1981. (X2)

R4. Smith, R.N.; "Inability of Tolerant Males to Sire Tolerant Progeny," Nature, 292:767, 1981. (X2)

R5. Lewin, Roger; "Lamarck Will Not Lie Down," Science, 213:316, 1981. (X0, X1)

R6. Tudge, Colin; "Lamarck Lives---in The Immune System," New Scientist, 89:483, 1981. (X0)

R7. Robertson, Miranda; "Lamarck Re-Visited; the Debate Goes On," New Scientist, 90:230, 1981. (X0, X2)
R8. Steele, Ted; "Lamarck and Immunity: a Conflict Resolved," New Scientist, 90:360, 1981. (X2)
R9. Brent, L., et al; "Lamarck and Immunity: the Tables Turned," New Scientist, 90:493, 1981. (X2)
R10. Anderson, Ian; "Gene Heretic Mounts Fresh Challenge to Darwin," New Scientist, p. 6, December 10, 1994. (X3)
R11. Rothenfluh, Harald S., et al; "Analysis of Patterns of DNA Sequence Variation in Flanking and Coding Regions of Murine Germ-Line Immunoglobulin Heavy-Chain Variable Genes: Evolutionary Implications," National Academy of Sciences, Proceedings, 91:12163, 1994. (X3)

BMI2 Immunity to Rattlesnake Venom

Description. The apparent immunity of some members of the pig family to the venom of rattlesnakes. In this entry, the word "tolerance" might well be substituted for "immunity."

Data Evaluation. Passing references to the phenomenon have been found in two mammal guides. Even so, we do not yet know the extent of the phenomenon as concerns: (1) the immunity to (or "tolerance" of) the varying potencies and quantities of venom injected; and (2) the identities of the species so endowed. It is quite apparent from all this that our data base is wanting. Rating: 3.

Anomaly Evaluation. From the literature surveyed so far, it appears that only some pigs are immune to rattlesnake venom. Furthermore, it is uncertain whether this is an inherited characteristic or merely a bodily defence acquired through occasional non-fatal encounters with rattlesnakes. Rattlesnake bites are often not fatal to the larger mammals, including humans, and some degree of tolerance to rattlesnake venom may accumulate. Since peccaries favor rattlesnake meals, venom exposure is almost unavoidable. For this reason, a buildup of acquired tolerance rather than inherited immunity seems a reasonable explanation of the phenomenon. However, if some pigs are in reality protected from birth, we would have to postulate a series of favorable mutations that led to glands that can synthesize an effective biochemical antivenin. In this case, we would again have to ask whether Darwinistic evolution really can achieve the requisite levels of innovation and complexity in a reasonable length of time. Unfortunately, we do not know whether we are dealing with acquired tolerance or inherited immunity. Evaluation of the phenomenon's anomalousness is, therefore, impossible.

Possible Explanations. See above discussion.

Similar and Related Phenomena. The synthesis of venoms and poisons by mammals (BMC1-X2); and other animals (BRC, BBC, etc.)

Entries

X1. General observations.

Peccaries. In discussing the habits of peccaries, L.L. Rue, III, mentioned their apparent immunity to rattlesnake venom.

> Mine tunnels are favorite refuges, and miners welcome the peccary because of its penchant for rattlesnakes. Like the domestic hog, the peccary seems to be immune to the bite of the rattler. It was thought that the domestic pig's fat prevented the snake's venom from getting into its bloodstream. Because the peccary never becomes as fat as the pig, it is now believed that the entire swine family possesses a built-in immunity to the poison. (R1)

That some members of the pig family seem to be immune to rattlesnake venom is confirmed in Walker's Mammals of the World. (R2) But we have not been able to discover if all pigs are so endowed.

References

R1. Rue, Leonard Lee, III; Pictorial Guide to the Mammals of North America, New York, 1967. (X1)
R2. Nowak, Ronald M.; Walker's Mammals of the World, Baltimore, 1991. (X1)

BMI3 Tropical Mammals with Thick Subcutaneous Fat

Description. The presence on some tropical aquatic mammals of thick, insulating layers of subcutaneous fat. These layers of blubber sometimes require special types of behavior to prevent hyperthermia.

Data Evaluation. All information has been extracted from authoritative mammal guides. Rating: 1.

Anomaly Evaluation. At the very least, heavy layers of subcutaneous fat seem incongruous on tropical mammals. Its presence is actually doubly curious because the same phenomenon affects several distantly related species. Usually, animals fit neatly and efficiently into their environmental niches. An evolutionist would expect that thick layers of blubber would be strongly selected against in the tropics; and that these apparently superfluous cargos of fat would have been eliminated long ago, especially in the monk seals and hippos. In this context, thick subcutaneous fat on tropical mammals is considered a significant anomaly. Rating: 2.

Possible Explanations. Given that subcutaneous fat is very useful in cold climates, it is possible that its presence on tropical animals reflects either a recent climate change and/or a recent shift of ranges for the mammals involved. Perhaps the forces of natural selection have not yet had enough time to slim down these blubber-burdened tropical mammals.

Similar and Related Phenomena. Human subcutaneous fat and the Aquatic Ape Hypothesis (BHI14 in Humans 11).

Entries

X0. Background. Most aquatic mammals inhabiting cold waters are thermally protected by thick layers of subcutaneous fat (blubber). This useful characteristic has appeared in several distantly related mammalian orders: cetaceans (whales and dolphins; sirenians (dugongs and manatees), seals, sea lions, river otters, and the polar bear---up to an impressive 10 centimeters (4 inches) for the latter mammal. (R1, R2) Subcutaneous fat is an adaptation to cold, like the thicker fur coats worn by many mammals in the more northerly portions of their ranges. In fact, thicker coats of fur can be coaxed to grow on laboratory mice just by reducing the temperature of their environment. (BMF10)

Like many aquatic animals, terrestrial humans have appreciable deposits of subcutaneous fat. This feature, virtually unknown in other terrestrial mammals, helped foster the so-called Aquatic Ape Hypothesis. Unaccepted by mainstream science, this hypothesis asserts that human subcutaneous fat is left over or relict from a previous aquatic phase of our evolution. (BHI14 in Humans 11)

X1. Subcutaneous fat in tropical aquatic mammals. While it is easy to see how cold-water mammals have adapted by adding blubber to their bodies, several warm-water mammals also possess thick, thermally insulating fat layers. Often, these tropical mammals must adopt special strategies to overcome this burden. Assuming that blubber layers are inherited from their cold-weather relatives, why have these warm-weather mammals retained these unnecessary blankets?

Monk seals. Today, three species of monk seals are isolated in the Mediterranean, the Caribbean, and around the islands of Hawaii. They are all closely related, but the Hawaiian monk seal is considered the most "primitive." It is also totally tropical in its range and seems to be the most discomfited by its layer of blubber. R.R. Reeves et al have written the following.

> Hawaiian monk seals, like their congeners, live in a tropical climate where the avoidance of overheating is at least as important as keeping warm, especially when they haul out. Their blubber is of a thickness similar to that of phocids living in polar regions. Monk seals do a number of things to keep from over-heating while hauled out on sunbaked sandy beaches. They lie on and wallow in damp sand at the water's edge, assume postures that expose the pale-colored belly more than the dark back, and curtail vigorous movements when hauled out. They also reduce their breathing and heart rates to minimize metabolic heat production. (R2)

Of course these seals do dive into deeper, colder waters when foraging for food, but these forays are brief and do not seem severe enough to account for the monk seals' subcutaneous fat.

Sirenia (manatees and dugongs). Primarily tropical in their ranges, today's sirenia are also clothed in thick layers of blubber. (R2) Note that Steller's sea cow, now believed extinct, was an arctic inhabitant. (BMD13)

Hippopotamuses. Even though they live in warm-to-tropical climates, hippos carry around a heavy layer of subcutaneous fat---up to 5 centimeters (2 inches) thick. Keeping cool is a problem. It is solved by remaining in rivers and lakes during the day and foraging on land at night. The hippos, however, do not have any cold-weather relatives from whom they could have inherited their fat! (R1)

Cetaceans (whales and dolphins). Many whales and dolphins live in or transit tropical waters. Their blubber layers are easier to account for than the above mammals because they frequently dive deep into cold waters for food.

References

R1. Nowak, Ronald M.; Walker's Mammals of the World, Baltimore, 1991. (X0, X1)

R2. Reeves, Randall R., et al; Seals and Sirenians, San Francisco, 1992. (X0, X1)

BMI4 Curiosities of Mammalian Urogenital Systems

Description. Curious differences and similarities in the arrangements of the reproductive and excretory systems of mammals.

Data Evaluation. The primary source here is Walker's Mammals of the World. This immense compendium is supplemented by some articles from science journals and magazines. Rating: 2.

Anomaly Evaluation. This entry is merely a collection of oddities harboring no obvious anomalies. Rating: 3.

Possible Explanations. None required.

Similar and Related Phenomena. Atavisms and reversions in mammals (BMA6, BMA42); morphological parallelisms between marsupials and placental mammals (BMA1); face-to-face copulation in mammals (BMB23). All in Mammals 1.

Entries

X1. Common urogenital and feces-excretion orifices. In common with most birds and reptiles, some allegedly primitive mammals have only a single orifice for the discharge of urine and feces as well as the introduction and excretion of "reproductive products"; that is, sperm and embryos. The cavities adjacent to these orifices are termed "cloacas."

Monotremes (platypus and echidnas). The word "monotreme" means "one-ender" and it is apt here. The monotremes discharge their urine, feces, and eggs through a single opening. (R3-R5) The "advanced" mammals usually have three separate orifices.

X2. Common urogenital orifices. Some mammals possess two orifices; one for feces and the other for urogenital "products."

Insectivores (shrews, tenrecs, etc.). A common urogenital orifice occurs frequently, but not universally, in the insectivores. (R3, R5) Insectivores are considered to be rather "primitive" mammals.

Xenarthrans (sloths, anteaters, armadillos). The females only in this mammalian order have common urogenital orifices. (R5) Such sexual dimorphism is very unusual. The evolutionary rationale is not apparent.

X3. Common orifices for excreting urine and feces (cloacas). A common exit chamber for urine and feces is called a "cloaca," as in X1. Reproductive products (sperm and infants) have separate orifices.

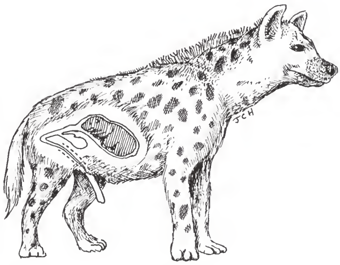
Beavers. These placental mammals are most unusual in possessing a cloaca. (R5) One can speculate that this feature is either an evolutionary innovation (with no readily identifiable purpose) or an atavism harking back to more primitive mammals. In this connection, beavers are a bit like platypuses in outward appearance and behavior.

X4. Vaginas and birth canals.

Marsupials. In the placental mammals, females have only one vagina which also serves as a birth canal. The following quotation demonstrates just how different marsupials can be from placental mammals internally while looking much like them externally.

> In marsupials the female reproductive tract is bifid; that is, the vagina and uterus are double. The two lateral vaginae spread sufficiently to allow the urinary ducts to pass between them. During birth, however, the young typically are extruded through a third canal, the birth canal, or median vagina, which passes from a point of medial fusion between the two uteri to the urogenital sinus. (R5)

To match the females, many male marsupials have bifid penises. (R5)



A pregnant spotted hyena. The vaginal canal takes a sharp turn, passes through the pelvis, and emerges at the clitoris.

Spotted hyenas. Female spotted hyenas are highly masculinized and give birth in a bizarre fashion.

> Females are not only more aggressive than the males but look just like them; their enlarged clitorises are the same size as the male penis and are fully erectile. The vaginal labia are fused to form a "pseudoscrotum'; the female mates and gives birth through the clitoris. (R6)

The spotted hyena's birth canal is even more bizarre than indicated in the above quotation. As the illustration shows, birth requires that the emergent fetus negotiate an almost-180° turn to reach the clitoris. This roundabout passageway makes the birth canal about twice the length seen in mammals of a similar size. Unfortunately, the umbilical cord has not lengthened accordingly. The fetus sometimes dies from lack of oxygen if birth is delayed too long after disconnection from the uterus. Hyenas giving birth for the first time are often in labor for hours. Birth is delayed until the clitoris, which is only about 2 centimeters in diameter, has stretched to permit passage of the 6-7 centimeter head of the fetus. Understandably, mortality of both mother and fetus is high in these first births. It is reasonable to wonder why hyena development took this strange turn.

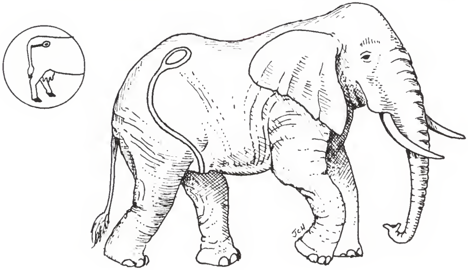
Female hyenas are highly aggressive and dominate the males. High levels of aggression lead to higher social rank, more food, and improved survival of offspring that survive birth. These factors are tied in with the masculinization of their reproductive tract. In this is found the Darwinian explanation:

> Selection for female aggressiveness apparently counters the mortality costs attributable to the associated genital masculinization. (R7)

Elephants. Female elephants are only a little less bizarre than the spotted hyenas in their reproductive anatomy.

> The vaginal canal of the female elephant follows a route unknown in any other terrestrial mammal. It emerges in such an unusual position that it used to be believed that elephants copulated ventro-ventrally. (R1)

Today's elephants are highly aquatic and may have been more so in the past. Ventro-ventral (face-to-face) copula-



The elephant's vaginal canal takes an extraordinary route compared to that of the cow (inset) and most other mammals, although it is manifestly not as bizarre as that of the spotted hyena.

tion is characteristic of aquatic mammals.

X5. Uteri.

Marsupials. As remarked above, female marsupials have two uteri. (R5)

Belugas (white whales). Occasionally. the male beluga develops a uterus. (R2) No further information available.

Perhaps this phenomenon is akin to human males occasionally developing large breasts and even lactating.

X6. Placentas. Marsupials are usually separated from the "placental mammals," implying that marsupials have no placentas. This is not completely true.

Bandicoots. The 21 species of bandicoots in Australia and New Guinea develop structures that somewhat resemble the placentas of placental mammals. Called "chorioallantoic placentas," they form after the transient "yolk-sac placenta," typical of all marsupials, has disappeared. It differs from the placentas of placental mammals in its lack of villi (finger-like projections extending from membranes). (R5)

X7. Ovaries

Platypuses. The female platypus possesses only one functional ovary. In this, the platypus is like the birds (except rarely in some hawks). In all other mammals, including even the other monotremes (the two echidnas), both ovaries are operational. (R8)

References

R1. Morgan, Elaine; The Aquatic Ape, New York, 1982. (X4)
R2. Bergman, Jerry, and Howe, George; "Vestigial Organs" Are Fully Functional, Terre Haute, 1990. (X5)
R3. Swan, Lawrence W.; "The Concordance of Ontogeny with Phylogeny," BioScience, 40:376, 1990. (X1, X2)
R4. Hoffman, Eric; "Paradoxes of the Platypus," Scientific American, 264: 18, March 1991. (X1)
R5. Nowak, Ronald M.; Walker's Mammals of the World, Baltimore, 1991. (X1-X6)
R6. Frank, Lawrence; "When Hyenas Kill Their Own," New Scientist, p. 38, March 5, 1994. (X4)
R7. Frank, Laurence G., et al; "Masculinization Costs in Hyenas," Nature, 377:584, 1995. (X4)
R8. Editors of Time-Life; Amazing Animals, Alexandria, 1990. (X7)

BMI5 Reversal of Viscera

Description. The mirror-image reversal of a mammal's viscera, including heart and associated vessels, liver, intestines, and all asymmetrical internal elements. Scientists have dubbed this condition sinus inversus viscerus (SIV). SIV is associated with mirror-image twins and, in humans, with primary ciliary dyskinesia.

Data Evaluation. SIV is a rare but medically recognized condition in humans and other mammals. Our data sources include professional papers in mainstream science journals and magazines. Despite intensive literature surveys, we have not found any notices of SIV occurring in either wild mammals or in mammals processed for food. One would expect meat-processing plants to report an occasional case of SIV! We suspect we have only part of this story. Rating: 2.

Anomaly Evaluation. Experiments with mice (see below) show that some instances of SIV have a genetic origin. Although SIV can be artificially induced under very special conditions, the molecular basis for its appearance outside the lab remains mysterious. Rating: 2.

Possible Explanations. See above discussion.

Similar and Related Phenomena. Mirror-image twins (BHA9 in Humans I and BMA5 in Mammals I). See also the Subject Indexes in the Series-B catalogs under: Asymmetry, Handedness.

Entries

X1. General observations. Apparently this phenomenon has been observed only in domestic cats, laboratory mice, and humans. Probably it also occurs in wild mammals; but, since internally reversed animals are usually also afflicted with pulmonary, cardiovascular, and sundry other defects, they rarely reach the dissecting tables. Whatever the reason, we have not yet come across any reports of wild animals exhibiting SIV.

Domestic cats. The basic phenomenon is seen in the following note to Science from a biology teacher.

> An adult female cat purchased for student use in comparative anatomy was found, upon dissection, to have its internal organs completely reversed in every detail studied. Lungs, kidneys, veins and arteries and all parts of the digestive tract were normal in size and shape but so situated that descriptions for the left side fitted the right side perfectly and vice versa. The aortic loop arose from the larger right ventricle and arched to the right. Other parts of the heart and its vessels were changed accordingly. The animal, although heavily infested with tapeworms and undernourished, appeared sound and normal in every other respect. No reference to an entirely reversed cat has been found in the literature. It may have been one of a pair of identical twins, since it is supposed that the occurrence of the phenomenon of reversal in man and other mammals is due to splitting of the embryo at some early stage. (R1)

Another cat with "mirror-image" innards was reported by T.D. Bair in 1953. (R2)

Laboratory mice. SIV can also be reliably induced artificially.

> In one of those rare and remarkable papers announcing the completely unexpected, [T.] Yokoyama and colleagues last month reported an insertional mutation that causes mice to develop with a body plan that is the mirror image of normal. For those intrigued by handedness this is a striking finding, not because of the reversed configuration itself, but because it occurs in all homozygous mutants. This has never been previously achieved, by experiment or nature (except perhaps in teleosts), and begs speculation on the molecular mechanism. (R4)

The discovery of Yokoyama et al was serendipitous. He and his coworkers were actually trying to create pigmented mice from albino mice! (R3, R4) (See Science, 260:679, 1993, for the original paper by Yokoyama et al.)

Humans. SIV appears in about one in every 10,000 human births. (R3) More complete coverage may be found in BHA9 in Humans 1 in connection with human mirror-image twins.

References

R1. Wragg, Helen A.; "A Reversed Cat," Science, 88:475, 1938. (X1)
R2. Anonymous; "Mirror Image Organs Discovered in a Cat," Science News-letter, 64:215, 1953. (X1)
R3. Ewing, Tania; "Genetic 'Master Switch' for Left-Right Symmetry Found," Science, 260:624, 1993. (X1)
R4. Brown, Nigel A., and Lander, Anthony; "On the Other Hand...," Nature, 363:303, 1993. (X1)

BMI6 Fundamental Differences between Micro- and Megabat Neural Pathways

Description. The substantial differences between the eye-brain neural connections of micro- and megabats. The megabat circuitry clearly resembles that characteristic of primates.

Data Evaluation. Based upon papers in Nature, Science, and other journals, there seems to be general agreement that the subject phenomenon is real and easily demonstrable in the laboratory. The interpretations and not the data are controversial. Rating: 1.

Anomaly Evaluation. The controversy over the interpretation of the phenomenon is considered an adequate basis for cataloging it. The basic scientific question is whether eye-brain neural pathways are more accurate reflections of evolutionary relationships than wings plus molecular evidence. Although consensus favors the latter view, the differences in bat neurology remain difficult to account for, except by invoking some seemingly unlikely convergent evolution. Anomaly ratings, however, depend upon the severity of challenges to established dogma. Here, the key dogma is monophyly---the single origin of bats. This dogma is highly important to most phylogenists, and a rather high anomaly rating seems appropriate. Rating: 1.

Possible Explanations. See X1 below.

Similar and Related Phenomena. Other megabat affinities to primates (BMC4-X1, BMC6-X2, BME1-X5, BME1-X6, BMG1-X2, BMO3-X5). Other discordances between phylogenies established from visible traits and meolcular data (BMG1); disparities between human and ape phenotypes and genotypes (BHG11 in Humans 111).

Entries

X0. Background. The bats (Order Chiroptera) are traditionally divided into two Suborders (Microchiroptera, small echolocating bats; and Megachiroptera, large fruit-eaters, also called "flying foxes"). Bats look so much alike with their unique "hand-wings" that everyone assumes they must be closely related. Beneath the superficial similarities are many important differences as seen, for example, their teeth and circulatory systems. (R5) Bat expert B. Fenton has observed that the two bat Suborders:

> ...have an interesting blend of similarities and differences. Your're left with the age-old question: Which are more important, the similarities or the differences?" (R4)

With today's scientific fascination with DNA and molecular comparisons as the "ultimate" arbiters in taxonomic controversies, the molecular similarities of the micro- and megabats seem to be carrying the day. (See BMG1-X1.)

Even so, some fundamental neurological differences exist between the two bat Suborders, and they cannot be explained away easily. As the history of science demonstrates over and over again, these awkward observations may erupt in future paradigm shifts. They are obvious candidates for any Catalog of Anomalies.

X1. Bat neurological pathways. In 1986, the long-simmering concerns about bat phylogeny boiled over. J.D. Pettigrew, an Australian biologist and an expert on the neural circuitry employed by mammalian brains in processing visual information, was shocked by what he observed through his microscope. Looking at some brain tissue from flying foxes (megabats), he discovered that the visual neurological connections were of a type thought to be unique to primates. In contrast, the same neural pathways in microbats were basically different and, in fact, the same as he had observed in all other non-primates. (R1, R4) Further studies of micro- and megabat brain tissues brought forth still more differences, as well as additional links between megabats and primates. Bats, he surmised, were really biphyletic. Mammalian wings and flight might have evolved twice---a near impossibility in the minds of the traditionalists and a scientific call to arms in defense of bat monophyly.

Pettigrew's findings required the phylogenists to consider at least three potential evolutionary scenarios:

(1) Primitive bats (ancestors of both Suborders) first evolved wings and flight. Then, the megabats split off and acquired their "advanced" primate-like eye-brain pathways through "convergent evolution," that ever-handy solution to the problem of parallelisms.

(2) Micro- and megabats evolved along different lineages, with the megabats inheriting their eye-brain circuitry from an ancestor they have in common with primates. Then, the megabats evolved their wings and power of flight via "convergent evolution"! (R2, R4)

(3) Primitive bats (ancestors of both Suborders) inherited the primate-like neural connections from an ancestor they have in common with primates. Next, they evolved wings and flight before splitting into the micro- and mega-types. Then, while still possessing the primate-like eye-brain pathways, the microbats evolved echolocation. With this new sensory equipment, they no longer needed the advanced eye-brain neurology. They discarded it and reverted to the more primitive neural pathways common to almost all other nonprimates. (R4)

Traditional biologists prefer Choice #1 or, possibly, Choice #3. Choice #2 is anathema. How could "hand-wings" ever evolve twice? Pettigrew, however, sees the eye-brain neural pathways as more fundamental than wings and, therefore, a better indicator of evolution's true history. Naturally, Pettigrew opts for Choice #2.

(Warning: It is all too easy to concoct these neat little evolutionary scenarios and then argue about them. Hard data are difficult to come by. On top of this, these postulated "splits" and evolutionary innovations took place tens of millions of years ago and are difficult to see clearly in the fossil record.)

X2. Contrary evidence. We have already mentioned that the molecular evidence strongly favors monophyly; that is, a single origin for bats (choice #1 or #3). So do the findings of J.G.M. Thewissen and S.K. Babcock on the neural connections in bat wings. (R3) Lastly, R. Baker, M. Novacek, and N. Simmons have reviewed much the same evidence used by Pettigrew and have come to the opposite conclusion. (R4)

The traditionalists (monophylists) certainly seem to have the upper hand as this is written, but their explanations of the differences in the eye-brain pathways seem weak.

References

R1. Pettigrew, John D.; "Flying Primates? Megabats Have the Advanced Pathway from Eye to Midbrain," Science, 231:1304, 1986. (X1)

R2. Martin, R.D.; "Are Fruit Bats Primates?" Nature, 320:482, 1986. (X1)

R3. Thewissen, J.G.M., and Babcock, S.K.; "Distinctive Cranial and Cervical Innervation of Wing Muscles: New Evidence for Bat Monophyly," Science, 251:934, 1991. (X2)

R4. Goodman, Billy; "Holy Phylogeny! Did Bats Evolve Twice?" Science, 253:39, 1991. (X0-X2)

R5. Wesson, Robert; Beyond Natural Selection, Cambridge, 1991. (X0)

BMI7 Evolution without Associated Increases in the Complexity of Vertebral Columns

Description. The absence of any general increase in the complexity of mammalian skeletons over time periods on the order of 30 million years.

Data Evaluation. One science magazine has reported how one evolutionary biologist has measured museum skeletons of five mammalian lineages to establish the subject phenomenon. No similar or confirmatory work has been found so far. Also lacking in our files: peer-reviewed scientific evaluations of the work. Rating: 3.

Anomaly Evaluation. While it is true that many scientists and laymen believe that evolution is a progressive process leading to ever more sophisticated and complex organisms, in reality evolution is generally believed to be basically directionless. Survival is all that counts; and the simple may sometimes survive better than the complex. In this reductionist reading of evolution, the subject phenomenon is no surprise and certainly not anomalous. Nevertheless, a widespread perception is challenged; and the phenomenon deserves cataloging for this reason alone. Rating: 3.

Possible Explanations. None required.

Similar and Related Phenomena. Atavism in humans (BMA26, 40, 49, and 53 in Humans I); in other mammals (BMA5 and 42 in Mammals 1).

Entries

X0. Introduction. Evolutionary family trees usually begin with simple organisms at the bottom and progress upward toward creatures of ever-increasing complexity. At least this is the common expectation. Mutation plus natural selection mean greater complexity and, presumably, better survival skills. Obviously, humans are more complex than amoebas, but is this Law of Increasing Complexity universally true in all evolving lineages?

To answer this question, one first must define complexity, and this is not easy for living creatures. Is complexity measured by the number of parts, the intricacy of the parts, the arrangement of the parts, or what? Settling upon a definition of complexity, one must then follow the lineage through the fossil record, measuring as one goes. Since bones are predominant in the fossil record, it makes sense to study the complexity of skeletons. One biologist has done just that, and his results confound expectations.

X1. A study of vertebrae. D. McShae, an evolutionary biologist at the University of Michigan, decided to look at the vertebral columns of several mammalian lineages over 30 million years or so to see if the the backbones had, as expected, become more complex over that period. Vertebral columns were a good choice; the museums are filled with them. McShae chose the following mammalian lineages: squirrels, ruminants, whales, pangolins, and camels. Complexity, he decided, could be quantified by measuring six different dimensions for each vertebra in each column. Two dimensions used were the length and thickness of each vertebra. A "simple" vertebral column might start out with all vertebrae having the same dimensions, and then change over the eons; one getting larger of changing shape relative to others in the column. Such increases of complexity (as defined by McShea) might result from environmental challenges. (A pertinent example, well used in discussions of evolution, would be the changing vertebrae in the necks of giraffes.) McShea's results did not show the anticipated increases of complexity as the geological ages rolled by.

> "In most of the comparisons, there was no significant change in complexity in either direction," says McShea. And the few cases in which complexity seemed to increase from ancestor to descendant were offset by complexity decreases in other pairs [of vertebrae]. "The bottom line," says McShea, "is that this showed no preferred tendency for complexity to increase. Increases and decreases tend to happen about as often." (R2)

X2. Contrary observations. If the period of geological time studied by McShea were extended, marked changes in complexity must been seen. Take bats, for example. If they are truly monophyletic, as discussed in BMI6, then substantial changes in the lineage's vertebral column occurred when the megabats split off from the microbats. These two Suborders of bats have radically different neck bones. The flexibility of the microbat neck is much greater, as desirable for snatching insects out of the air. (R1) One could reasonably call this an advance in complexity.

References

R1. Fenton, M. Brock; Bats, New York, 1992. (X2)

R2. Oliwenstein, Lori; "Onward and Upward?" Discover, 14:22, June 1993. (X0, X1)

BMI8 Magnetite in Mammals

Description. The presence of magnetite in the tissues of mammals. Some of these synthesized particles seem to be surrounded by innervated tissue, suggesting that they might somehow sense ambient magnetic fields.

Data Evaluation. The basic data were acquired through dissection, microscopic examination, and the measurement of magnetic moments, usually using induced magnetic remanance techniques. Reports were found in the major science journals and magazines. Rating: 1.

Anomaly Evaluation. Magnetite's purpose in mammals is still a matter of speculation, although it is well established that bacteria use it to determine the direction of the geomagnetic field. If magnetite synthesis is simply a mammal's way of storing excess iron, there is no anomaly. But if the magnetite particles actually form the basis for practical magnetic orientation and navigation, biologists have to devise a reasonable evolutionary scenario for an impressive biological innovation. Since we do not know the real purpose of the magnetite particles in mammals, we have to rate its presence as a bit more than merely curious. Rating: 2.

Possible Explanations. Mammals synthesize magnetite to store iron and/or measure the geomagnetic field for navigational purposes.

Similar and Related Phenomena. Magnetic orientation and navigation in mammals (BMT1 in Mammals I) and humans (BHT17 and 18 in Humans II).

Entries

X0. Background. Birds are reknowned for their feats of navigation over great distances. When particles of magnetite were discovered in the necks of pigeons, it was widely thought that these bits of magnetic material might form the basis for a biosensor of the geomagnetic field.

It is not at all clear just how such a sensor might work and, especially, how it might have evolved. Presumably, the magnetic particles, like compass needles, would experience torques exerted by the geomagnetic field. Innervated tissue surrounding the particles would respond to the torques and send appropriate signals to the brain, which would interpret them as navigational data. Reasonable as this all sounds, no one has yet demonstrated that birds or any other animals really do possess effective biosensors that respond to the geomagnetic field.

Realistic Darwinistic scenarios for the evolution of a magnetic biosensor tend to stretch one's credulity. Here, random mutation and natural selection face formidable challenges in terms of innovation and complexity; as in: (1) the synthesis of magnetite particles of adequate size; (2) the formation of the innervated tissue around them; (3) the construction of appropriate communication lines to the brain; and (4) the circuitry required to turn the signals into action. This coordinated series of developments is similar to those postulated for the evolution of the vertebrate eye and bat echoloation.

With this preamble, which echoes a major theme of this volume, we turn to the mammals themselves to see whether they, like pigeons and bacteria, have secreted bits of magnetite in their tissues.

X1. Magnetite deposits in mammals. The cetaceans (whales and dolphins) and some microbats are noted for their long-distance migrations. (BMT1 in Mammals I) It is logical to look to them first for magnetic biosensors.

Common Pacific dolphins. In homing pigeons, the magnetite thought to aid their navigation occurs in the head between the dura mater and skull. Guided by this knowledge, J. Zoeger and two colleagues dissected the heads of four dead, stranded dolphins and found strongly magnetized material in the same area where the pigeons' magnetite is concentrated. This magnetic material, assumed to be magnetite, occurred in particles only several microns in size. But these were strongly magnetized, displaying a magnetic moment of 2×10^{-5} gauss-cubic centimeter, or about 20 times the ambient geomagnetic field. Such strong particle magnetization would certainly be appropriate in a navigation device. Of additional interest is the fact that the largest particles were coated with fibers that might be associated with the nervous system. All this does not prove that these dolphins actually have and use magnetic sensors. In fact, no one has yet shown that dolphins actually do make practical use of the geomagnetic field. (R1-R3)

Nevertheless, the word "suggestive" seems applicable here.

Cuvier's beaked whales. The same team that discovered the dolphin magnetic material, located similar deposits in the same location in the corpse of a Cuvier's beaked whale. (R4)

Big brown bats. Deposits of magnetic material have been located in the brains of big brown bats. (R6) Its nature and purpose are not yet known.

White-footed mice. Homing experiments with these mice plus lab studies of their tissues led P.V. August et al to write:

> Tissues of P. leucopus exhibit strong isothermal remanent magnetization and may contain biogenic ferrimagnetic material. Our results suggest that white-footed mice have a magnetic sense and use the geomagnetic field as a compass cue. (R5)

Additional discussion of this work can be found in BMT1-X1 in Mammals I.

Monkeys. J.L. Kirschvink has stated that monkeys (species not given) have magnetic deposits in their skulls in the same location as dolphins. These bits of magnetic material are surrounded by innervated tissue. (R4)

But why would monkeys need such navigation sensors? They do not migrate nor do they have great need for a homing sense.

Humans. The thin bones in our sinus walls have been found to be magnetic. Details in BHI15 in Humans II.

Suggestive though the above findings may be---particularly the innervated tissues around the magnetite particles---there is no proof that the magnetite is used to sense the geomagnetic field. Magnetite is the hardest mineral to be synthesized biologically and may well have unappreciated uses. For example, the teeth of chitons (a type of mollusk) are made of magnetite---just the material for scraping algae off rocks. (R4)

References

R1. Anonymous; "Magnetic Dolphins...,' Science News, 117:376, 1980. (X1)

R2. Zoeger, J., et al; "Magnetic Material in the Head of the Common Pacific Dolphin," Science, 213:892. 1981. (X1)

R3. Anonymous; "Magnetic Butterflies and Dolphins," Science News, 120: 156, 1981. (X1)

R4. Maugh, Thomas H., II; "Magnetic Navigation an Attractive Possibility," Science, 215:1492. 1982. (X1)

R5. August, Peter V., et al; "Magnetic Orientation of a Small Mammal," Journal of Mammalogy, 70:1, 1989. (X1)

R6. Fenton, M. Brock; Bats, New York, 1992. (X1)

BMO ORGANS

Key to Phenomena

BMO0 Introduction

The mammalian body is studded inside and out with a marvelous array of biological transducers and machines called "organs." The outside organs are mostly devotcd to rcporting the state of the environment to the brain, itself an organ. The inside organs keep the body alive and healthy. All of these organs pulse with electrical signals. They consume and synthesize hundreds of chemical substances. They are all wonderfully complex and sophisticated, facts that stimulate one to ask how such bioengineering masterpieces arose. The standard answer is, of course, that they evolved from simpler structures, which in turn evolved from even simpler structures. At the core of all this biological construction work, the creative genie, is, according to the theory of evolution, the mechanism of random mutation modulated by natural selection. The anomalies cataloged in this chapter almost all cast doubt upon the capability of this accepted mechanism for producing biological innovation, complexity, and sophistication. To be sure, some phenomena cataloged below might well be categorized as merely "marvels" or "curiosities," but the majority ask the reader to consider if random mutation can really account for the brain, the eye, echolocation, and the rest of a mammal's intricate bodily machinery. Since such doubts are not allowed by the evolutionary paradigm, the facts that encourage the doubts must be called anomalies.

BMO1 High Complexity and Sophistication of the Mammalian Eye

Description. The presence in the mammalian eye of many diverse components, employing advanced design principles of science and engineering, integrated into a smoothly functioning whole.

Cross Reference. This important subject occupies a full seven pages in Catalog volume Humans II (BHO1). Since the human eye and those of the other mammals are basically the same, despite the interesting adaptations put forward in BMO3, it would be excessively redundant to repeat all this material here. It will suffice to reproduce only the Anomaly Evaluation and Possible Explanations paragraphs from BHO1, as lightly edited so as to apply to mammals in general.

Anomaly Evaluation. The baseline against which the anomalousness of the eye's complexity and sophistication must be measured is the theory of evolution. Is it credible that the effects of small, random mutations modulated by natural selection can account for all the vertebrate eye's characteristics? In principle, given enough time, the answer has to be "yes." This "yes" supporting the efficacy of evolution is strengthened by the observation of many variations within species boundaries in response to environmental pressures, such as the increasing resistance of pathogenic organisms to antibiotics. But has there been enough time for the evolution of an organ as complex as the eye? In truth, we do not know for several reasons: (1) Mutation rates through geological time are unknown; (2) The probability of successive favorable mutations can only be guessed at; (3) The probability of synchronous favorable mutations required for the simultaneous development of the eye's many components is a mystery; and (4) The environmental pressures acting upon the eye, over several hundred million years, to select the "fittest" in a long series of ever-better eyes are likewise unknown. The thrust of this incomplete list is that no one can prove whether the currently accepted mechanisms of evolution can or cannot produce the vertebrate eye in the time available since the first vertebrates arose. Scientists are generally satisfied with evolution's efficacy in this matter--- what other choice do they have? Creationists, on the other hand, have long labelled the vertebrate eye a major biological anomaly that disproves evolution. The anomalist, hopefully more objective, must conclude that an anomaly rating here is impossible. The eye is manifestly a marvelously complex and sophisticated organ, but the basic mechanisms of evolution (random mutation and natural selection) can, in principle, explain any level of organ complexity and sophistication---given enough time. Anomalousness exists only if the reigning paradigm is inadequate to account for the phenomenon, and this cannot be shown at present for the eye. Despite the admitted existence of logically possible evolutionary mechanisms, the complexity and sophistication of the human eye still cast suspicion, in some minds, upon the theory of evolution as it is presently formulated. That is why we catalog this phenomenon.

Possible Explanations. Are there other ways in which the mammalian eye might have developed---something between the extremes of random mutation plus natural selection and outright creation by a supernatural being? The time problem mentioned above could be reduced in severity by one or more of the following possibilities: (1) Evolution is "guided" by the organism itself, as claimed in the experiments with bacteria by J. Cairns; (2) Morphogenic fields, such as those proposed by R. Sheldrake, could make the development of structures and chemicals easier, if they had already been created elsewhere; (3) Templates providing genetic information for the development of some structures and chemicals vital to the eye could have been developed long ago in the history of the universe (perhaps 10-15 billion years old) and brought to earth in cometary debris, as speculated by F. Hoyle and C. Wickramasinghe; (4) Ordinary matter naturally possesses the properties necessary for the rapid synthesis of some eye structures, just as it does for the spontaneous synthesis of salt, water, and even much more complex chemicals (especially when catalysts are present). Many other similar suggestions have been made down the years; and (5) Some scientists, such as S. Kauffman, expand convincingly upon the foregoing thoughts, in their development of the concept of "self-organization." Here, the basic idea is that complexity and sophistication "emerge" naturally, when matter is poised on the brink between order and chaos. (R1) Of course, the mathematical modelling of these "emergent properties" does not explain why matter happens to be endowed with those properties leading to life and structures like the vertebrate eye. Finally, one might conceive, as science fiction writers sometimes do, that human biological evolution is controlled by entities that are not supernatural!

Apparently, we need not be stuck forever between extreme evolutionism and equally extreme creationism.

Reference

R1. Kauffman, Stuart; At Home in the Universe, New York, 1995.

BMO2 Blindsight

Description. The ability of some clincially blind mammals to detect and identify some events and situations with their eyes, but without forming conscious visual images. This phenomenon must not be confused with "facial vision." (BHT10 in Humans I)

Cross Reference. This phenomenon, long-recognized in humans, also extends to some other members of the Class Mammalia. Verified examples: macaques, tree shrews, and domestic cats. (R1, R2) We reproduce here the Anomaly Evaluation paragraph (slightly edited) from BHT3 (in Humans I), where the subject is covered more thoroughly.

Anomaly Evaluation. In effect, the phenomenon implies that the mammalian midbrain also processes information received from the eyes, even though no images are formed. The receptors, neural pathways, and information-processor contributing to blindsight remain to be identified. Blindsight is an unexpected faculty that does not seem to be widely recognized or investigated by science. The phenomenon is at odds with prevailing thinking about the faculty of sight, but it could be incorporated without too much reworking of scientific paradigms. Rating: 2.

References

R1. Kaas, Jon H.; "Vision without Awareness," Nature, 373:195, 1995.
R2. Cowey, Alan, and Stoerig, Petra; "Blindsight in Monkeys," Nature, 373:247, 1995.

BMO3 Remarkable Adaptations of Mammalian Eyes

Description. Adaptations of the normal vertebrate eye that enable mammals to survive more successfully in specialized niches. These modifications often involve rather sophisticated changes in the optics and/or the spectral sensitivity of the eye, while others concern the discarding the unneeded characteristics of the eye for purposes of higher efficiency.

Data Evaluation. The adaptations selected here were highlighted in science journals and books authored by recognized professionals. They are generally controversy-free. It is certain, though, that we have overlooked other equally interesting adaptations of the mammalian eye. (Catalogs are never complete!) Rating: 1.

Anomaly Evaluation. All of the adaptations entered below fall into the category of "fine tuning"; that is, the normal vertebrate eye is altered to enable its owner to catch prey more easily and operate in its environment more effectively. In other words, innovation is limited---no brand new organs are required. Evolutionists have little trouble in explaining such changes in terms of slow, continuous modifications of optical parameters. There is, therefore, little here for the anomalist, except to remark that some of the adaptations are quite sophisticated and seem to challenge evolutionary mechanisms based upon random processes. Typical of this concern is the phenomenon of mixed color vision in the same species (X6). Rating: 3½.

Possible Explanations. Evolution via random mutation and natural selection could well suffice here; although the controversial concept of "adaptive evolution" is also pertinent.

Similar and Related Phenomena. The Series-B catalogs contain many other examples of similar adaptations. Typical of these are: the giraffe's long neck (BMA47) and callosities (BMA18), all in Mammals 1). Mammalian eye oddities (BMA24 in Mammals 1).

Entries

X1. Rudimentary eyes as photoperiod sensors.

Blind mole rats. The blind mole rats of Ukraine and the eastern Mediterranean (Genera Spalax and Nannospalax) can be distinguished from all other rodents by their rudimentary eyes which are completely covered with skin and fur. Most subterranean mammals evolve weakened or reduced eyes, but these blind mole rats are truly blind. Flashes of light evoke no neurological signals according to electrodes implanted in the brain. Even so, their eyes do have lenses, but these are irregular and cannot focus images. These eyes are, in fact, the smallest of all the mammals. One is tempted to classify these tiny eyes as vestigial and, being so useless. well on their way to complete elimination. (R3, R6)

The problem is that these blind mole rats, though clinically blind, do respond to changes in the photoperiod; that is the varying lengths of daylight and darkness. J.H. Kaas has speculated:

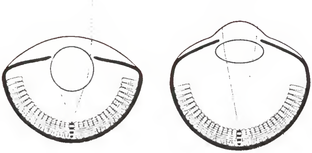
> Apparently, the tiny eyes beneath the skin of the mole rats living in dark tunnels receive enough light to provide useful information about daily changes in ambient light levels, and nearly all their remaining visual system is relegated to processing this information. Information on light levels and durations may be critical in timing the mating season for mole rats, and in regulating patterns of feeding and thermoregulatory behavior. (R6)

It would seem that these tiny remnants of the normal sophisticated and complex mammalian eye are still useful in a very specialized way. All the usual eye functions have withered away except this ability to detect extremely low light levels (in tunnels and through the furred skin!) and relay this photoperiod information to the brain and, likely, the pineal gland.

Kaas pointed out that we have here an example of "mosaic evolution" in which different components of a complex system change independently. Just how this delicate selectivity of function is actually achieved is as yet unknown. (R6)

X2. Aquatic eyes.

Marine mammals. It isn't obvious when you look at a seal or dolphin, but their eyes are markedly different from our own and those of other terrestrial mammals in general. A glance at the accompanying illustration shows three differences: (1) The lens of the aquatic eye is spherical rather than convex-convex;



Camera-type eye of an aquatic vertebrate (left) compared with that of a terrestrial vertebrate (right). In the aquatic eye, the lens is spherical and the cornea flattened.

(2) The aquatic eye's cornea is much flatter and has little refractive power; and (3) The distance between the lens and the retina is much shorter than in the terrestrial eye. Marine mammals possess what is called a "spherically graded index lens." This is useful to animals that have to operate in water, which has an index of refraction of 1.33 as compared with air's 1.00. The aquatic lens is also free from spherical aberration and produces excellent images over a wide field. (R2)

Aquatic lenses are found in fish, tadpoles, squid, pond snails, conchs, and sundry other marine creatures. D-E. Nilsson has commented:

> The widespread occurrence of graded-index spherical lenses makes this type of eye an astonishing example of parallel evolution. (R2)

X3. Spectral sensitivity adapted to prey.

Southern elephant seals. Not only do these seals have aquatic eyes (X2), but their eye pigments are "tuned" to their food sources.

> The eyes are large, and the retina contains pigments similar to those of deep-sea fishes. These pigments correspond in their sensitivities with the light emitted by the bioluminescent mesopelagic and epibenthic cephalopods and by some of the fishes on which southern elephant seals prey. (R4)

It is likely that other seals and cetaceans have similar adaptations to their prey.

How can such fine technical adaptations be achieved? One must suppose that random mutations are always altering the eye pigments responsible for spectral response. Those animals that finally attain pigments with sensitivities that match prey light emissions will be favored by natural selection.

As too often remarked in these catalogs, this sort of mechanism can in principle explain any adaptation.

X4. Crystal layers that enhance night vision. As is well known, the eyes of many mammals reflect light at night. Such animals possess a special reflecting membrane, the tapetum, which may incorporate crystals, leading to irridescence and various colors of reflected light. The operational purpose of the tapetum is the enhancement of night vision. Its widespread appearance among mammals can be associated with the postulated early evolution of mammals as creatures of the night rather than the day.

Pottos. These nocturnal primates live in Africa. We have selected this species to demonstrate the phenomenon at hand.

Night vision of the potto is intensified by a special layer of cells behind the retina at the back of the eyeball. This layer contains guanine crystals; light passing through the retinal cells is reflected back again by the guanine, doubling its effectiveness. (R1)

We do not know if the tapetums of all nocturnal mammals incorporate guanine crystals, or whether some other crystals are used. In any case, the formation of a useful layer of crystals in the eye via a random process is an evolutionary tour de force.

X5. Color vision in bats.

Megabats. Only the megabats (Old World fruit bats or flying foxes) have color vision. The microbats lack the eye pigments that confer color vision. (R5)

This advanced vision capability again allies the megabats with the primates, which also have good color vision. This accords with the finding that the eye-brain neural pathways of the megabats resemble those of the primates, suggesting an origin separate from the microbats. (BM16)

X6. Sexual differences in color vision.

New World monkeys. In some species of New World monkeys, some of the females are trichromatic; that is, they have enhanced color vision. All of the males and the rest of the females are dichromatic and have poorer color vision. Surprisingly, this mixture of color-vision capabilities in a band of foraging monkeys is advantagenous. Trichromatic females can detect and identify colored fruit better; the dichromatic monkeys are better at discerning color-camouflaged fruit. (R6) A remarkably sophisticated adaptation and a tribute to the efficacy of random mutation and natural selection in finding clever ways to promote the welfare of a species.

References

R1. Carrington, Richard; The Mammals, New York, 1963. (X4)
R2. Nilsson, Dan-E.; "Vision Optics and Evolution," BioScience, 39:298, 1989. (X2)
R3. Gould, Stephen Jay; "Through a Lens, Darkly," Natural History, 98: 16, September 1989. (X1)
R4. Reeves, Randall R., et al; Seals and Sirenians, San Francisco, 1992. (X3)
R5. Fenton, M. Brock; Bats, New York, 1992. (X5)
R6. Kaas, Jon H.; "Vision in Blind Mole Rats," Nature, 361:113, 1993. (X1)
R7. Shyue, Song-Kun; "Adaptive Evolution of Color Vision Genes in Higher Primates," Science, 269:1265, 1995. (X6)

BMO4 The Purposeful Emission of Sound by Mammalian Ears

Description. The generation of sound by the ears of several species of mammals for practical, operational purposes. These "otoacoustic emissions" are sometimes evident to human listeners, who liken them to whistling. Otoacoustic emissions are not related to tinnitus.

Data Evaluation. The reality of these unexpected otoacoustic emissions has been confirmed anecdotally and in the laboratory. Reports can be found in science journals and magazines. What is not known with any certainty is the purpose of the emissions, if any. Data are rudimentary in this respect. Furthermore, there is a difference of opinion concerning the actual source of the sound within the ear itself. Rating: 3.

Anomaly Evaluation. If the sounds emitted by a mammal's ears are merely normal body noise, like the sound of the heart, no anomaly exists. But, if the ear purposefully emits a reference sound signal to generate holograms or interference patterns in order to better judge the direction of incoming sounds, then the ear is a much more sophisticated organ than usually acknowledged. (It is already astoundingly complex!) An ear that creates acoustic holograms would have required the coordinated evolution of the cochlea, the organ of Corti, and the ear-brain circuitry that generates and interprets the holograms. This complexity and sophistication, subjectively at least, puts pressure on the theory of evolution in the same way the vertebrate eye does. (See BMO1 for a general discussion that applies to complex and sophisticated organs.)

Possible Explanations. The simplest explanation is that otoacoustic emissions are purposeless---like audible heartbeats.

Similar and Related Phenomena. The very sophisticated, active echolocation systems of microbats and toothed whales (BMO6 and BMO7); human-ear sound emissions (BHO9 in Humans II); tinnitus.

Entries

X1. General observations. Ears are usually considered to be passive sound receivers only---one does not expect to "hear ears"! But some mammals, perhaps many of them, do generate sound using this organ. Except in rare cases, ear sounds are inaudible to human observers, being either too faint or at frequencies too low or too high. We now provide some interesting exceptions.

Chinchillas. N.L. Powers has found that these animals elevate their auditory thresholds by generating sound inside their ears. Some sentences from the abstract of his 1995 Nature paper suggest that the phenomenon is not restricted to chinchillas.

> The inner ear sometimes acts as a robust sound generator, continuously broadcasting sounds (spontaneous otoacoustic emissions) which can be intense enough to be heard by other individuals standing nearby. Paradoxically, most individuals are unaware of the sounds generated within their ears.

Humans. As Powers implied above, the ears of humans may sometimes produce sound that is detectable by nearby listeners. This phenomenon, as it applies to humans, is covered in Humans II. (BHO9) There, a theory is proposed that human otoacoustic emissions are actually reference signals enabling the creation of acoustic holograms or interference patterns for purposes of determining the direction of incoming sounds.

Horses. Vets at the Animal Health Trust in New Market, United Kingdom, had just removed a tumor from the lip of a 5-year-old Welsh pony, when they heard a strange, high-pitched hum emanating from its right ear. The hum was surprisingly loud and quite obvious to the surgical team standing a meter away. The hum's pitch was a steady 7 kilohertz.

E. Douek, an ear, nose and throat surgeon, stated that audible sound coming from ears is extremely rare. Such sounds are usually caused by muscle spasms in the inner ear or throat, or by resonance due to abnormalities in the ear's blood supply.

In this case, no practical value of otoacoustic emissions was suggested.

References

R1. Powers, Nicholas L.; "Elevation of Auditory Thresholds by Spontaneous Cochlear Oscillations," Nature, 375:585, 1995. (X1)
R2. Bonner, John; "Humming Horse Puzzles Vets," New Scientist, p. 5, April 29, 1995. (X1)

BMO5 Mammals Apparently Sensitive to Barometric Pressure

Description. Observations that some bats that roost in deep caves seem to use low barometric pressure as a signal that insect-hunting is good. The implication is that these bats, uniquely among mammals, possess an organ sensitive to barometric pressure.

Data Evaluation. The data supporting the claimed phenomenon are circumstantial in nature and limited to a single group of bats. Likewise, the implication that some bats can sense barometric pressure is tenuous, since other cues as to surface conditions (such as air motion) may also be useful to bats. Although found in a respected science magazine, the data are certainly not robust! Rating: 3.

Anomaly Evaluation. The fundamental phenomenon is, of course, the mysterious ability of some bats to undertake hunting forays only when prey are likely to be abundant. Intrinsically, this is only mildly anomalous---a minor enigma of natural history. However, if the bats' Vitali organ (mentioned below and apparently unique among mammals) is really a sensor of barometric pressure, as suspected in birds, which also possess it, we have a case of either independent invention or parallel evolution of a very specialized sensor in distantly related species. This is considered highly anomalous where the source of mutation is random in nature. Rating: 1.

Possible Explanations. Bats may detect air movement rather than changes in barometric pressure for, when external pressure drops, caves "breathe" as air stored inside under higher pressure flows out through cave mouths.

Similar and Related Phenomena. Bird sensors sensitive to infrasound (BBO).

Entries

X1. Bat hunting activity associated with low barometric pressure.

Pipistrelles. In his studies of eastern pipistrelles, K. Paige, University of Illinois at Urbana, noticed that these microbats seemed to use barometric pressure to guide their feeding activity. In spring and autumn, eastern pipistrelles roost deep inside caves where temperature and humidity are very constant. Yet, they can somehow sense when their insect prey at the surface are flying in appreciable numbers and, accordingly, emerge from their deep caves to feed only when hunting is good. These times of insect abundance are usually associated with lower barometric temperatures and warmer temperatures. While bats roosting in caves could not detect outside temperature changes, it is possible that they could sense pressure variations, since this meteorological variable is transmitted throughout cave systems. Ergo, based upon these facts and observations, pipistrelles might possess barometric-pressure sensors that guide their hunting activities. No mammals are definitely known to have organs capable of sensing barometric pressure. (Except, of course, for ears popping due to altitude changes!) In the middle ears of birds, however, biologists recognize a structure called the Vitali organ. This organ is believed to be sensitive to the barometric pressure. Interestingly enough, bats are the only known mammals possessing this mysterious Vitali organ. (R1)

Perhaps we have here another case of parallel evolution.

Reference

R1. Timson, John; "When the Pressure's Low, Bats A-Hunting Go," New Scientist, p. 20, July 22, 1995. (X1)

BMO6 Complexity and Sophistication of Some Microbat Ears

Description. The presence in the ears of some insectivorous microbats of many diverse components, employing advanced principles of science and engineering, all integrated with the bats' sound-producing subsystems and brains into efficient and effective wholes.

Data Evaluation. Field observations and laboratory experiments demonstrate conclusively that microbats operate echolocation systems that not only can detect small insect prey in the dark but can also identify them from their sizes and wing beats. These bats can also overcome prey acoustical countermeasures and evasive maneuvers. Lab tests and dissection confirm remarkable structural adaptations and receptor fine tuning of the outer, middle, and inner ears. Rating: 1.

Anomaly Evaluation. To avoid redundancy, the reader is directed to BMO1, where the compiler's position on the anomalousness of complex and sophisticated organs is stated.

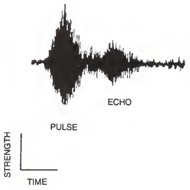
Possible Explanations. See BMO1.

Similar and Related Phenomena. The complexity and sophistication of cetacean echolocation systems (BMO7); the operational capabilities of mammalian echolocation systems as observed in bats, cetaceans, seals, sea lions, and some insectivores (BMT3 in Mammals 1).

Entries

X0. Introduction. The vertebrate eye is usually pointed to as the example par excellence of evolution's capacity for fashioning complex and sophisticated biological structures. (BMO1 and BHO1 in Humans I1) We have delayed until now the description of mammalian ears in the same reverent manner! You see, marvelous though the human ear may be in its construction and operation, the ears and associated information-processing equipment of the insectivorous microbats, are even more amazing.

When the insectivorous microbats hunt, they emit strings of sound pulses at rates of about 10/second as they scan for prey. When closing in on a target, the pulse rates increase to 50, even 200 per second. These ultrasonic pulses cannot be heard by humans (except in the case of the spotted bat), but they would be about as intense as those from a smoke detector---specifically, 110 db (decibels) 10 centimeters in front of the face of a little brown bat. The echoes, of course, are much, much weaker. A 0.25-millimeter wire located 30 centimeters in front of a bat reflects only a 45-db echo from a 100-db emission. The bat's ears obviously must be extremely sensitive to pick up these very weak echoes. Also, the bat must not be deafened by the much more powerful signal it sends out. The echo from the above-mentioned wire returns in only 17.6 milliseconds, implying that bats must also possess some sort of internal clock capable of measuring very short time intervals and a means of converting these to distances. That bats have mastered acoustic echolocation is obvious in the big brown bat's ability to detect a 19-millimeter sphere at 5 meters in the dark. (R9)



The strength of the echolocation signal and its echo for a big brown bat. The transmitted pulse is about 2.5 milliseconds long. Here, the echo returned in 4.4 milliseconds, indicating a target at about 0.66 meter. (R9)

Bat echolocation is actually much more involved than simply detecting a small target in the night sky. Bats can also estimate the relative speeds of their prey through use of the Doppler Effect. Some idea as to the identity of the target can be derived from Doppler-shifted sound reflections from the beating wings.

Further, some flying insects can hear bats closing in for the kill and in desperation emit jamming sounds to confuse the bats. But bats have evolved counter-countermeasures to foil such defenses: they switch frequencies, for example.

If bats are hunting in the company of other bats, as is often the case, they can adjust the frequencies and pulse rates of their sound transmissions to avoid confusing each other.

To achieve such operational finesse, bats employ both constant-frequency pulses and frequency-modulated (FM) pulses, as well as combinations of both. Thus, bat ears, which are the real focus of this entry, somehow have to convert very weak, structurally complex echoes, detected amid a welter of jamming noise and other night sounds, into nerve impulses that their brains can transform into a "picture" of their surroundings and, especially, their insect targets.

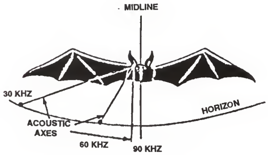
It is obvious from the above sketch that bat ears are just one part of a remarkably complex sensory system. In addition to the ears, there is the sound-generating subsystem (covered in BMO10) and the information-processing subsystem (brain and central nervous system, BMO13). The ear subsystem has to mesh precisely with the other two subsystems if echolocation is to be effective in the pursuit of flying insects with their elaborate escape strategies and, in the case of the fishing bat, the substantially different problem of the faint ripples left by fish swimming near the dappled surface of a pond or river. Here, echoes from the target must be separated from those from water disturbances.

Finally, it must be noted that all three echolocation subsystems had to evolve together to be useful to bat survival. Unfortunately, we have no fossil trail to tell us how (or if) this was accomplished in a step-by-step fashion. The fossil record uncovered so far tells us only that the very earliest of the microbats---prowling the night skies some 50 million years ago---had ears obviously designed for echolocation. (R9)

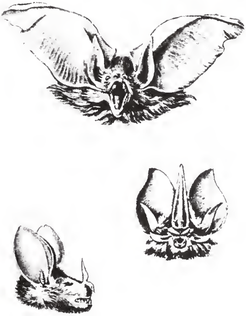
Now it is time to examine some of the modifications of the basic mammalian ear that have made the microbats so proficient at hunting in the dark. Some of these changes are remarkable indeed.

X1. Face and external-ear design. Once bat echolocation had been demonstrated by D.R. Griffin in 1940, it was quite obvious that the giant, cup-like external ears of many microbats were analogous to radar antennas; they were gatherers of those faint echoes reflected from the bat's surroundings. Actually, other features of bat faces, such as those bizarre nose leaves, also probably have something to do with either focussing emitted sound pulses and/or channeling the returning echoes.

The external ears, called "pinnae," can be surprisingly sophisticated. For example, consider that bats have but two ears, one has to wonder how they can develop a three-dimensional image from a two-dimensional sensor; i.e., two ears give right-and-left information only. The moustached bat has made up for this deficiency by generating echolocating pulses at three distinct harmonics: about 30, 60, and 90 kilohertz. This bat's external ears are so shaped that each of these three frequencies has a different acoustic axis, giving the bat in effect three separate sets of ears pointing in three different directions. In the bat's inner ear, the three different frequencies are converted to signals that the bat's brain processes---somehow ---into a "display" it can use in swooping after insects at night. (R1, R2, R5) (Note: The moustached bat flies again in X4!)



The three acoustic axes of the mustached bat.



Microbat faces are adorned with spikes and leaf-like projections that help focus the transmitted echolocation pulses and collect the returning echoes.

X2. Outer-ear motions that enchance echo interpretation. To better interpret sounds, mammals can usually turn their heads, move their ears, or both. Most echolocating bats can and do swivel their large pinnae and move their heads as well. The horseshoe bats, though, seem to take a large step further in using their pinnae to improve echo analysis. R. Dawkins explained as follows:

> Another curious trick of horseshoe bats concerns movements of their outer ear flaps. Unlike other bats, horseshoe bats move their outer ear flaps in fast alternating forward and backward sweeps. It is conceivable that this additional rapid movement of the listening surface relative to the target causes useful modulations in the Doppler shift, modulations that supply additional information. When the ear is flapping towards the target, the apparent velocity of movement towards the target goes up. When it is flapping away from the target, the reverse happens. The bat's brain 'knows' the direction of flapping of each ear, and in principle could make the necessary calculations to exploit the information. (R3)

Dawkins is speculating, but it is unlikely that the ear flapping has no purpose at all. Nature rarely evolves such an unusual characteristic for no reason!

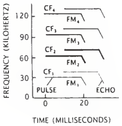
X3. An on-off switch in the middle ear. Echolocation systems, such as radars, require a fast-acting switch that disables the sensitive receiver while the powerful transmitter is sending out its electromagnetic pulse. Bat ears, too, must have such a switch or the ears will be deafened by emitted sound pulses. Of course, the ear must be turned on again in a few milliseconds (ms) if the returning echoes are to be heard. As M.B. Fenton relates, special muscles in the middle ears operate as biological on-off switches.

> About 6 ms before beginning to produce an echolocation call, muscles in the middle ear contract, reaching their full contraction during the production of the vocalization. After the call, the middle-ear muscles begin to relax, and they are fully relaxed 2 to 8 ms later. The contraction of the middle-ear muscles separates the three bones of the middle ear, the malleus, incus and stapes, reducing the transmission of sounds from the ear drum to the inner ear. (R9, also see R3, R7)

Note that the middle-ear muscles begin to operate before sound-pulse emission commences and must be synchronized with a pulse rate that may reach 200 pulses per second as the bat closes in on its prey. Microbat ears and vocalization equipment had to coevolve and be neurologically interconnected.

X4. Inner-ear tuning. The inner ear or cochlea of bats is much like that of the other mammals in its basic design. There are, though, exquisite modifications that tune it to those frequencies most useful to the hunting bat. The auditory subsystem of the mustached bat has received the most scientific attention, and it is in this species that surprising sophistication has been confirmed.

Typically, the mustached bat emits a constant-frequency fundamental sound pulse at about 30.5 kilohertz, with a downward-sweeping frequency-modulated tail. Harmonics at 61.0, 91.5, and 122 kilohertz are prominent in the emitted pulse, each followed by appropriate FM tails. The mustached bat seems to rely upon the echoes from the second harmonic to detect the Doppler-effect ripples caused by the beating of insect wings. In operational terms, when the bat searching at 61.0 kilohertz detects a Doppler-shifted target echo at, say, 63.0 kilohertz, it immediately reduces its second-harmonic pulse by 1.8 kilohertz, so that the target's echoes are stabilized at about 61.2 kilohertz. This turns out to be just the frequency to which the mustached bat's inner ear is tuned in terms of: (1) the distribution of the thickness of the basilar membrane; (2) the sensitivity of the spiral ganglion cells; and (3) the sensitivity of the auditory periphery. (R6)



The bisonar pulse of the mustached bat consists of a long, constant-frequency (CF) component followed by a short, frequency-modulated (FM) component. Four harmonics are transmitted. (R6)

In this fine tuning of the structures making up the mustached bat's inner ear we see astounding technical sophistication well worth major notice in any catalog of anomalies.

Streaming out along the nerve fibers leading to the mustache bat's brain is an avalanche of signals that require processing before the animal can capture its insect target---a target that may be emitting jamming noise and engaged in evasive maneuvers as well. These data are analyzed in milliseconds by a pea-sized biological computer which then issues commands to the appropriate muscles to effect capture. See BMO10-X2 for more on this even-more-sophisticated subsystem within the bat echolocation system.

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R2. Anonymous; "The Ins and Outs of a Bat's Ears," New Scientist, p. 20, August 30, 1984. (X1)
R3. Dawkins, Richard; The Blind Watchmaker, New York, 1986. (X3, X4)
R4. Downer, John; Supersense, New York, 1988. (X2)
R5. Eisenberg, John F.; Mammals of the Neotropics, vol. 1, Chicago, 1989. (X1)
R6. Suga, Nobuo; "Bisonar and Neural Computation in Bats," Scientific American, 262:60, June 1990. (X5, X6)
R7. Thomas, Warren D., and Kaufman, Daniel; Dolphin Conferences, Elephant Midwives, and Other Astonishing Facts about Animals, Los Angeles, 1990. (X3)
R8. Wesson, Robert; Beyond Natural Selection, Cambridge, 1991. ((X4)
R9. Fenton, M. Brock; Bats, New York, 1992. (X0, X3, X4)

BMO7 Innovation and Adaptation in the Auditory Subsystems of Echolocating Cetaceans

Description. Features of the ears of cetacean echolocation systems that, in the compiler's opinion, represent innovations and adaptations so remarkable that the accepted evolutionary paradigm is endangered. The use of the lower jaw as a "sound pipe" is singled out as an innovation worthy of note.

Data Evaluation. Our data file on cetacean echolocation systems is very skimpy. Biologists are not even certain how the sound pulses used in echolocation are produced. (BMO10) The identification of the lower jaw as a "sound pipe" still seems tenuous. We know even less about how (or if) cetaceans use the Doppler Effect and frequency-modulated signals in echolocation. This relative ignorance is easy to understand because whales and dolphins are hard to study in their marine environment. Rating: 3.

Anomaly Evaluation. Several orders of terrestrial mammals utilize echolocation systems. Those of the seals, sea lions, and insectivores are rather crude when compared to those of the insectivorous microbats and cetaceans. In fact, their characteristics seem amenable to explanation via the evolutionary paradigm. The microbat echolocation equipment, however, is potentially anomalous by virtue of its complexity and sophistication. (BMO6) In contrast, the cetacean's echolocation devices are, according to what we know today, considerably simpler than those of the microbats. When we look at the cetacean ears---the subject of this catalog entry---we see innovation and adaptation to the marine environment as the features most like to be anomalous rather than complexity and sophistication. The simple adaptations (loss of external ears and inner-ear modifications) actually seem straightforward enough to have evolved via random mutation and natural selection. On the other hand, the modification of the cetacean lower jaw to serve as a "sound pipe" is so innovative and unexpected that we deem it worthy of a modest anomaly rating. Our rationale is that it seems highly improbable that any sequence of random mutations would hit upon the sound-pipe idea and bring it to fruition, especially since we know of no similar development in earlier mammalian history that might be buried in the genetic codes of whales and dolphins. This is, of course, a subjective evaluation. Rating: 2.

Possible Explanations. None offered.

Similar and Related Phenomena. Mammals as a class exhibit many important innovations. The cetaceans, in particular, have had to be innovative in their invasion of the marine environment; viz., the development of dorsal fins and propulsive tails (BMA 46 and BMA45, respectively, in Mammals 1). For more examples, see the Subject Indexes of the Series-B catalogs under: Innovations.

Entries

X1. General observations. The insectivorous microbats are not the only mammals that echolocate (BMO6), but they do seem to possess the most complex and sophisticated auditory subsystems. Many cetaceans are certainly echolocators; some seals, sea lions, and insectivors (notably shrews) may also employ generated sound in finding their ways around. (BMT3 in Mammals 1) Of these, only the echolocation systems of the toothed whales and dolphins even approach those of the microbats in terms of complexity and sophistication. Unfortunately, much less is known about the cetacean echolocation equipment because marine mammals are much harder to study in the field and laboratory. In fact, we really do not appreciate how complex and sophisticated cetacean echolocation is, although we do know that dolphins can detect small objects quite well with their sonar; for example a 7.5-centimeter sphere at 120 meters. (BMT3-X2) Beyond such performance figures, our knowledge is rudimentary.

We use this catalog entry to contrast the cetacean auditory subsystems, as used in echolocation, with those of the microbats. Although, we cannot yet claim remarkable complexity and sophistication for the toothed whales and dolphins, we can assert that these marine mammals have evolved some remarkable innovations and adaptations for echolocating in an underwater environment.

The "external ears" of toothed whales and dolphins. The microbats often sport huge ears that gather in weak echoes and, in addition, give their owners information on the direction of their targets. In contrast, the cetaceans possess no external ears at all, there being only a pinhole-size opening or a membrane flush with the skin where the ears should be. (R1) Prominent external ears would unduly compromise the streamlining so essential in the marine environment. Apparently, these "vestigial" ears are not used in echolocation anyway. Rather, the echoes returning from the surroundings and targets are collected and conveyed to the middle ears by the animals' lower jaws, which are filled with fatty deposits that conduct sound well. (R2-R4) Presumably, these tube-like channels or "sound pipes" also provide some directional sense. (Incidentally, whales and dolphins cannot nod and swivel their heads over wide angles. The white whale or beluga being an exception to this general rule.) (R1) Although few specifics seem to be known about the performance of this unique "external ear" or "sound pipe," one must admit that it is a rather bizarre innovation---one that seems an unlikely product of random mutations.

In this connection, it is interesting that dugongs possess squamosal bones that are inflated and saturated with oil. These bones, too, seem to be associated with the dugong's ability to detect underwater sound. Dugongs produce a wide variety of squeaks and chirps that may be associated with echolocation. Although dugongs are sirenians, like the manatees, they are considered to be more completely adapted to the marine environment. Initial studies show remarkable parallelisms between dolphin and dugong sound production and detection. (R6)

That these two distantly related mammals should both "invent" similar acoustical "sound pipes" by means of a random process is astonishing.

The middle ears. Received echoes that are transmitted to the middle ears via the lower jaw are passed on to the inner ears through an interesting modification of the basic mammalian middle ear. Because the cetaceans are immersed in a fluid environment, the received sound waves are characterized by much higher pressures and lower amplitudes than those perceived in air by terrestrial mammals. The middle ear components (malleus, incus, stapes) are arranged differently to accommodate the marine acoustic environment. (R5) (This source gives no details.)

A further adaptation helps the whales and dolphins cope in an environment that is often extremely noisy. S. Bunney described some of these modifications in a 1993 number of New Scientist.

> The ears of whales have many other distinctive features. For example, the bones surrounding the inner and middle ears fit into the other bones of the skull much more loosely than they do in all other mammals. They are formed from very hard, dense material and are almost completely surrounded by cavities filled with a fine bubbly foam.
>
> Such an arrangement isolates the cetacean's left and right ears, and insulates them from background noise conducted through the bones of the head. This helps a whale to pinpoint sound signals from outside that are funnelled down the air tube. (R5)

The on-off switch. In the microbats, the sensitive auditory subsystem is, in effect, turned off by muscles when sound pulses are emitted. (BMO6-X3) The cetaceans seem not to have evolved any specific biological device to protect the ears during sound generation. Perhaps the physical separation of the sound emitter (BMO10) from the lower jaw is sufficient for them.

The other echolocation subsystems. Cetacean sound generation is treated in BMO10; the data-processing subsystem in BMO13.

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R3. Wesson, Robert; Beyond Natural Selection, Cambridge, 1991. (X1)

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BMO8 Repeated Development of Electrosensitivity in Mammals

Description. The appearance of electroreceptors in several species of mammals, some of which are distantly related.

Data Evaluation. The presence of electroreceptors in the platypus, short-nosed echidna, and star-nosed mole have been deduced from both behavioral experiments and laboratory tests. These discoveries have been widely reported in the scientific press. Nevertheless, replication of the work by other investigators is needed. Rating: 1.

Anomaly Evaluation. Electrosensitivity is fairly common among the "lower" animals, but the mammalian electroreceptors do not appear to have been inherited from fish or amphibians, for reasons detailed below. Even among the few mammals that exhibit electrosensitivity, implementation of the characteristic seems to be quite different, leading to the supposition that we are dealing with repeated independent invention of unusual (for mammals) sensory equipment. As in the cases of high complexity and sophistication, Darwinistic evolution apparently provides a theoretical explanation. The compiler, however, harbors doubts that this is the whole story. For a fuller discussion of such reservations, see BMO1.

Possible Explanations. Granted that fish, monotremes, and insectivores are distantly related, it is still within the realm of possibility that the basic mechanism of electrosensitivity was evolved only once, long before mammals appeared on the scene, but passed on to them genetically in latent form, awaiting only the proper environmental cues to manifest itself.

Similar and Related Phenomena. Innovation in mammalian echolocation (BMO7); see also Series-B Subject Indexes under: Innovations.

Entries

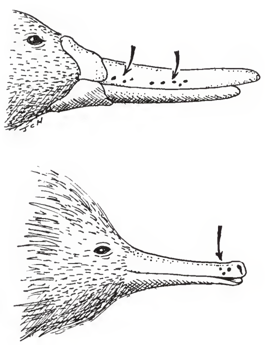
X0. Background. Many orders of fish, including sharks and rays, plus a few amphibians use electroreceptors to locate prey and navigate in murky surroundings. Only in the 1980s was it discovered that a very few mammals, too, have evolved sensors that can detect the very weak electrical fields generated by the muscles of their prey. First, the platypus and shortly thereafter the short-nosed echidna, another monotreme, were found to possess electrosensitive bills or snouts. Of course, nothing is surprising in these "primitive" mosaics of biological features that the monotremes have seemingly borrowed from all over the animal kingdom!

But, in 1993, the tentacled nose of the star-nosed mole, a "more advanced" insectivore and placental mammal, was shown to be electrosensitive also. As we shall see below, the monotremes did not seem to inherit their electrosensivity capability from the fish, and neither does the star-nosed mole seem to owe anything to the monotremes. The mammals very likely have invented electroreceptors at least twice.

X1. The monotremes. Since both the platypus and short-nosed echidna are monotremes, and Australian specialties at that, it is reasonable to suppose that they inherited electrosensitivity from a common ancestor, but we know very little about the monotreme lineage. In fact, the platypus and echidna are so starkly different from each other that they may have invented electrosensitivity independently. Note that the long-nosed echidna, found mostly in New Guinea, can reasonably be expected to have an electrosensitive snout, too, but so far we have found no announcement that this is so.

Platypuses. When a platypus submerges in Australian creeks and ponds, it does so with closed eyes, ears, and nostrils. It still manages to locate its prey by swinging its bill from side to side, like a hammerhead shark scanning for buried flounders. The platypus probes in crevices and under rocks looking for freshwater shrimp, worms, and other aquatic prey. Since it finds and catches them without the senses of sight, hearing, or smell, that strange, probing bill must have some special property. To some naturalists, electrosensitivity seemed a likely explanation for the platypus's obvious hunting successes.

Such was confirmed when H. Scheich et al tested some platypuses in a tank. The animals were clearly attracted to a



(Top) The electroreceptors of the platypus are located along the edge of its leathery "bill." (Bottom) In the short-nosed echidna, the electrosensitive areas are found at the tip of its snout.

live battery but ignored a dead one! They would bump into a plastic plate placed in their paths, but easily avoided it if it was electrified. (R1, R2)

> This behavior encouraged a more sophisticated experiment which involved placing two aluminum plates 3 meters apart in the tank. Tiny varying voltages were applied to the plates and the platypus's reactions showed that it could detect field strengths as low as 500 millionth of a volt per centimeter. With this sensitivity it could easily detect a shrimp from over a meter away for these crustaceans generate tiny electrical fields of up to one thousandth of a volt (0.2-1 millivolt) per centimeter each time they flick their tails. (R4) [This quote was edited slightly.]

In addition to these behavioral experiments, Scheich et al recorded the brain waves of platypuses in lab tests. When the animals' bills were stimulated with voltage pulses of only 300 microvolts, the brain waves responded accordingly. (R1, R2)

Platypus bills are pliable and leathery ---not at all like a duck's. Located on the bill are some 850,000 pore-like electroreceptors with long filaments derived from nerve fibers. These electroreceptors appear more sophisticated in their design than those found on sharks and other fish. (R7)

In 1987, J.E. Gregory et al, at Australia's Monash University, reported further details from an electrophysiological study of the platypus electroreceptors. They wrote:

> The fact that, in platypus, electroreceptors are supplied by the trigeminal (5th cranial) nerve, not the 8th cranial nerve as in fish, strongly suggests the <u>independent</u> evolution of electroreception in montotremes. (R3) [Emphasis and two commas added.]

Of most interest to the anomalist is a comment by U. Proske, the leader of the Monash University investigators: "Far from being a primitive mammal, the platypus is clearly very highly evolved." (R5) Thus, although the platypus surely <u>looks</u> primitive and we assign it to the "lowest" group of mammals, this poor animal is obviously being maligned!

<u>Short-nosed echidnas</u>. Areas structurally similar to the electrosensitive regions of the platypus bill occur at the tips of the snouts of the snort-nosed echidna. This observation led U. Proske and the group at Monash University to put the echidna (a.k.a. the "spiny anteater") through tests like those they applied to the platypus.

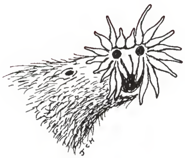
> Proske's group stimulated small areas of the snout electrically and then recorded the transmission of the resulting nervous activity to the brain. Although tactile receptors can also respond to electrical stimuli, they do so only at voltages about 1000 times greater than those that excite electroreceptors. While the echidna's receptors are as sensitive as those in the platypus, and can detect fields as weak as 1 millivolt per centimetre, they do not respond as vigorously. (R6)

Short-nosed echidnas consume ants and termites primarily. It is not clear just how useful an electrosensitive nose is in locating these insects. Furthermore, the echidnas <u>can</u> see and do not have to forage in murky environments. We know also that the more conventional anteaters of South America do very well without electrosensitive noses. One would also expect that a characteristic as unique and specialized as an electrosensitive snout would require a very strong push from natural selection--- something that seems to have been lacking in the echidna's case!

X2. <u>Insectivores</u>.

<u>Star-nosed moles</u>. These mammals are about 6 inches long and look pretty much like those that dig up your lawn--- except for their noses. Clustered about this mole's nostrils are 22 fleshy tentacles that are constantly probing and writhing like something out of a science fiction movie. (R9)

The star-nosed mole is one of North America's more bizarre mammals. The Medusa-like appendages on its nose are richly suppled with nerves and blood vessels. They have long been considered a tactile organ used for feeling for prey. However, behavioral experiments by E.



The 22 writhing tentacle-like structures of the star-nosed mole are sensitive to the electric fields generated by its prey.

Gould et al indicate that the star may be more than a tactile organ. It seems to sport electrical sensors that detect the minute electrical fields surrounding worms, leeches, insect larvae, and other favorite mole tidbits. This conclusion derives from experiments in which star-nosed moles preferentially attacked the parts of worms that are most strongly electrical.

Actually, scientists have been puzzled as to how this mole found its prey, for this mammal is semiaquatic and somehow locates its dinner in muddy water even though it has poor eyesight.

Isn't it curious that such distantly related animals as the star-nosed mole and the platypus have evolved similar organs and hunting strategies when confronted with like environments? This is called "parallel evolution;" but naming the process does not tell us how nature accomplishes it. Chance mutations and natural selection? Theoretically possible, but not particularly convincing. Nature must still be withholding some secret from us! Could it be that life cannot after all be described completely in the language of physics and chemistry?

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R4. Downer, John; Supersense, New York, 1988. (X1)

R5. Anderson, Ian; "Sixth Sense Is the Platypus's Secret," New Scientist, p. 39, May 12, 1988. (X1)

R6. Verma, Surendra; "Second Mammal with a Nose for Electricity," New Scientist, p. 26, March 25, 1989. (X1)

R7. Hoffman, Eric; "Paradoxes of the Platypus," Scientific American, 264: 18, March 1991. (X1)

R8. Gould, Edwin, et al; "Function of the Star in the Star-Nosed Mole, Condylura cristata," Journal of Mammalogy, 74:108, 1993. (X2)

R9. Zimmer, Carl; "The Electric Mole," Discover, 14:16, August 1993. (X2)

BMO9 Parallelisms in the Tongues and Teeth of Specialized Feeders

Description. The presence in distantly related mammals specializing in certain types of food of: (1) similar major innovations in tongue design to improve feeding efficiency; and (2) the degeneration or complete loss of teeth no longer useful in a particular environmental niche.

Data Evaluation. The primary reference is Walker's Mammals of the World, an authoritative reference work. This is supplemented by a more popular book on Australian wildlife. Rating: 1.

Anomaly Evaluation. The currently accepted neo-Darwinian paradigm holds that random mutations guided by natural selection operating in similar environments can, given sufficient time, account for all parallelisms. However, the compiler and others, even some scientists, have reservations about the evolutionary paradigm. Some of the parallelisms among distantly related animals, as recorded below, are so remarkable that random mutation plus natural selection seem inadequate. In other words, a suspicion exists that other, yet unrecognized factors may be involved. In these situations, which occur frequently in this Catalog, no anomaly rating is attempted. See the discussion in BMO1 for additional heretical thoughts on this matter.

Possible Explanations. (1) Parallelism and convergence arise through separate, independent chains of random mutations modulated by natural selection. (2) So-called "morphic resonance," a radical concept proposed by R. Sheldrake, may accelerate such processes. (3) Parallelisms may be the consequence of traits inherited from a distant common ancestor. (4) "Directed" or "adaptive" evolution, a highly controversial process, may greatly accelerate the evolutionary accommodation of an animals to new environmental conditions.

Similar and Related Phenomena. Parallelisms in the external appearance of mammals (BMA1); toothlessness in mammals (BMA35); parallelisms in mammalian extremities (BMA42)---all in Mammals 1. See the Subject Indexes in the Series-B catalogs under: Parallelisms, Innovation.

Entries

X0. Introduction. It is not unusual to find parallelisms in distantly related mammals that occupy similar environmental niches. Most cetaceans, for example, have evolved dorsal fins and propulsive tails (BMA46 and BMA45 in Mammals 1). When tongues are compared, one finds similar parallelisms among the mammals that feed on ants/termites and, again, among the nectar/pollen feeders. What makes these tongue parallelisms so interesting is that they are almost always accompanied by the degeneration or outright absence of teeth. This, of course, is not surprising to naturalists, because both ants/termites and nectar/pollen are soft foods requiring little or no mastication. This combination of tongue innovation and teeth degeneration illustrates once again how precisely animals become adapted to narrow niches. Can evolution adequately account for such parallelisms when they span the entire spectrum of mammals---monotremes, marsupials, and placental mammals?

X1. Ant/termite eaters. Four groups of mammals are customarily called "anteaters," although they predominantly feed on termites ("white ants"). Their tongue/teeth parallelisms were mentioned briefly in BMA1-X5 (in Mammals 1). We expand on this theme here and, in addition, record two other mammals that fit in rather well but do not bear the "anteater" label.

New World anteaters. The "classic" anteaters comprise three terrestrial species, all of which are characterized by long, sticky tongues and the complete absence of teeth. (R2)

The silky anteater is also a New World anteater but radically different in both appearance and behavior. It is almost exclusively arboreal and often hangs by its prehensile tail. Like its terrestrial cousins noted above, the silky anteater has that typical long, sticky tongue and no teeth at all. (R2)

Scaly anteaters (pangolins). Found in Asia and Africa, the several species of pangolins are toothless but possess a remarkable tongue that can be extended about 25 centimeters. Its muscular roots pass down through the chest cavity and are anchored in the pelvis! (R2)

Banded anteaters (numbats). Numbats are the marsupial counterparts of the placental anteaters. Their long tongues flick into and out of ant/termite nests, capturing up to several hundred insects per second. (R1) They defy the usual anteater rule by boasting more teeth than any other land mammals (54 of them). These teeth, though, are small and delicate. (R2) (Perhaps they are on the road to oblivion?)

Spiny anteaters (echidnas). There are two species of these monotremes (the short-nosed and long-nosed), and they both have long, sticky tongues and survive very well without teeth. (R2)

Aardvarks. Mainly an ant/termite feeder, the African aardvark sports a 30-centimeter, tapering tongue, the end of which is often seen hanging out of the mouth coiled up like a clock spring. The infant aardvark does have teeth, but soon the front ones fall out, and the adult retains only those in the rear of the mouth. (R2) Aardvark teeth are "tubules" and strange in several other ways. (BMA30-X7 in Mammals 1)

Sloth bears. An Asian bear, this animal is fond of termites, which it sucks up like a vacuum cleaner. (BMA30-X8) To facilitate this substitution for the anteaters' flicking, sticky tongues, the sloth bear has a mobile snout, a hollowed palate, and, most interestingly, lacks its inner incisors. (R2)

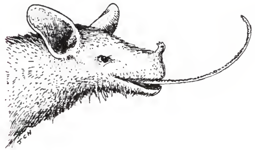
X2. Nectar/pollen eaters. Many nectar-eating birds have brush-like tongues designed to collect nectar efficiently. This useful adaptation extends to both marsupials and placental mammals.

Honey possums.

> The honey possum (Tarsipes rostratus) is one of the few mammals in the world adapted to feed exclusively on nectar and pollen. Like the honey-eating birds, it has a long, brush-tipped tongue to probe flowers, especially banksia blossoms, and take up the nectar. Though it is called a possum, it's only distantly related to that group, and appears to be the only survivor of a long-extinct marsupial family. (R1)

As with the ant/termite eaters, the honey possum's teeth are not essential to survival. Only the upper canines and lower incisors are well-developed. (R2)

Microbats. Several species of microbats subsist mainly on nectar/pollen. Saussure's long-nosed bats, of which there are three New World species, are taken



Nectar-feeding microbats often possess remarkably long tongues.

here as representative of this group.

> The diet consists of nectar, pollen, fruit, and insects. The insects may be ingested accidentally while feeding on pollen and nectar...The bats probably use their long muzzle to reach the spineless parts of the cactus fruits, their canine teeth to tear the skin, and their tongue to lap up the juices. The tongue of L. nivalis can be extended to 76 mm. (R2)

These bats are unusual in that they lack the third molars, a feature they share with only one other bat, Lichonycteris obscura, also a nectar feeder with a long tongue, and lacking even more teeth (lower incisors). (R2)

References

R1. Vandenbeld, John; Nature of Australia, New York, 1988. (X1, X2)

R2. Nowak, Ronald M.; Walker's Mammals of the World, Baltimore, 1991. (X1, X2)

BMO10 Innovation in Sound-Generating Organs

Description. The presence in some mammals, especially the microbats and the cetaceans, of unique, highly innovative structures for generating and projecting sounds for the purposes of communication and, in particular, echolocation.

Data Evaluation. Bat echolocation has been the subject of considerable field and laboratory experimentation. Consequently, much is known about their vocalization and acoustic-signal-generation biology. Cetaceans, on the other hand, are very difficult to study because of their size and aquatic environment. Research on the organs and "devices" they employ for sound production and projection is still in the rudimentary stage. This is unfortunate because it is in the cetaceans that we see the greatest biological innovation. Rating: 2.

Anomaly Evaluation. Like the properties of complexity and sophistication, innovation is hard to quantify. Some biological features that the compiler would deem highly innovative and requiring much explanation would probably be categorized as reasonable adaptations by a biologist---something well within the capacity of evolution to produce, given enough time. The compiler, as must be obvious, takes a less sanguine view of the efficacy of random mutation and natural selection in producing innovations such as the sperm whale's sonar apparatus. Intuitively, the present evolutionary paradigm seems to need a scientifically acceptable mechanism for accelerating and/or directing thc processes of adaptation and innovation.

Possible Explanations. "Adaptive" or "directed" evolution could dispel the doubts expressed above, but no one knows how "directed" evolution might work or even if it really exists. The mere suggestion of "purpose" in evolution is anathema to most biologists and all reductionists.

Similar and Related Phenomena. The "innovation" objection to evolution crops up frequently in the Series-B catalogs, as exemplified by the cetacean dorsal fin (BMA46), propulsive tails (BMA45), bat flight (BMA41)---all in Mammals I.) See also the Subject Indexes under: Innovation.

Entries

X0. Introduction. Humans generate their words and some of their music in their larynxes, where their vocal cords are located. Most other mammals use the same sound-generating equipment, but some, such as the cetaceans, lack vocal cords altogether. Whales and dolphins have had to evolve new ways of making sound for communicating with each other and, where useful to them, echolocating. Other common (and non-anomalous) body parts employed in making sound are: the lips (whistles); the teeth (clicking and gnashing); and the tongue (clicking). All of these mechanisms are employed by mammals and are difficult to label as anomalous.

The real purpose of this catalog section is the description and evaluation of some different and unusually innovative methods of sound generation that some mammals have evolved for communication, echolocation, and, perhaps, the actual stunning of prey with sound.

First, though, we emphasize that the sound-generating organs comprise only one subsystem of a mammal's communication and/or echolocation system. The indispensable auditory and data-processing subsystems are covered in BMO6, BMO7, and BMO13. The engineering properties of all three subsystems must mesh neatly for optimum system performance. To achieve this compatibility, they and their interconnections doubtless coevolved. Otherwise, to use an engineer's viewpoint, the pulse rates, frequencies, data-flow rates, etc. might not match.

X1. Innovations in sound-generating organs for communication.

Elephants. Elephant watchers had long been puzzled by the apparent ability of elephants to coordinate their movements even though out of sight of one another. (BMT8-X1 in Mammals I) The answer to the enigma came when it was discovered that these animals communicated via infrasound, which travels with little attenuation over large distances. Infrasound frequencies are under 20 hertz, the lower limit of normal human hearing.

Elephant infrasound emanates from the pachyderm forehead, though it originates in the larynx, as vocalization does in most mammals. What is innovative in the case of the elephant is the presence of a cavity in its forehead which acts as a resonator for the sound arriving from the larynx, thereby amplifying it. The forehead itself acts like a natural sounding board or diaphragm. (R8) There exists here a curious parallel between the elephant's forehead structure and that of the sperm whale's forehead as discussed at the end of X2. This rough parallelism accords with the other affinities linking elephants and marine mammals like the manatees. (Both possess "marching teeth," as described in BMA31 in Mammals I.)

Rhinos, hippos, okapis. All of these mammals emit infrasound, but their sound-generating mechanisms have not yet been identified. (R18) (See also BMT8-X1 in Mammals I.) Surely, more infrasound-using mammals will be identified in the future.

Baleen whales. Baleen whales have not yet been confirmed as echolocators, but they do communicate with each other with sound. In the humpback, these communications consist of long, stylized "songs." Gray whales and other baleen species are not such virtuosos, although they do moan, groan, and emit sound pulses. All these sounds are generated without recourse to vocal cords. The best guess is that this acoustic energy is produced by air passing through the tracheal region. (R13) Really, though, no one yet knows exactly how the humpback sings!

Toothed whales and dolphins. These cetaceans are echolocators as well as accomplished communicators. In fact, they emit two distinct varieties of sound: clicks for echolocating and whistles for communication. Both types of sound can be produced at the same time. (R2) Like the baleen whales, the toothed whales and dolphins have no vocal cords. When they click and/or whistle, no bubbles escape from their blowholes, suggesting that expelled air may not be involved in sound production. Furthermore, J. Cousteau has pointed out that dolphin clicks are sometimes produced at the rate of 1200 per second---faster than any muscle or vibrating membrane can operate. (R2) In the light of these facts, B. Wursig has speculated:

> It is likely that both click and whistle sounds are generated near the nasal region [blowhole], where a muscular plug and several sets of air sacs connected to the narial passages allow for the shunting of air back and forth in the odontocete forehead and cause the vibration of tissue. The entire process probably evolved from the sibilant nasal sounds made by ungulates on land, transposed during evolution to an internal shunting of air due to the necessity of keeping the nares closed underwater. Some delphinids can produce clicks and whistles simultaneously, possibly by bilateral use of the paired air sac system. (R13)

Whatever their origin(s), to be effective, the echolocating clicks of the cetaceans must somehow be focussed by an additional biological structure---some invention of evolution that acts like a parabolic mirror and/or lens for sound. This is brings us to our next subject: echolocating mammals.

X2. Innovations in sound-generating organs for echolocation.

Tenrecs. Because of their spines, the tenrecs inhabiting Madagascar have been dubbed "Madagascar hedgehogs." Experiments have shown that these shrew-like insectivores employ echolocation to find their ways about. The echolocation sound pulses are mostly tongue clicks. (BHT3-X2 in Mammals I) Manifestly, there is nothing especially innovative in this sound source. However, these animals also have a second sound generator which may also be employed in echolocation. E. Gould mentioned this puzzling additional pulse emitter in the summary of his 1965 paper.

> Sounds produced by a highly specialized organ on the back of Hemicentetes and Centetes are described. It is a noisy pulse having frequencies between 2 kc/sec and 70 kc/sec. The sound may not be related to echolocation but more likely to communication and the social habit of these animals. (R1)

Gould gave no further details on the nature of this organ and how it works. We know of no other mammals with sound-generating organs on their backs; so we deem it an innovation worth cataloging.

Megabats in general. Bats of the genus Rousettus, which includes the Egyptian fruit bat, echolocate using tongue clicks as their sound sources. No facial ornaments are present to focus these sounds, nor are there large ears to gather in the echoes. All in all, these bats have crude echolocation systems displaying little innovation. (R9, R17)

Microbats in general. The several hundred species of microbats apparently all echolocate to some degree, even though all are not insectivores. The fruit, nectar, and blood consumers forage at night, when echolocation is useful in avoiding obstacles and finding their food sources.

Microbats emit an impressive variety of sound pulses over a wide frequency spectrum, almost all are ultrasonic and beyond the range of human hearing. Some microbat pulses are at a constant frequency, some others are frequency-modulated, still others are combinations of both. This sophisticated repertoire is useful in ascertaining the distance, speed, and identity of prey. The pulse rates vary, too. So-called "feeding buzzes" may occur as bats home in on their targets and are forced to increase their pulse rates. As we shall see, scientists know considerably more about microbat echolocation than they do about cetacean sonar. (R7, R8, R10, R11, R14, R17)

Be that as it may, the subject at

hand is the biological mechanism(s) that microbats use to generate their echolocation signals.

Microbat echolocation pulses apparently all originate in the larynx where the vocal cords are found. The varied cries and chirps, as indicated above, may be highly complex, just like a human singer's voice. In many bats, these sounds emerge through the mouth---one's natural expectation. Some other bats, though, project their sound pulses through their noses! Among these nose-emitters are the Old World and New World leaf-nosed bats, slit-faced bats, false vampire bats, horseshoe bats, and others. (R17) Sound emission through the nose is not all that remarkable; many mammals hum and snort! But, in sum, microbat sound making differs little from that of most other mammals and innovation here has been minimal.

The real innovation in microbat echolocation is manifest in the facial ornaments seen mainly on those bats that emit sound via their noses. On this subject, M.B. Fenton wrote:

> The species emitting their calls through their nostrils often have elaborate facial ornamentation. Typically the ornaments are leaf-like, but the details vary from family to family and species to species. Work with the Short-tailed Fruit Bat, a New World Leaf-nosed Bat, has revealed that the nose leaf is important in the transmission of echolocation calls. Temporarily changing the nose leaf with Crazy Glue altered the pattern of sound radiation from the bat, directly affecting the bat's perception of its surroundings. (R17)

The ornaments on some bat faces are truly bizarre, even grotesque. (BMO6-X1 and BMA22 in Mammals 1) Useful though the ornaments have been shown to be, mutation and natural selection seem to have run amok in some species! But this is a human perception, the bats may know well what all the fantastic ornaments are for.

To explain bat face ornamentation---such as a simple nose leaf---evolutionists usually postulate something like a random mutation that creates a small projection on the nose that, in turn, improves echolocation performance and thereby bat survivability. Additional random mutations improve upon the design until the present, but not necessarily the last, version is produced. No other acceptable "scientific" mechanism is presently available to explain the creation of such highly innovative biological structures. Of course, this does not means that a better theory is not waiting in the wings.

Cetaceans in general. As already indicated in X1, the echolocating cetaceans, the toothed whales and dolphins, create whistle-like sounds for communication and clicks for sonar operations. (The sperm whales also use clicks for communication.) Furthermore, both whistles and clicks can be emitted simultaneously. Since the cetaceans possess no vocal cords and do not employ the tongue or expelled air to produce sounds, their sound-generating organs must represent some sort of biological innovation. The echolocating species generally make use of another invention of evolution: a sound lens for focussing the clicks and, perhaps, even stunning or disorienting prey with intense sound. This sound lens is the so-called "melon" or bulge seen on many cetacean foreheads. In the pattern-defying sperm whale, it is the waxy, so-called spermaceti organ that is also located in the forehead.

Much remains unknown and contentious in the biology of cetacean echolocation. We begin with a general description of cetacean acoustic equipment from Walker's Mammals of the World and then move on to some curious specifics, especially those associated with the sperm whale, the most anomalous of all the cetaceans.

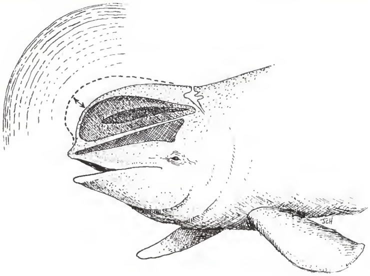
> There is still some question where sounds are produced, but there is increasing evidence that both clicks and whistles originate in a series of air sacs that lie above the bony cranium in the soft tissues around the blowhole on top of the head. Sounds are reflected off the concave dorsal surface of the skull and then focused and directed by the melon, a large pocket of fat on the forehead of most odontocetes. This pocket is especially well developed in genera that regularly feed in the lightless bathy-pelagic zone and those that live in turbid rivers. (R15)

Recently, a computer model of sound propagation in the dolphin head narrowed the search for the echolocation sound source to a small packet of fatty tissue close to the animal's blowhole. X-ray scans of dolphin heads confirmed the presence in all species examined that these packets were flap-like and could very well perform somewhat like the lips of a trumpet player when air is forced past them. (R16) The sound produced is then reflected off the inside of the skull, which acts like a sound mirror. The sound is next refracted (focussed) by the fat-filled melon in the forehead, which is in effect a sound lens. All in all, from what we now know about it, the biological aspects of cetacean sonar sound generation and projection are more impressive and innovative than in the microbats.

Belugas (white whales). Often dubbed "sea canaries," these loquacious mammals are characterized by the prominent melon on their foreheads. This feature of the beluga is well worth singling out because the animal can change the shape of the melon. (See figure.) In doing this it can focus the sound it emits to suit the purpose at hand. In a sense, the melon becomes a zoom lens for out-going sound pulses! (R5, R19) Other cetaceans may also change their sound lenses a bit, but in the beluga it is most obvious. What a major innovation in cetacean acoustical engineering, but why was only the beluga so favored?

Humpback whales. Noted for their eerie "songs," humpbacks, being baleen whales, are not generally considered echolocators. However, in a long paper on symbiosis, B.D. Dyer alluded to a fascinating conjecture concerning these whales and their barnacle companions.

> An interesting observation has been made by Peter Beamish (Ceta Research, Inc., Newfoundland) concerning the humpback whale Megaptera novianglia and its associated barnacle Coronula diadema. The barnacles, attached to the fins and other parts of the whale, are within 6-sided exoskeletons. Beamish has determined that the skeletons have a particular acoustic property---they can focus sound. These 6-sided exoskeletons are modified at the base to accommodate folded outgrowths of whale skin, forming an intimate whale-barnacle connection. As the barnacle feeds on phytoplankton it makes clicking sounds, which are enhanced and transmitted by the exoskeleton. Beamish hypothesizes that the whale may be using the barnacle clicks to echo-



The beluga (white whale) can change the shape of it "melon" and thus its sound emissions. The melon thus serves as a "sound lens."

locate small fish, the whale's probable prey. (R12)

Sperm whales. Sperm whales do not seem to whistle like the dolphins, but instead both communicate and echolocate with clicks. (BMT8-X1, X3 in Mammals 1) Sperm whales may also use sound to stun their prey, a possibility suggested by the ability of individuals with grossly deformed jaws to feed themselves adequately in the wild. (BMB14-X5 in Mammals 1)

The acoustical apparatus of the sperm whales is impressive. The massive forehead occupies some 30% of the animal's length. Inside it are found the spermaceti organ, air sacs, and connective tissues. Clicks focussed by this huge structure are remarkably powerful. A juvenile sperm whale corralled in a New York yacht basin produced clicks that could be heard in air across the entire expanse of the basin. A hand held against the forehead just above the upper jaw felt the clicks' impacts and was forced away. (R4, R6)

K.S. Norris and B. Møhl have detailed some of the astoundingly involved internal structure of the sperm whale forehead.

> The soft tissue of the sperm whale forehead is structurally complex. A huge curving chamber filled with liquid wax (the spermaceti organ) forms the upper forehead. It is encased in thick muscle and a tendinous case. At either end and below it are large air sacs that are diverticula of the right nasal passage. To its left runs the large hoselike left nasal passage ending in an anterior blowhole. Below the spermaceti organ and continuous with it posteriorly is a larger mass of tissue, the junk, composed on wax-invested connective tissue wedges alternating with spermaceti-filled spaces that resemble a series of stacked lenses. These terminate beneath the anterior snout just above the rostrum, approximately where the sounds were found to emanate.
>
> This unusual anatomy has been implicated by Norris and Harvey in the production of the unique burst-pulsed sound packets of the sperm whale. (R6)

It is an interesting exercise to try to formulate a reasonable sequence of random mutations which, when modulated by natural slection, would arrive at such a unique assemblage of acoustic devices!

Considerable modification of the basic whale body form was required to accommodate all this acoustic apparatus. To illustrate, the sperm whale's blowhole is far off center. In fact, the sperm whale is the most asymmetrical of all mammals. (BMA22-X2 in Mammals 1) In the sperm whales we see evolutionary innovation in high gear. The conversion of a cow-like land mammal to a marine mammal capable of diving 2 miles deep and subduing giant squid is truly a remarkable accomplishment. Furthermore, in this section we have only touched upon the changes wrought that give this animal the capability to echolocate and, possibly, stun their favorite food items!

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R16. Peterson, I.; "Dolphin Sonar: Using Their Heads to Click," Science News, 142:325, 1992. (X2)
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BMO11 Absence of REM Sleep in Echidnas

Description. The absence of REM sleep in the echidnas.

Data Evaluation. None of the sources (R1, R3) are forthcoming in details about the discovery of the phenomenon. Furthermore, both of these sources are from the popular literature. Rating: 2.

Anomaly Evaluation. The phenomenon is all too easily attributable to a "more primitive" nature of the echidnas. They simply did not climb high enough up the evolutionary ladder to acquire REM sleep. If the only other monotreme, the platypus, had also been slighted, we would not catalog this curious case of the echidna at all, since the phenomenon would then conform to evolutionary expectations. Rating: 3.

Possible Explanations. See above discussion.

Similar and Related Phenomena. REM sleep in mammals (BMF24) One-of-a-kind anomalies are not unknown among the mammals. The beaver's "primitive" cloaca, for example, is apparently unique among the placental mammals.

Entries

X1. General observations. The pages of this catalog volume and those of Mammals 1 record the many eccentricities of the echidna or spiny anteater. It therefore comes as no surprise to learn that the echidna's brain waves also differ from those of its mammalian relatives, and even those of the platypus, the only other monotreme.

First, it is interesting but not particularly pertinent to note that the brain of the echidna lacks the corpus callosum, that nerve-rich bridge linking the two hemispheres of the human brain. However, evolution also neglected the platypus and all of the marsupials (also all of the reptiles) in this matter (R2), so we cannot blame the echidna's anomalous brain waves on this evolutionary oversight.

The subject anomaly manifests itself when the echidnas (both species) doze off, as related by J. Mortenson:

> Additional studies have shown that the brain waves of all mammals and birds are basically alike. In both groups, active animals have fast, low-voltage brain waves. Inactive animals show either slow-wave or REM [Rapid Eye Movement] sleep. The only exception is the spiny anteater or echidna (Tachyglossus aculeatus) of Australia, which is one of the last living representatives of an early group of mammals. This odd egg-laying animal has only slow-wave sleep. (R1)

In a 1992 article in Discover, J. Kinoshita points out that the echidna's brain is characterized by an oversized prefrontal cortex. This feature may have packed the animal's skull so tightly that further evolution of the brain ceased at that point. However, other mammals, when faced with a similar lack of skull space, came up with a strategem that used the limited volume available more efficently. The answer was REM sleep, which some researchers maintain is a form of off-line data processing. (R3)

Strangely, the brain of the platypus, the only other monotreme, and certainly just as "primitive-looking" as the echidna, did not encounter this roadblock, for it apparently does exhibit REM sleep.

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R2. Nowak, Ronald M.; Walker's Mammals of the World, Baltimore 1991. (X1)

R3. Kinoshita, June; "Dreams of a Rat," Discover, 13:34, July 1992. (X1)

BMO12 Repeated Independent Development of a Key Part of the Carnivore Brain

Description. The repeated independent evolution of the cruciate sulcus, a "major landmark" in the development of the carnivoran brain---an excellent example of parallel evolution.

Data Evaluation. We have at hand only a single report on the phenomenon. It is from a first-line scientific journal. Rating: 2.

Anomaly Evaluation. Parallel evolution appears several times in this volume. To avoid redundancy in compiler discussion, the reader is directed to BMO9.

Possible Explanations. See BMO9.

Similar and Related Phenomena. See BMO9.

Entries

X1. Fossil survey.

The following abstract is from a 1971 paper by L. Radinsky in Evolution. We have here still another example---from a very long roster---in which evolution has repeatedly created the same feature in a broad spectrum of animals, even though the feature never occurred in their forebears.

> A survey of the external brain morphology of fossil Carnivora revealed that the cruciate sulcus, a major landmark of the cerebral cortex which is present in all living carnivoran families, did not exist in the common ancestor of those families, and thus evolved independently several times. The history of the carnivoran cruciate sulcus is of interest as a major example of parallel evolution in mammals, and for the insight it provides into mammalian brain evolution and the significance of brain morphology for interpeting phylogeny. (R1)

In the body of his paper, Radinsky ventured that the cruciate sulcus evolved independently at least five times.

Reference

R1. Radinsky, Leonard; "An Example of Parallelism in Carnivore Brain Evolution," Evolution, 25:518, 1971. (X1)

BMO13 Microbat Information Processing:

Brain Complexity and Sophistication

Description. The ability of a microbat's brain to produce useful data on target distance, relative speed, and identity from echoes in a noisy environment. Of course, the brain also issues appropriate control signals to the bat's body so that prey capture can be effected.

Data Evaluation. Although we cite only two references, these are distillations of a large corpus of research on bat echolocation. We know much more about bat echolocation than cetacean sonar. Rating 1.

Anomaly Evaluation. For the compiler's views on the anomalousness of examples of high complexity and sophistication in biological systems, see BMO1. This cross reference avoids redundancy.

Possible Explanations. Also see BMO1.

Similar and Related Phenomena. Also see BMO1.

Entries

X1. General observations. By 1940, D.R. Griffin had proven to incredulous scientists that microbats coursed unerringly through the night sky with the help of ultrasound echolocation. Even after Griffin's conclusive demonstrations, the acuity of bat sonar was deemed crude compared to eyesight. But, the more researchers studied bat echolocation, the more complex and sophisticated these sensory systems appeared. In 1990, one authority, N. Suga, stated:

> ...bisonar has since been shown to be anything but crude: an echolocating bat can pursue and capture a fleeing moth with a facility and success rate that would be the envy of any military aerospace engineer. (R1)

The echolocation system meriting such applause possesses a data processor that is only the size of a pea---the microbat's brain---a biological computer. The other subsystems comprising this tiny but astonishingly effective sonar system are the sound-generating and auditory subsystems introduced in BMO6 and BMO7.

The input to the microbat's brain originates in the auditory subsystem.

> Input from the auditory nerve is passed up through different parts of the brain to the auditory cortex. For the most part, the chiropteran auditory system is typical of mammals, although some echolocating bats have unique connections and pathways conducting impulses to the midbrain, specifically, the inferior colliculus. The auditory cortex of some echolocating bats is specialized for representing bisonar information. From the auditory cortex, echolocation information is relayed to the cerebrum. (R2)

The data flooding into the brain via the auditory nerve contain sufficient information for the bat to determine:

- Target distance (from the time taken for the echoes to return)
- Target relative velocity (from the Doppler shift from the emitted pulse)
- Target wingbeat frequency (also from Doppler shifts)
- Target size (from echo amplitude)

As related in BMO6, the sound pulses emitted by microbats must be sophisticated for the animal to be able to extract all the information it requires from a noisy environment, which is often filled with the emissions of other bats and acoustic countermeasures from the bats' prey. A mix of constant-frequency and frequency-modulated pulses, replete with harmonics under the bat's control, are sent out at a variable rate. We hate to use the word "sophisticated" too often, but the microbat's brain certainly warrants this adjective for its ability to make sense out of the melange of acoustical information in the echoes it receives.

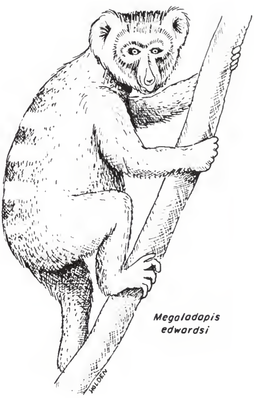
To illustrate further the acuity of bat echolocation, a microbat can recognize a difference in target distance of between 12 and 17 millimeters (less than an inch). Given the speed of sound in air, this means that bats can sense and utilize a difference in echo delay time of between 69 and 98 microseconds! (R1) How do bats discern such small time differences? Can nerve impulses travel fast enough?

Our observations of bats demonstrate that bat echolocation is a highly developed sensory tool; tiny electrodes inserted into the brain tell us where some of the data are processed; but exactly what is happening to the nerve signals and how the muscles are controlled to capture prey remain a mystery.

Even more amazing is the possibility that this marvelously complex and sophisticated type of echolocation system evolved repeatedly in distantly related mammals via cumulative random mutations.

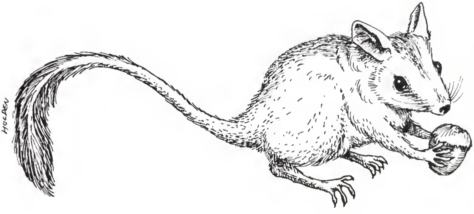
References

R1. Suga, Nobuo; "Bisonar and Neural Computation in Bats," Scientific American, 262:60, June 1990. (X1)
R2. Fenton, M. Brock; Bats, New York, 1992. (X1)



Megaladapis edwardsi

The koala lemur, a now-extinct primate from Madagascar, closely resembled the still-living koala (a marsupial) from Australia. The parallelisms are striking. (See BMD14-X3 in this volume and BMA1-X11 in Mammals I.)



Wild male brush-tailed marsupial mice (tuans), Genus Phascogale, expire en masse after mating. (See BMF25-X1 for details.)

BMU UNRECOGNIZED MAMMALS

Key to Phenomena

BMU0 Introduction

Within the compiler's memory, zoologists confidently asserted that all large mammals had already been discovered. During the last 30 years, however, there has been a steady stream of newly recognized mammals found prospering in the seas and in remoter terrestrial regions. B. Heuvelmans, in the Preface to the 1995 revision of his On the Track of Unknown Animals mentioned several of these recent zoological surprises. (R2) Here we mention just two of them to demonstrate that this chapter is not just the wishful thinking of an anomalist:

1966: A new beaked whale (Mesoplodon carlhubbsi) found off California;
1991: A desert warthog (Phacochaerus aethiopicus) discovered in Africa.

The magnitude of the task confronting those who do not subscribe to the "they-have-all-been-discovered" pronouncements; i.e., the "cryptozoologists," was sketched out in a 1986 survey by B. Heuvelmans, the generally acknowledged father of cryptozoology. At that time, Heuvelmans estimated that there were between 79 and 92 unrecognized mammals for which significant evidence of existence had accumulated. (R1) His breakdown was:

Marine mammals	16
Freshwater mammals	6-8
Terrestrial mammals	57-68

Surprisingly, 24-30 of these as yet unrecognized terrestrial mammals are in the Order Primates, including even putative hominids. In this matter of unrecognized hominids, the reader should refer to Chapter BHU in Humans III, where 13 possible man-like creatures are cataloged. In the present chapter, we focus on the other mammalian orders. From the several score potential candidates, we choose 18 of the more interesting for discussion.

Cryptozoology also encompasses mammals that are formally recognized as legitimate species by zoologists, but which have been officially declared to be extinct, but which are, nevertheless, still being reported. The thylacine or Tasmanian tiger is a typical example of this genre. The thylacine and other possible late survivors are cataloged in BMD10 through BMD14.

References

R1. Heuvelmans, Bernard; "Annotated Checklist of Apparently Unknown Animals with Which Cryptozoology Is Concerned," Cryptozoology, 5:1, 1986.
R2. Heuvelmans, Bernard; On the Track of Unknown Animals, New York, 1995. (revised and updated edition)

BMU1 MacFarlane's Bear: A Yellow Giant

Description. An immense, yellow-furred, North American bear with skull characteristics so different from those of the grizzly that one expert assigned it to a new species and genus.

Data Evaluation. Only one specimen has been obtained by science, although the natives of northern Canada have reported seeing this animal in the wild. Both of the sources used here are based on a 1918 scientific report. Rating: 2.

Anomaly Evaluation. Since grizzly bears are admittedly highly variable in size and color, and hybrids with other bears (black and polar) are recognized, MacFarlane's bear is generally disregarded by taxonomists. It is thought to be only a freak or hybrid rather than a legitimate new species. Rating: 3.

Possible Explanations. Hybridization or, less likely, nature's unsuccessful experimentation in mutation---a sort of "hopeful monster"!

Entries

X1. Only a single specimen. On June 24, 1864, two Inuit hunters killed an immense, yellow-furred bear near Rendezvous Lake in Canada's Northwest Territories. Three months later. R. MacFarlane, a naturalist, arrived on the scene, examined the remains, was impressed by the anomalous nature of the bear. He decided to preserve its skin and skull. These he shipped to the U.S. National Museum, where they were cataloged and then languished for a half century.

The next naturalist to take an interest in MacFarlane's specimen was C.H. Merriam, who was preparing a survey of North American grizzlies with emphasis on their wide variations. (Grizzlies are notoriously variable in size and color.) Although Merriam knew this, he asserted that MacFarlane's giant, yellow bear was too different---too far off the grizzly baseline.

His detailed morphological studies suggested to Merriam that this was no ordinary Barren Ground grizzly. In fact, he felt that it was not a

Artist's concept of an encounter with MacFarlane's bear!

grizzly bear at all. Neither its hair coloration nor (of much greater taxonomic significance) its skull characteristics seemed consistent with a grizzly. In Merriam's opinion these features were so different that he decided this anomalous bear may be more closely related to the spectacled bear and the extinct giant bear Arctotherium. Consequently he designated it as the type specimen of a totally new species---and genus---of bear, which he chistened Vetularctos inopinatus ("the ancient, unexpected bear"), and formally documented it on February 9, 1918, in the Survey of North American Fauna, No. 41, produced by the U.S. Department of Agriculture's Biology Division. (R1)

Although there were Inuit tales of other bears that resembled MacFarlane's bear, no other acceptable scientific observations or specimens have sufaced in more than 130 years. MacFarlane's bear, therefore, is duly regarded as a freak and certainly not a throwback to any ancient bear species. Of course, it could be an unusual hybrid between a grizzly and a black or, perhaps, a polar bear, both of which have been recorded. (R1, R2)

References

R1. Shuker, Karl P.N.; "Mystery Bears," Fate, 42:30, April 1989. (X1)
R2. Bille, Matthew A.; Rumors of Existence, Blaine, 1995. (X1)

BMU2 The Onza:

An Unrecognized North American Cat?

Description. A large North American cat resembling the puma, but rangier and with longer legs, and with faint stripes on the front wrists.

Data Evaluation. Two skulls, one carefully studied specimen, and a long anecdotal history comprise the main foundation of this catalog entry. As far as we know, onza information is mostly confined to cryptozoological publications. Rating: 1.

Anomaly Evaluation. Mainstream science has taken scant interest in the onza. It looks so much like an aberrant puma that this neglect is understandable. Nevertheless, the single specimen studied is definitely anomalous in its proportions and external appearance. The onza is different, but probably it is, like MacFarlane's bear (BMU1), only a genetic freak or perhaps an unappreciated puma subspecies. Rating: 3.

Possible Explanations. See above.

Entries

X1. Two skulls and a carcass. Modern mammalogists recognize two large cats native to North America: the jaguar and the puma (a.k.a. panther, mountain lion, catamount). The Aztecs, however, were familiar with a third species, a rangy, long-legged cat a bit like a puma---but different. They called it a cuitlamiztli. Modern Mexicans, especially those living in Sinoloa's Sierra Madre region, have named this animal an onza. (R1)

For science to name this purported beast, some physical evidence is required. And, in this century, some intriguing bits have surfaced. First of all, there are two onza skulls available for study, plus a good photograph of a possible onza. The photographed animal had been shot in 1938 by D. and C. Lee, a hunter-brother team. The Lees insisted that their animal was distinctly different from the puma, which they knew very well indeed after having killed almost 500 of them! There was in fact enough information on the onza available in 1961 for R.E. Marshall to produce an entire book entitled The Onza.

The latest chapter in the onza story commenced in January 1986, when information reached J.R. Greenwell, secretary of the International Society of Cryptozoology, that an onza had just been shot in Mexico. Fortunately, the hunter, A. Rodriquez, knew of the onza and the doubts about its existence. He carried the carcass to a nearby ranch, where it was placed on a pickup truck and rushed to Mazatlan and refrigerated for further study. Greenwell was soon on the scene, as were scientists T. Best and N. Gentz. Measurements and dissection commenced.

J.R. Greenwell wrote as follows about the animal's external features:

> The cat, a female, had legs which seemed longer than those of an ordinary puma. At the same time, its body seemed very slender, and also long. The ears also seemed disproportionately long, as did the tail, but we knew without having to say so that these were subjective impressions, and that we would later have to do careful comparative studies.
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> .....
>
> One striking feature we found, not previously reported, was a series of horizonal stripes on the distal ends of the animal's inner forelimbs (the 'wrists'). Although the stripes were relatively modest, they stood out unmistakably against the tan color of the fur. In all my discussions with zoologists---and with Dale Lee---nobody has reported seeing such leg stripes on a puma. (R2)

Greenwell has set down five hypotheses regarding the zoological status of the onza. Based on the information at hand, he favors the second and fourth.

(1) The onza is a new species that is taxonomically close to the puma, perhaps with Pleistocene affinities.
(2) It is a new subspecies of puma.
(3) It is a puma-jaguar hybrid.
(4) The onza is some sort of genetic quirk or mutation found only in Sinoloa.
(5) The studied specimen is only an emaciated puma.

T. Best, one of the scientists who helped measure and dissect the 1986 carcass, believes that even the two extant skulls and the carcass are not sufficient to declare a new species. This caution is well-advised because tissue analysis strongly suggests that the carcass is a puma. But, given the animal's abnormal build and proportions, it is clearly not a "normal" puma.

The onza definitely exists, but whether is a geographical variant of the puma, a new subspecies, or, unlikely it now seems, a new species is undetermined. (R3)

References

R1. Heuvelmans, Bernard; "A Check-list of Apparently Unknown Animals with Which Cryptozoology Is Concerned," Cryptozoology, 5:1, 1986. (X1)
R2. Greenwell, J. Richard; "Is This the Beast the Spaniard Saw in Montezuma's Zoo?" BBC Wildlife, 5:354, 1987. (X1)
R3. Bille, Matthew A.; Rumors of Existence, Blaine, 1995. (X1)

BMU3 De Loys' Ape or Mono Grande

Description. The existence in South America of a very large monkey (mono grande) and/or anthropoid ape, which resembles a spider money in many of its attributes, but is almost twice its size.

Data Evaluation. Besides anecdotal evidence accumulated over the past three centuries, we have a controversial photograph of a dead animal propped up on a crate. The photo may show an animal new to science or it could be an outright fraud. No one can say for certain. The relevant data have been published in a wide spectrum of scientific and popular sources. Manifestly, the data are unsatisfactory. Rating: 3.

Anomaly Evaluation. The confirmation that a new species of monkey exists in South America would be much less of a surprise to zoologists than proof that the animal in question is an ape rather than a monkey. Monkeys, even giant ones, are allowable in South America, but science maintains very firmly that the apes reside only in the Old World. Our anomaly rating is based on the latter possibility, which is the claim of F. de Loys, as expounded below. Rating: 1.

Possible Explanations. De Loys' ape is a fraud perpetrated by de Loys himself. Mono grande is only an aberrant (oversized) spider monkey. (Recall that a very few humans have reached about twice the height of the average human!)

Entries

X0. Introduction. No New World apes are recognized by science. The chimpanzees, gorillas, and the orang-utan are all confined to the Old World. Of course, an abundance of monkeys clamber through the jungles of Central and South America, but even they are distinctly different from the Old World monkeys. Most obvious are the different noses of New World monkeys; their nostrils are well-separated and open to the sides instead of being close-set and opening forward. New World monkeys also count 36 teeth rather than 32. All recognized New World monkeys are rather small, rarely reaching a meter in height. (R6) These points will be useful in the discussion that follows.

X1. Anecdotes and a famous photograph. Early explorers of South America heard many tales from the native peoples about very large monkeys---almost as large as humans---with long tails and all the usual monkey attributes. This purported animal is the mono grande ("big monkey" in Spanish). Laced throughout these stories are claims that the males of this species covet human women. (Similar stories are found in Africa.) (R6) Be that as it may, we must return to less sensational matters; that is, the possible reality of the mono grande. As for the stories and anecdotes, they are not the stuff by which new species are recognized. This situation changed dramatically in 1920 with the click of a camera.

F. de Loys was a Swiss geologist. In 1917, he and 19 men set out into the Sierra de Parijaa, a range of mountains astride the Venezuela-Columbia border. The virgin forest of this region is the home of the unfriendly Motilone Indians and sundry jungle hazards. When de Loys returned to civilization in 1920, he had lost 16 of his men to the Indians, disease, and accidents. He also had a remarkable story to tell and a photograph to back it up. De Loys' experience has been told and retold several times. For this catalog record, we choose a terse version by F.M. Ashley-Montague that appeared in 1929, right after the announcement of de Loys' discovery.

Dr. de Loys, a geologist, was exploring in the neighborhood of the Tarra River, an affluent of the Rio Catatumbo, in the Motilones districts of Venezuela and Columbia, at a bend of a western minor affluent of the Tarra River, when two huge monkeys, one male, the other female, suddenly broke out upon the exploring party, which was then at rest. Owing to the violence of their attitude, the animals had to be received at the point of the rifle. One of the two was instantly shot dead at very close range, the other, which was unfortunately wounded, managed to get away in the thick growth of the jungle and make good its escape.

The dead animal, which was found to be an adult female, was immediately set up on a box and photographed, certain measurements were then taken, the animal was skinned and its bones cleaned. The subsequent hardships encountered by the party on their long and hazardous journey across the forest unfortunately prevented the final preservation of either the skin or the bones.

When measured, the height of the animal was found to be 157 cms (approximately five feet two inches), and its weight was roughly estimated to be somewhat over eight stone (say 115 pounds). The body, which was entirely covered with a thick coat of coarse, long, grayish-brown hair, was, according to Dr. de Loys, entirely devoid of any trace of tail. "The jaw, carefully examined, revealed the presence of thirty-two teeth only, without on the back portion of the mandible, any protuberances hinting at the possibility of a greater number of embryonic molar teeth."

All of these features, "size, absence of tail, number of teeth and ground habits, together with the strongly humanoid aspect of the face and the ruggedness of build," lead Dr. de Loys to believe that this creture is a hitherto unknown anthropoid ape. (R4)

In the light of what science knows about apes and monkeys, de Loys' discovery is highly anomalous. If the animal is an ape, it shouldn't be in South America; if it is a monkey, it is much too large. Doubtless, de Loys himself knew this and, despite the severe trials of the expedition, made an effort to preserve some hard evidence. It is sad that only the photo survived, but in it we could be seeing an primate entirely new to science. But, some scientists see other things, including fraud.

F. de Loys snapped his famous photograph some 80 years ago in South America. The animal resembles a spider monkey, but de Loys claimed its large size, teeth, and lack of tail made it an ape. Apes are unknown in South America

The problem is that the pictured animal looks for all the world like a giant spider monkey: hands, feet, general proportions, even the oversized clitoris so typical of female spider monkeys. However, three important claims deny the spider-monkey interpretation:

(1) The absence of a tail

(2) The 32 teeth instead of the usual 36 in all New World monkeys

(3) The height of 5 feet plus, which is almost double that of a normal spider monkey.

Certainly no tail shows in the photo. Skeptics claim it could have easily been concealed behind the box or even cut off intentionally. The teeth, of course, cannot be counted in the photo. As for apparent size, the only gauge in the photograph is the box under the animal. We can only speculate as to what kind of box it was and how big it was. So, everything really depends upon de Loys' testimony. If, as I. Sanderson (R7) and A. Keith (R3) suspected, de Loys engineered a hoax, it is more than strange that he let his claimed discovery languish for nine years.

Actually, there are some subtleties in the photo that tend to support de Loys' claim. Heuvelmans has pointed out a few of them.

> On the other hand, it is hard to deny that Loys' monkey has a more massive body and thicker limbs than the ordinary spider monkeys. A detail which I do not think has been pointed out is that its thorax seems to be flattened dorso-ventrally, like an anthropoid's---as one can see from its broader shoulders---and it is much longer than a spider-monkey's. Its face is also much more oval. Its hind legs seem to be shorter than its fore-legs, like those of the anthropoids, but this is not enough to put it into a different genus; all of the spider monkeys have a similar tendency. (R6)

Heuvelman concludes it is a new species of spider-monkey. Good photo in his book

In 1991, M. Shoemaker defended de Loys' account by noting that the head of the animal in the photo is quite unlike that of a spider monkey's.

> The most extraordinary characteristics lie in the shape of the head. Spider-monkeys have a distinctly triangular face, with a pronounced prognathism. The creature's face is oval, with its lower half much heavier, and with more powerful jaws, than a spider-monkey's. The creature also has little or no prognathism. (A profile would be needed to know whether its face is as flat as a human's, but it obviously has far less prognathism than a spider-monkey.) Although many New World monkeys tend to have a more prominent forehead than do Old World monkeys, none has a forehead so highly developed as this creature's forehead. (R7)

Thus, the matter rests on de Loys' honesty, a range of debatable features seen in a old photograph and, as we will now demonstrate, upon continuing rumors from the South American jungles hinting at the reality of the mono grande.

In 1990, five Americans traveled to the general area where de Loys snapped his famous picture, Their purposes were to interview the inhabitants and, if possible, turn up more evidence concerning mono grande and/or de Loys' ape. A brief summary of their findings appeared in a 1991 issue of Cryptozoology.

> Zoologists will find it difficult to reach any conclusions from this expedition report. However, we believe that there is a high probability that some form of large, unknown monkey, from 3 to 5 feet (91-152 cm) tall, has been heard and seen by many Indian villagers and townspeople; and tracks have been reported by reliable sources, such as Lorenzo Rodriguez. All of the reports appear to contain the same description: a large monkey, somewhat thin in stature, with long arms, and having reddish hair. (R8)

In terms of evidence, de Loys' ape or mono grande, remains in a scientific limbo much like that occupied by the North American Big Foot or Sasquatch. (BHU1 in Humans III)

Perhaps pertinent to the problem of de Loys' ape is the recent discovery of the complete skeleton of a very large primate in a Brazilian cave. Found in Pleistocene deposits, this primate was about twice the mass of any extant South American primate. In some ways, the skeleton resembles those of both the living spider and howler monkeys. Evidently, primates not too unlike the creature de Loys says he saw and photographed were alive in South America just a few thousand years ago. (R7) Could de Loys' ape have been a "late survivor"?

References

R1. Anonymous; "An Alleged Anthropoid Ape Existing in America," Nature, (no photo) 123:924, 1929. (X1)

R2. Anonymous; "American Ape Reported," Science News-Letter, 15:313, (no photo

with 2d photo of head, enlarged

1929. (X1)
R3. Keith, Arthur; "The Alleged Discovery of an Anthropoid Ape in South America," Man, 29:135, 1929. (X1)
R4. Ashley-Montague, Francis M.; "The Discovery of a New Anthropoid Ape in South America?" Scientific Monthly, (has good photo) 29:275, 1929. (X1)
R5. Tate, G.H.H.; "The 'Ape' That Wasn't," Natural History, 60:289, (poor photo) 1951. (X1)
R6. Heuvelmans, Bernard; On the Track of Unknown Animals, New York, 1958. (X0, X1)
R7. Shoemaker, Michael T.; "The Mystery of the Mono Grande," Strange Magazine, p. 2, no. 7, 1991. (X1)
R8. Miller, Marc E.W., and Miller, Khryztian; "Further Investigation into Loy's 'Ape" in Venezuela," Cryptozoology, 10:66, 1991. (X1)
R7. Hartwig, Walter Carl, et al; "A Complete Skeleton of the Giant South American Primate Protopithecus," Nature, 381:307, 1996. (X1)

BMU4 The Minhocao: A Giant Armadillo?

Description. The existence in South and Central America of earth disturbances that, according to natives, are the work of a monstrous underground animal.

Data Evaluation. In Brazil, especially, and Nicaragua, possibly, native anecdotes and traditions are emphatic that a large subterranean beast is responsible for curious trenches and upheavals of soil. Actual sightings of the rumored animal are very rare and inconsistent. The accounts of the "physical traces" all predate 1878. Several of these were printed in respected science journals. It will be obvious to the reader, that no modern journal would countenance such material. But, given the number and internal consistency of the stories, anomalists are loath to discard completely such curious lore. Rating: 3½.

Anomaly Evaluation. Many underground mammals that disturb the surface are recognized by zoologists---and gardeners as well---but they are very small. In fact, they are much too small to wreak the geological havoc described below. A truly giant animal would be required. Zoologists and even the most radical cryptozoologists would be surprised if such a giant were to be found tunneling in the Brazilian outback. Sheer size, though, does not make an anomaly. Large mammals new to science are being discovered every year in places where zoologists assured us they none lived. In this light, a new large underground animal would be shocking but would not endanger any fundamental biological paradigms. Rating: 2.

Possible Explanations. Most likely, the minhocao is fabulous; least likely, it is a late-surviving glyptodon or giant armadillo.

Similar and Related Phenomena. Giant ground sloths still surviving in South America (BMD11).

Entries

X1. Earth upheavals and anecdotes. Cryptic animals usually owe their existences to fleeting sightings, enigmatic tracks, perhaps even roarings in the night. In the case of the South American minhocao, the great bulk of the evidence is in the form of disturbed earth. The purported minhocao, you see, is an underground creature---and a giant one at that. The descriptions of the geological havoc wrought by the minhocao are truly fantastic. Nevertheless, these tales are so ingrained in Brazilian lore that we decided to give the minhocao a place in this catalog rather than cast it aside like we did the mermaids and unicorns.

The appellation "minhocao" signifies "earthworm" in Portugese. Certainly the earth-moving feats ascribed to this animal might have been perpetrated by a giant earthworm---if such a creature exists. (R1) In fact, the few Brazilians who claimed to have seen the minhocoa described a worm-like creature covered with armor 50 meters long! Other sightings tell of a much smaller creature with a pig-like snout. Obviously, these tales, all vague and well over a century old, are of little help in identifying the minhocao---assuming its reality. More interesting are the descriptions of the palpable earth upheavals ascribed to the minhoaco. Can modern cryptozoologists make anything out of these?

The minhocao has survived as a target of the crytozoologists in at least two well-known anthologies compiled by B. Heuvelmans (R4) and D. Cohen (R5). These accounts rely heavily upon a collection of anecdotes by a Brazilian, F. Muller, who communicated them to the editor of Nature, who duly printed some of them in a 1878 issue of this preeminent scientific journal. From Muller's stories, we select two that seem to display a bit more substance and objectivity, qualities which are scarce in the minhocao saga.

> About fourteen years ago, in the month of January, Antonio Jose Branco, having been absent with his whole family eight days from his house, which was situated on one of the tributaries of the Rio dos Cachorros, ten kilometres from Curitibanos, on returning home found the road undermined, heaps of earth being thrown up, and large trenches made. These trenches commenced at the source of a brook, and followed its windings; terminating ultimately in a morass after a course of from 700 to 1,000 metres. The breadth of the trenches was said to be about three metres. Since that period the brook has flowed in the trench made by the "Minhocao." The path of the animal lay generally beneath the surface of the earth under the bed of the stream; several pine trees had been rooted up by its passage. One of the trees from which the Minhocao in passing had torn off the bark and part of the wood, was said to be still standing and visible last year. Hundreds of people from Curitibanos and other places had come to see the devastation caused by the Minhocao, and supposed the animal to be still living in the marshy pool, the waters of which appeared at certain times to be suddenly and strangely troubled. Indeed on still nights a rumbling sound like distant thunder and a slight movement of the earth was sensible in the neighbouring dwellings.
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> .....
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> In the neighbourhood of the Rio dos Papagaios, in the province of Parana, one evening in 1849 after a long course of rainy weather, a sound was heard in the house of a certain Joao de Deos, as if rain were again falling in a wood hard by, but on looking out, the heavens were seen to be bright with stars. On the following morning, it was discovered that a large piece of land on the further side of a small hill had been entirely undermined, and was traversed by deep trenches which led toward a bare open plateau covered with stones, or what is called in this district a "legeado." At this spot heaps of clay turned up out of the the earth marked the onward course of the animal from the legeado into the bed of a stream running into the Papagaios. Three years after this place was visited by Senhor Lebino Jose dos Santos, a wealthy proprietor, now resident near Curitibanos. He saw the ground still upturned, the mounds of clay on the rocky plateau, and the remains of the moved earth

in the rocky bed of the brook quite plainly, and came to the conclusion that it must have been the work of two animals, the size of which must have been two to three metres in breadth. (R2)

These "physical traces" hardly seem the work of a giant earthworm; a giant mole, perhaps? The writer in Nature ventured that giant armadillos had been abundant in past geological epochs and might still survive. In fact, he speculated even further:

> May there still not exist a larger representative of the same or nearly allied genus, or, if the suggestion be not too bold, even a last descendent of the Glyptodonts? (R2)

Glyptodonts still surviving? Refer back to BMD11, where we find stories, not too dissimilar to those above, relating to the possible continued survival of the giant ground sloth in the same part of the world.

Muller's collection of Minhocao tales inspired S. Baird, of the Smithsonian Institution, to submit to Nature additional testimony about an animal with similar subterranean habits, but existing in Nicaragua rather than Brazil. (R3)

In the end, the minhocao seems to be an underground UFO. Something did happen; there were witnesses; accounts were submitted to the scientific community. At least the Nature of 1878 recorded them for us to wonder about, be amused by, and reject!

References

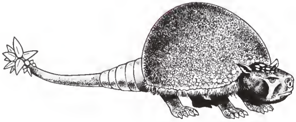
R1. de Saint Hilaire, Auguste; "On the Minhocao of the Goyanes," American Journal of Science, 2:4:130, 1847. (X1)

R2. Anonymous; "A New Underground Monster," Nature, 17:325, 1878. (X1)

R3. Anonymous; "Underground Monsters," Nature, 18:389, 1878. (X1)

R4. Heuvelmans, Bernard; On the Track of Unknown Animals, New York, 1958. (X1)

R5. Cohen, Daniel; The Encyclopedia of Monsters, New York, 1982. (X1)



Some have suggested that the putative minhocao might be a late-surviving glyptodont, as sketched above.

BMU5 The King Cheetah: Evolution in Progress?

Description. The occasional, but persistent, appearance of an aberrant form of the common cheetah that is larger, with stripes or bars rather than spots, and possessing thicker, silkier hair. This animal is called a "king cheetah."

Data Evaluation. Many skins and observations have accumulated since the 1920s when the king cheetah was first noticed. The existence of this animal is well-documented. (R3) Rating: 1.

Anomaly Evaluation. Aberrant individuals appear once in a while in all animal species, but the persistence of the king cheetah, even in normal cheetah litters, implies the presence of mutations that are not deleterious but possibly advantageous. In this interpretation, we see evolution operating as advertised in the prevailing paradigm. Therefore, no anomaly can be claimed, although evolutionists have not detailed how the cheetah genome changes to simultaneously alter, using random mutations, the animal's size, markings, and hair structure. Rating: 4.

Possible Explanations. None required at the superficial level of the standard evolutionary paradigm.

Similar and Related Phenomena. Evolutionary modifications that allow species to occupy new niches are seen in Darwin's finches and the peppered moth.

Entries

X1. General observations. The sleek cheetah is a favorite of wildlife photographers. The normal animal is fast, lanky, and wears an attractive spotted coat. Cheetahs also display little diversity, either in their genetic makeup or external appearance. It comes a bit of a surprise to find records of deviant cheetahs. First, "wooly" cheetahs with pale coats adorned with brown splotches are known. (R4) Second, a remarkable variety with a silky coat and bar-like markings keeps cropping up in the cheetah population. This latter variety---called the "king cheetah"---seems to be due to a trait passed along through the males. In the eyes of some zoologists, the king cheetah is a new race in the making, an experimental thrust of evolution! The evolutionary rationale is that the historical range of the cheetah, the African plains, is shrinking. The king cheetah is thought to be more appropriately marked and configured for a forested habitat. Evolution is conveniently supplying the species with a variant that can more readily prosper in forested refuges. (R2, R4)

The king cheetah story actually began in the 1920s. Interestingly enough, no earlier king cheetah records seem to exist. Was it because the human hand had not yet significantly altered the African environment? As is often the case, B. Heuvelmans has this early history well in hand.

> ...one day in 1926 Major A.L. Cooper saw a most unusual cat-like beast near Salisbury in Southern Rhodesia and immediately shot it. It proved to be a strange animal very like a cheetah but covered with fur as thick as a snow-leopard's and marked with spots which ran together to form stripes. Cooper was puzzled by the beast and wrote to the Field (October 1926) suggesting that it might be a cross between a leopard and a cheetah. Then other specimens were obtained; they all had non-retractile claws---a feature peculiar to the cheetah---and there was now no doubt that they belonged to a new variety of cheetah distinct from the one species, Acinonyx jubatus, found in both Africa and Asia. R.I. Pocock, the famous British zoologist, bap-

The "king cheetah" is not only larger than the normal cheetah but is also characterized by its stripe-like markings and thicker, silkier hair.

tised it Acinonyx rex---or, in plain English, king cheetah---remarking that it was "most extraordinary that so large and distinct a species should remain for so long unknown." (R1)

The king cheetah did not keep its full-species designation long. Many considered it only an aberrant form of the species. When king cheetahs were found in the litters of normal cheetahs, its taxonomic status collapsed. Walker's Mammals of the World now describes the king cheetah as a mere variant of the ordinary, wildlife-film cheetah. (R3)

Perhaps king cheetahs should not be be ignored so facilely as simple "variants." Supporting this view is M.A. Bille's discussion of P. and L. Bottriel's expedition to Botswana aimed specifically at elucidating the status of the king cheetah. After examining every known king cheetah pelt, the Bottriels claimed that the king cheetahs are always larger than the normal animal, and that their longer, silkier hair is markedly different from normal cheetah hair, being more like leopard's hair. Furthermore, no intermediate forms are known. The king cheetah is almost a macromutation, with size, hair, and external appearance changing in step and in a quantized manner. The Bottriels favored the hypothesis that the king cheetahs would have survival advantages in a forested habitat and were, in effect, Nature's answer to the shrinking plains environment. (R4) Most king cheetahs have, in fact, been found in forested habitats. (R3)

References

R1. Heuvelmans, Bernard; On the Track of Unknown Animals, New York, 1958. (X1)

R2. Heuvelmans, Bernard; "Annotated Checklist of Apparently Unknown Animals with Which Cryptozoology Is Concerned," Cryptozoology, 5:1, 1986. (X1)

R3. Nowak, Ronald M.; Walker's Mammals of the World, Baltimore, 1991. (X1)

R4. Bille, Matthew A.; Rumors of Existence, Blaine, 1995. (X1)

BMU6 The Spotted Lion or Marozi

Description. The existence of a small, spotted lion in several mountainous regions of Africa, particularly Kenya, where is is called the "marozi."

Data Evaluation. Several sightings of the marozi have been recorded in the cryptozoological literature. A skull and a skin are housed in a natural history museum in Britain. So far, though, our search of the mainstream scientific literature has yielded nothing. Rating: 2.

Anomaly Evaluation. If the marozi is only an aberrant lion or a leopard-lion hybrid, there is no anomaly. If it is a new subspecies of lion adapted to life in the mountain forests, we have still another example of conventional microevolution in operation. No anomaly exists here either. Rating: 4.

Possible Explanations. None required.

Similar and Related Phenomena. The king cheetah (BMU5), which occupies a similar uncertain status.

Entries

X1. A skin, a skull, and many anecdotes. Best known from the mountains of Kenya, the marozi is distinctly smaller than the lion of the African plains. It is also dappled with gray-brown spots that are more like the rosettes of the jaguar than the spots evident on juvenile lions. In any event, those juvenile spots soon fade away on the plains lions, but on the marozi they are permanent. The male marozi has virtually no mane to show off, but this is not a diagnostic feature since some ordinary male lions are sometimes nearly devoid of mane. To sum up, the three key external characteristics of the purported marozi are: (1) small size; (2) permanent spots; and (3) restriction to a mountainous habitat. (R1, R3) No forms intermediate between the marozi and plains lion have been observed or collected. The animal is thus widespread but occupies a habitat that the plains lions virtually never enter.

The marozi is not restricted to Kenya. Reports have come in from several other mountainous regions of the African continent: Ethiopia, the Cameroons, the Central African Republic, Rwanda, and Uganda. (R2)

Anedotal evidence is profuse. Kenyan game warden R.E. Dent saw four marozi crossing the path in front of him in 1931. Seeing four at once seems to militate against theories that the marozi is merely an aberrant lion or a hybrid of some sort. Dent's sighting was at an altitude of 10,000-11,000 feet; the same altitude where a farmer shot two marozi a short time later. Said farmer, not being a naturalist, was prepared to discard the skins when a Game Department official spotted and rescued them. One skull and a skin are now preserved in the Natural History Museum in Britain. They are the only extant "physical traces" of the marozi. Sightings, though, are much more numerous. Cryptozoologist B. Heuvelmans recounts several in his classic On the Track of Unknown Animals. (R1)

The evidence for the existence of the marozi is not as robust as that for the king cheetah. (BMU5) Most zoologists dismiss the marozi as merely an aberrant lion. In fact, Walker's Mammals of the World does not even mention it as a subspecies or race of Panthera leo, the common lion of the plains.

Nevertheless, the consistency of those three key characteristics---size, spots, habitat---might well be interpreted, as in the case of the king cheetah, in terms of the marozi being a race of the plains lion adapted for making a living in the forested mountains. The spots, for example, would help the marozi blend into the shadowy environment.

A third possibility put forward by Heuvelmans is that the marozi is actually a leopon; that is, a hybrid between a male leopard and a lioness. In the Preface to the 1995 revision of his book (R1), Heuvelmans states that such hybrids were born in a Japanese zoo in 1959, but he gives no information on the characteristics of the hybrids.

In the end, we can say only that the mountains of Africa are probably home to a small, spotted variety of lion. Its taxonomic status is in question, but it seems that the mainstream zoologists could care less.

References

R1. Heuvelmans, Bernard; On the Track of Unknown Animals, New York, 1958. (X1)

R2. Heuvelmans, Bernard; "Annotated Checklist of Apparently Unknown Animals with Which Cryptozoology Is Concerned," Cryptozoology, 5:1, 1986. (X1)

R3. Bille, Matthew A.; Rumors of Existence, Blaine, 1995. (X1)

BMU7 The Mngwa or Nunda

Description. The existence in the jungles of coastal Tanzania of a giant, gray-furred, striped feline of great strength and ferocity. The most frequently used appellations for this beast are "mngwa" and "nunda."

Data Evaluation. Visual observations of the mngwa have been rare and fleeting. Its bloody handiwork was reported often in the early 1900s, but we have seen no modern reports. Apparently, no skins, skeletal material, nor any other physical traces are in the museums. All of our data come from popular magazines and cryptozoological sources. The mngwa is definitely a shadowy, ephemeral creature. Rating: 3.

Anomaly Evaluation. The confirmation of the existence of a giant, striped feline in East Africa, now much more densely populated than when most of our mngwa testimony originated, would certainly greatly surprise scientists, but the news would be anomalous only in the sense that it was unexpected. No biological paradigms would be challenged. Rating: 3.

Possible Explanations. None offered.

Similar and Related Phenomena. Other African mystery felines: the king cheetah (BMU5); and the spotted lion (BMU6). See also the Nandi bear (BMU8).

Entries

X1. Tales of manglings. The mngwa is probably the most feared of all Africa's unknown animals. Even to the natives, who know much more about the continent's wildlife than the whites, the mngwa is a mystery. In fact, the name "mngwa" comes from the Kiswahili "mu-ngwa," which means "strange one." The animal also goes by the name "nunda." (R3)

Whatever one calls it, the mngwa is cat-like in appearance, not bear-like like the Nandi bear (BMU8), with which it is sometimes confused, and it is a giant feline if the old accounts are at all close to the mark.

Most of our mngwa story comes from two articles written more than 50 years ago by an author known only as Fulahn (R1) and a colonel W. Hichens (R2), who was a British colonial officer in Tanzania (then Tanganyika) in the 1930s. (Actually, it was learned that Fulahn and Hichens are one and the same!) We now quote liberally from these two hard-to-get sources, beginning with Fulahn.

> Another mysterious animal---seen, shot at, spoored, but never killed or captured---is the nunda, the giant cat of East Africa's coast. Not long ago a reign of terror gripped a small fishing village of the coast of Tanganyika, where I was stationed as a native magistrate.
>
> It was the custom for native traders to leave their belongings in the village market every night, ready for the morning's trade, and to prevent theft and also to stop stray natives sleeping in the market-place, an askari or native constable took it in turns with two others to guard the market on a four-hour watch.
>
> Going to relieve the midnight watch, an on-coming native constable one night found his comrade missing. After a search he discovered him, terribly mutilated, underneath a stall. The man ran to his European officer, who went with me at once to the market. We found it obvious that the askari had been attacked and killed by some animal---a lion, it seemed.
>
> In the victim's hand was clenched a matted mass of greyish hair, such as would come out of a lion's mane were it grasped and torn in a violent fight. But in many years no lion had been known to come into town.
>
> We were puzzling the problem next morning at the boma when an old Arab Liwali or native governor of the district hurried into our office with two scared-looking men at his heels. Out late the previous night, they said, they had slunk by the market-place lest the askari see them and think them evil-doers; and as they crept by they were horrified to see a giant brindled cat, the great mysterious nunda which is feared in every village on the coast, leap from the shadows of the market and bear the policeman to the ground.
>
> The Liwali, a venerable and educated man, assured us that within his memory the nunda had visited the village several times. It was an animal, not a lion nor a leopard, but a huge cat as big as a donkey and marked like a tabby. I had heard this tale, and had put it down as silly superstition, but the Liwali's assertion put a different light on things.
>
> .....
>
> Followed a month of tragedies at other villages up and down the coast: which sent headmen trekking in to say that a huge, gray, striped animal like a cat, but big as a donkey was seizing men by night. Traps and poison were set, and armed police scoured the district. Then, as suddenly as they had begun, the raids of the nunda stopped. The mysterious beast was never found. (R1)

To Fulahn's account Colonel Hichens adds confirmation in the following paragraph:

> The mngwa, according to the natives in the fishing villages strung along the East African coast, is a giant cat, striped like a tabby, but large as a donkey and far more ferocious and fearsome than any lion. It can be said that such a beast is "impossible"; but, having trekked many a long mile in its reputed haunts and helped patch up more than one of its mangled victims, I am convinced that some beast answering to the mngwa's description does lurk in the dense

jungle which fringes this part of the coast. Patches of this dark jungle-growth have not been trodden by human foot for centuries, as may be judged from the fact that a large town of ruined stone mansions has stood in the bush not an afternoon's car-drive north of Mombasa, for over five hundred years, and was utterly unheard of until rediscovered about four years ago. What other secrets does this jungle-belt hold? The natives swear that it is haunted; and so it may be, by strange beasts. In any event, the mngwa, as a beast distinct from the lion and leopard, has been known to the coastal natives for more than six centuries. (R2)

A bit more specific was a P. Bowen, who, though skeptical about the reality of the Nandi bear (BMU8), was certain that the mngwa did inhabit the jungles of Tanzania's coast. Bowen had ample reason for his conviction, for once after a boy had been carried off by an unknown animal, he had followed its trail. Heuvelmans relates:

> Bowen and another hunter went to the village where the raid had taken place and followed the culprit's tracks. At first he thought it was a lion, but eventually the track crossed some hard wet sand, where the spoor was exceptionally clear, and then there was no doubt that it was not a lion. "The spoor we were following," he told Frank Lane, "appeared to be that of a leopard as large as the largest lion." The beast's hairs, found on the stakes where the mngwa had forced its way into the kraal, were brindled and quite different from a leopard's. (R3)

This is just about all that is known about the mngwa. Native lore and circumstantial evidence are fairly strong, but the zoologists have neither skin nor bones to ponder over.

References

R1. Fulhan; "On the Trail of the Brontosaurus: Encounters with Africa's Mystery Beasts," Chamber's Journal, 7:17:693, 1927. (X1)
R2. Hichens, W.; "African Mystery Beasts," Discovery, 18:369, 1937. (X1)
R3. Heuvelmans, Bernard; On the Track of Unknown Animals, New York, 1958. (X1)
R4. Cohen, Daniel; The Encyclopedia of Monsters, New York, 1982. (X1)

BMU8 The Nandi Bear: Bear-Like But Not a Bear

Description. The existence in East Africa of a ferocious, bear-like mammal which also seems to possess characteristics reminiscent of the ratel (honey badger), the hyena, and the baboon. The most frequently used names for this confusing, rumored animal are: Nandi bear, chemisit, and kerit.

Data Evaluation. Only anecdotes and native traditions are available, and even these are perplexing and inconsistent. One can say only that a mysterious animal something like a bear prowls East Africa, and that the varied accounts do not converge on any single, known species or on any well-defined animal as yet unrecognized by science. No wonder the Nandi bear is absent from the zoological literature and field guides. Rating: 3.

Anomaly Evaluation. The okapi was long believed to be only a native tale, and it is not inconceivable that a well-defined Nandi bear will ultimately emerge and follow the okapi into scientific respectability. Such would be surprising but not anomalous, for no biological laws forbid the discovery of new species---to the contrary, evolution predicts the creation of new species, even large, ferocious ones! Rating: 3.

Possible Explanations. The umbrella appellation "Nandi bear" actually collects many diverse mistaken and unexplained observations of known African mammals. In this view, the Nandi bear does not really exist as a definable species.

Similar and Related Phenomena. The mngwa (BHU7).

Entries

X1. Many stories but no specimens. Zoologists insist that no bears live in Africa today. Nevertheless, for at least a century, stories of a ferocious, bear-like animal have filtered out of East Africa. The natives of that region are terrified of this purported beast, but few whites have seen it. B. Heuvelmans, in his On the Track of Unknown Animals, devotes all of 41 pages to this creature that, according to long-held tradition, emits hideous cries and has a taste for the brains of its victims.

Already we are suspicious, given such sensationalism. This supposed ani- has many names. Chief among these is "Nandi bear" after the region where many of the reports originate. The names "chemisit" and "kerit" are also in common usage, but there are many others. In fact, the Nandi bear does not have a precise description. To make things worse, several well-known African mammals might well be misidentified as a Nandi bear if they happened to be larger than normal and the night was dark. In his 41 pages on the Nandi bear, Heuvelmans uses most of the space trying to match the Nandi bear profile, vague as it is, to exceptionally large ratels (honey badgers), giant baboons, and other animals.

Here, we shall concentrate upon the data, such as they are. From several accounts by Europeans who have either seen an animal thought to be a Nandi bear or who have lived long in Nandi bear country, we choose two. First, we reproduce a rather generalized sketch of the Nandi bear written by Captain W. Hichens, who was in the British Intelligence and Administrative Service of East Africa in the early 1900s.

> The kerit is another monster which, in some form or other, unquestionably exists and remains to be discovered. It is sufficiently notorious under the name, "The Nandi bear." On the Kenya coast the natives call it the dubu, the Lumbwa, up-country, call it the getet, and the mere mention of it evokes cries of horror throughout the East African kraals as far west as Ruanda, where it is known as the ikimizi and, elsewhere, as the kibambangue. It would be stupid to assert that this widespread native belief in the kerit is mere baseless superstition. The kerit is the author of numerous raids of the most frightful description. I have heard it described as a beast, half-man half-gorilla, breathing fire, with one flaring eye in the centre of its head, and emitting a fearful yowling howl. That is the kerit as terror sees it. But as to the howl I can testify, having heard it and having shared the experience of many other white men in hunting the monster. Though it does not always howl, it always attacks under of cover of dark, moonless nights and with the swiftness and ferocity of a veritable devil. It is certainly not a lion or a leopard. The kerit will plunge into the thick of a six-foot thorn zareba (a "wall" of piled spiked and hooked thorn-scrub), whereas lions and leopards

> are very chary of tackling such a defence, the tangled thorns in which painfully lacerate their tender pads and muzzles. I have known man-eating and cattle-snatching lions to leap over zarebas; but I have yet to hear of a lion boring through one as the kerit does, like a mole through the earth.
>
> Again, the kerit's spoor is nothing like a lion's or leopard's pad. Opinions vary upon it, but there is a body of evidence that this astonishing beast leaves a pug-mark with six pads and six claws showing on each paw. I was assured of that as long ago as 1912, and since then, with other hunters, have seen this unbelievable spoor at more than one kraal where the kerit has raided. Many white hunters have actually seen and shot at what has been thought to be a kerit. One of the best accounts is that of Major Braithwaite and Mr. C. Kenneth Archer, two well-known Kenya colonists, whose experience and word are not lightly to be imputed in such matters. They saw the animal in grass and scrub and took it for a lioness; later, a side-view of its head gave the impression of a snout, the head being very large, while the beast stood very high forward, 4 ft. 3 ins. to 4 ft. 6 ins. at the shoulder. "The back," they say, "sloped steeply to the hindquarters and the animal moved with a shambling gait which can best be compared with the shuffling of a bear. The coat was thick and dark brown in colour. Finally, the beast broke into a shambling trot and made for a belt of trees near the river, where it was lost." Many other observers have given similar accounts of the kerit. (R3)

In the above, we see both the sloping back of the hyena and the shambling movements of the bear. No wonder there is much confusion about the kerit or Nandi bear.

Our second quotation is by G. Williams, who had participated in an expedition to the Nandi district around the turn of the century.

> Several years ago I was travelling with a cousin on the Uasingishu just after the Nandi expedition, and, of course, long before there was any settlement up there. We had been camping on the edge of the Escarpment near the Mataye and were marching towards the Sirgoit Rock when we saw the beast. There was a thick mist, and my cousin and I were walking on ahead of the safari with one boy when, just as we drew near to the slopes of the hill, the mist cleared away suddenly and my cousin called out 'What is that?' Looking in the direction to which he pointed I saw a large animal sitting up on its haunches not more than 30 yards away. Its attitude was just that of a bear at the 'Zoo' asking for buns, and I should say it must have been nearly 5 feet high. It is extremely hard to estimate height in a case of this kind; but it seemed to both of us that it was very nearly, if not quite, as tall as we were. Before we had time to do anything it dropped forward and shambled away toward the Sirgoit with what my cousin always describes as a sort of sideways canter. The grass had all been burnt off some weeks earlier and so the animal was clearly visible.
>
> I snatched my rifle and took a snapshot at it as it was disappearing among the rocks, and, though I missed it, it stopped and turned its head round to look at us. It is in this position that I see it most clearly in my mind's eye. In size it was, I should say, larger than the bear that lives in the pit at the 'Zoo' and it was quite heavily built. The fore quarters were very thickly furred, as were all four legs, but the hind quarters were comparatively speaking smooth or bare. This distinction was very definite indeed and was the first thing that struck us both. The head was long and pointed and exactly like that of a bear, as indeed was the whole animal. I have not a very clear recollection of the ears beyond the fact that they were small, and the tail, if any, was very small and practically unnoticeable. The colour was dark and left us both with the impression that it was more or less of a brindle, like a wildebeeste, but this may have been the effect of light. (R1)

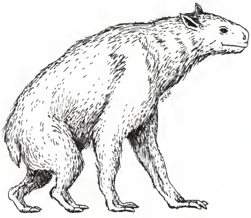
Again, above, we have the bear's shambling gait but this time it is mixed with smooth hindquarters, a feature typical of a baboon. But the baboon has an obvious tail!

As mentioned at the beginning, B. Heuvelmans spent many pages in his cryptozoological opus (R4) attempting to sort out the Nandi bear stories. In a 1986 survey of cryptic animals, he boiled down his recent thoughts on the Nandi bear to a short paragraph.

> An alleged bear of unparalleled ferocity in East Africa (chemisit, ketu, shivuverre, koddoelo, Nandi bear). Reports are often based upon sightings of very large black ratels or honey-badgers (Mellivora capensis), and upon the savage deeds of spotted hyenas of unusual color or size, but probably also, originally, upon encounters with gigantic baboons supposedly extinct (Theropithecus [Simopithecus] sp.) (R6)

One might well conclude from the foregoing quotation that the Nandi bear does not exist as a clear-cut species, but is instead a composite beast concocted from encounters with several well-known African animals. This is an honest, objective conclusion that even the most enthusiastic cryptozoologist must sometimes come to.

One other possibility, even though fairly remote, must be mentioned. C. Williams, of the British National Museum of Natural History, has suggested that the Nandi bear might be a late-surviving Chalicotherium. These horse-sized mammals had the short hind legs, sloping backs, short tails, and vicious claws attributed to the Nandi bear. Unfortunately, the Chalicotherium, although it resembled a giant hyena, was probably a vegetarian. (R4, R5)



The supposedly extinct Chalicotherium possessed the short hind legs and sloping back of the supposed Nandi bear. (R4)

References

R1. Williams, Geoffrey; "An Unknown Animal on the Uasingishu," Journal of the East Africa and Uganda Natural History Society, 2:123, 1912. (X1)

R2. Fulahn; "On the Trail of the Brontosaurus: Encounters with Africa's Mystery Animals," Chamber's Journal, 7:17:693, 1927. (X1) [Fulahn is the pseudonym of W. Hichens according to B. Heuvelmans. (R4)]

R3. Hichens, W.; "African Mystery Beasts," Discovery, 18:369, 1937. (X1)

R4. Heuvelmans, Bernard; On the Track of Unknown Animals, New York, 1958. (X1)

R5. Cohen, Daniel; The Encyclopedia of Monsters, New York, 1982. (X1)

R6. Heuvelmans, Bernard; "Annotated Checklist of Apparently Unknown Animals with Which Cryptozoology Is Concerned," Cryptozoology, 5:1, 1986. (X1)

BMU9 Bunyips and Waitorekes: Errant Seals, Sea Lions and/or Otters?

Description. The existence in Australia and/or New Zealand of unrecognized aquatic mammals resembling seals, sea lions, and otters.

Data Evaluation. The bunyip and waitoreke observations accumulated by the cryptozoologists are of little use to a zoologist. They are vague, inconsistent, and often fanciful. In fact, there are no good observations of either purported mammal by experienced naturalists. Neither are there any skins, skeletons, or other physical traces. All of the information in our hands comes from the cryptozoological literature. We have seen none in the mainstream scientific journals. Rating: 3½.

Anomaly Evaluation. If the bunyip and waitoreke are only wandering seals, sea lions, and/or otters, no anomaly can be claimed. Even if one or the other emerge as a new species of aquatic mammal, there will be nothing anomalous. Zoologists will doubtless be amazed, but none of their paradigms would be at risk. New species of mammals, even large ones, are discovered rather often in the more remote parts of the planet. Rating: 3.

Possible Explanations. Most likely, the bunyip and waitoreke observations, such as they are, are merely misidentifications of errant seals, sea lions, and/or otters.

Similar and Related Phenomena. All other sections in the chapter (BMU) and the corresponding chapter in Humans III (BHU).

Entries

X0. Introduction. From both Australia and New Zealand come accounts, frequently confused and inconsistent, that converge on aquatic mammals that resemble a seal, sea lion, or otter. In Australia, this animal is the "bunyip," in New Zealand, the "waitoreke." These may or may not be the same mammal. They could be two new, hitherto unrecognized species, or both could be misidentified seals, sea lions, and/or otters. Of course, the truth could be somewhere in between those extremes.

X1. The bunyip. The term bunyip means something god-like or spiritual to the Australian aborigines. To modern white Australians, the term is associated with the unexplained, the mysterious, even the satanic. Zoologically speaking, the appellation "bunyip" is applied to a creature or creatures responsible for a wide variety of perplexing and inconsistent observations of unrecognized aquatic animals that are said to ply Australia's billabongs, rivers, and inland lakes from Tasmania to Queensland.

The bunyip's official history began with the arrival of the white colonists and reached a peak in the mid 1800s. There seem to be few, if any, reliable, substantial modern observations. This has led to the assertion that the bunyip is now extinct. An alternate possibility is that the bunyip really never existed as an independent species but only as misidentified animals well known to science.

A representative observation of the bunyip, rare for its lack of sensational claims, was made in April 1872 at the Midgeon Lagoon, 16 miles north of Narandera. J. Michell and R.J.M. Rickard related what was seen.

> A man driving sheep to Melbourne camped by the lagoon, and the next day went to inquire at a nearby house what the animal was that sported boldly in the water. Disbelieving him, the property owner, the drover and two others went to the lagoon and had the luck to see the creature swimming very fast towards them. Apparently spotting them, it stopped within thirty yards of them and lingered for a considerable period before turning and swimming out of sight. It was described as half as long again as a retriever dog, with shining jet black hair which floated in the water about it for perhaps five inches. They could not see its eyes, but it had well-developed ears. (R3)

Combining many such observations and eliminating inconsistencies, C. Anderson, of the Australian Museum, gave a composite sketch of the bunyip.

> ...the bunyip is generally represented as a large furred animal, dog-like in form, and with shining eyes, which progresses by means of fins or flippers and haunts lagoons or billabongs. (R3)

Like it or not, this is about all the reliable knowledge we have on the bunyip. No skin, skeleton, or other physical trace has been collected.

In many encounters, the bunyip looks a lot like a seal, a sea lion, or perhaps an otter, although the latter does not possess fins or flippers. Seals and sea lions are common around southern Australia and often ascend rivers for great distances. They have even become permanent residents in inland lakes elsewhere, as with the Lake Baikal seals. (BMD5) On the other hand, an unrecognized marsupial otter might exist. Its flattened tail could be mistaken for a flipper.

One can readily see from the tenor of the above paragraph that no one really has a handle on the bunyip problem. Of course, the bunyip may be a non-problem---a zoological UFO. It is certainly more poorly defined and elusive than the Himalayan yeti!

X2. The waitoreke. The waitoreke (a Maori word) is another seal-like, sea lion-like, or otter-like mammal, depending on the writer. Reports, many modern, have been concentrated on South Island, especially Lake Ellesmere. B. Heuvelmans quotes F. von Hochstetter, an authority on New Zealand, as follows:

> Besides these names we find the name Waitoreke, which has been only lately clearly defined, having been hitherto applied sometimes to an otter-like, and sometimes to a seal-like animal. According to the reports of Dr. J. Haast, the existence of this animal has been recently established beyond a doubt; it lives in the rivers and lakes in the mountain ranges of the South Island, is the size of a large cony with glossy brown fur, and is probably to be classed with the otters. (R1)

Although this was published in 1867, we know little more about the waitoreke today. As for size, the creature seems to be about the dimensions of an otter---and this is what Heuvelmans believes it to be. P. Costello, in contrast, favors the seal or sea-lion identification.

As in the case of the bunyip, we have only unilluminating anecdotes and pronouncements. There is no physical evidence.

References

R1. Heuvelmans, Bernard; On the Track of Unknown Animals, New York, 1958. (X1, X2)
R2. Costello, Peter; In Search of Lake Monsters, New York, 1974. (X1, X2)
R3. Michell, John, and Rickard, Robert J.M.; Living Wonders, London, 1982. (X1)
R4. Cohen, Daniel; The Encyclopedia of Monsters, New York, 1982. (X1, X2)
R5. Eberhart, George M.; Monsters, New York, 1983. (X1)

BMU10 Steller's Sea Ape

Description. The existence in the extreme northern Pacific of an aquatic mammal that does not resemble any known cetacean, sirenian, or pinniped. Cryptozoologists call it a "sea ape" or "sea monkey."

Data Evaluation. Only a single observation exists, but it was made by an eminent naturalist at close hand over a period of two hours. Given the high reliability and acuteness of the observer, G.W. Steller, his "sea ape" has been embraced by cryptozoologists as an unrecognized sea mammal. Rating: 3.

Anomaly Evaluation. New species of animals, even large ones, are not accorded high anomaly ratings in this catalog because their discovery does not place any scientific paradigms at risk. Rating: 3.

Possible Explanations. A new species or, perhaps, a congenitally deformed seal.

Similar and Related Phenomena. All sections of this chapter (BMU) and those in the chapter on possible late-surviving mammals (BMD10-14).

Entries

X1. A one-and-only observation. This chapter being rather conservative in the matter of cryptozoology, it may surprise the reader that this entry is based entirely on the single observation of a single individual: G.W. Steller, the same Steller who discovered Steller's sea cow. (BMD13. Steller also described accurately and minutely, for the first time, many other animals and plants. Were it not for Steller's renown as an exacting naturalist, we would not include the animal he described below.

G.W. Steller (a German) sailed on the 1741 expedition of V. Bering (a Dane), which was commissioned by Russia's Peter the Great. The expedition's goal was to determine if a land connection existed between Siberia and the New World. It ended disastrously on November 28, 1741, when Bering's ship was wrecked on a desolate island off the Kamchatka Peninsula. Bering died there, and the island was later named for him.

Before the shipwreck, Steller had made many scientific discoveries, all but one of which have been confirmed by later scientists. Steller carefully recorded his findings in his journal; and it is here that we find his "sea ape," the only uncorroborated animal in his journal. R.P. Mackal quoted at length from Steller's journal, and we now reproduce the paragraph pertinent to the first and only sighting of the "sea ape."

> "On August 10 [1741] we saw a very unusual and unknown sea animal, of which I am going to give a brief account since I observed it for two whole hours. ---It was about two Russian ells [about 1.5 meters] in length; the head was like a dog's, with pointed erect ears. From the upper and lower lips on both sides whiskers hung down which made it look almost like a Chinaman. The eyes were large; the body was longish round and thick, tapering gradually towards the tail. The skin seemed thickly covered with hair, of a gray color on the back, but reddish white on the belly; in the water, however, the whole animal appeared entirely reddish and cow-colored. The tail was divided into two fins, of which the upper, as in the case of sharks, was twice as large as the lower. Nothing struck me more surpising than the fact that neither forefeet as in the marine amphibians nor, in their stead, fins were seen. In default of a more detailed description one can do no better than compare the shape of this animal with the picture which Gesner received from a friend and

which he has published under the name of Simia marina danica in his book on animals. At any rate our sea animal deserved this name because of its resemblance to Gesner's sea monkey as well as on account of its wonderful actions, jumps, and gracefulness. For over two hours it swam around our ship, looking, as with admiration, first at the one and then at the other of us. At times it came so near to the ship that it could have been touched with a pole, but as soon as anybody stirred it moved away a little further. It could raise itself one-third of its length out of the water exactly like a man, and sometimes it remained in this position for several minutes. After it had observed us for about half an hour, it shot like an arrow under our vessel and came up again on the other side; shortly after, it dived again and reappeared in the old place; and in this way it dived perhaps thirty times. There drifted by a large American seaweed 3 to 4 fathoms long, club-shaped and hollow at one end like a bottle and gradually tapering at the other, towards which, as soon as it was sighted, the animal darted, seized it in its mouth, and swam with it to the ship, making such motions and monkey tricks that nothing more laughable can be imagined, once in a while biting a piece off and eating it. Having now observed it for quite a while I had a gun loaded and fired at this animal in order to get possession of it for a more accurate description, but the shot missed. Though somewhat frightened it reappeared at once and gradually approached our vessel. However, it went off to sea as a second shot was fired at it without effect or perhaps slightly wounding it and did not appear again. It was seen later, however, several times at different places of the sea." (R1)

All cryptozoologists rely upon the foregoing quotation. One can only speculate, though, on what Steller observed. Was it a new, but never-seen-again species or, perhaps, a congenitally malformed seal? The lack of forefeet or forefins and the asymmetric tail pose the biggest problems in identification. (R1-R4)

Perhaps it is best to let B. Heuvelmans, the generally acknowledged "father of cryptozoology" present his opinion on the "sea ape."

> Could this be the aquatic form of primate alluded to above? Roy P. Mackal suggests that this animal, which sometimes raised itself one-third of its length out of the water (as pinnipeds often do), could be either a northern form of the leopard seal (Hydrurga leptonyx), only known at present from the Antarctic Ocean, or a very young specimen of a surviving zeuglodon (Basilosaurus). The survival of this archeocete [primitive whale] would moreover account for native traditions of a large long-necked sea "monster" called tizheruk on King Island and pal rai yuk on Nunivak Island. The front flippers of both animals could have been held so closely pressed to the body as to pass unnoticed in Steller's specimen. But none of these hypotheses can explain the disturbing shark-like tail of the "sea-ape." (R3)

References

R1. Mackal, Roy P.; Searching for Hidden Animals, Garden City, 1980. (X1)
R2. Cohen, Daniel; The Encyclopedia of Monsters, New York, 1982. (X1)
R3. Heuvelmans, Bernard; "Annotated Checklist of Apparently Unknown Animals with Which Cryptozoology Is Concerned," Cryptozoology, 5:1, 1986. (X1)
R4. Bille, Matthew A.; Rumors of Existence, Blaine, 1995. (X1)

BMU11 Unrecognized Marine Mammals Popularly Characterized as "Sea Serpents"

Description. The existence in the world's oceans of several unrecognized species of very large mammals possessing affinities to the pinnipeds and cetaceans. So large are these purported creatures that they are often called "sea serpents," but those cataloged here are definitely not reptiles.

Data Evaluation. Each of the mammals cataloged below has been seen and reported scores of times. In one case, hundreds of sightings are on record. Some of the reports from the Nineteenth Century did find their way into the scientific literature, but the Twentieth Century scientists have generally rejected the notion that very large marine mammals remain to be discovered. The recent scientific literature, therefore, is mostly mute, even antagonistic, as regards "sea serpents." Thus, modern sightings appear mainly in the so-called Fortean literature and in cryptozoological publications. Some of the latter are formatted like science journals, but they remain excluded by the zoological community. Hoaxes have been unmasked in the field of sea-serpentry, particularly at Loch Ness. Be all this as it may, the sheer volume of reports, many by ship's officers, do suggest that the oceans may still hold some surprises for zoology. Rating: 3.

Anomaly Evaluation. Even proof that a giant mammalian "sea serpent" does in fact swim the world's oceans would not alter the compiler's contention that this creature cannot be rated as anomalous. Biologists might be surprised, but no paradigm prohibits the existence of large marine mammals---look at the whales! More scientifically interesting would be a new marine mammal that is an obvious transitional form between land and marine mammals. But such a discovery would be a strong plus for the evolutionists, for they predict that such forms must now exist or have existed in the past. No anomaly here either; merely curiosity value. Rating: 3.

Possible Explanations. Many sightings, as in ufology, are misidentifications. Some others are hoaxes. But, there will always be a residue of "unexplaineds."

Similar and Related Phenomena. All other sections of this chapter (BMU), particularly Steller's sea cow (BMU10) and the bunyip (BMU9). Unrecognized hominids (BHU in Humans III).

Entries

X0. Introduction. Many of the so-called "sea serpents" are obviously reptiles, fish, or invertebrates, but some of the most common and notorious of the genre are very likely mammals. The Loch Ness Monster is of course foremost among these putative mammals, but there are also Ogopogo, Champ, and a host of other ephemeral aquatic creatures that, if they exist at all, possess mammalian characteristics.

The hundreds of recorded sightings of the Loch Ness Monster place it squarely among the pinnipeds; that is, with the seals and sea lions. Another possible large unrecognized pinniped is the so-called waterhorse or merhorse. It is oceanic in distribution but of lesser renown. In addition, we here catalog three distinct varieties of "sea serpents" that seem to be more closely related to the cetaceans. Given these apparent affinities, our treatment of these mammalian "sea serpents" is appropriately divided into potential pinnipeds (X1) and putative cetaceans (X2). Reptilian sea serpents, of which there are many, are treated in another volume. (BR)

Although most of the mammal guides, such as Walker's Mammals of the World, do not mention "sea serpents" at all, the sea-serpent literature is actually overwhelming in its volume. To illustrate, G.M. Eberhart, in his bibliographic treatment of "monsters" (R4) lists 743 references for fresh-water monsters alone. H.H. Bauer (R5) records hundreds of sightings just in Loch Ness! As with the UFO literature, we find many of these reports not in the major science journals but rather in newspapers, Fortean publications, and cryptozoological works. Happily, cryptozoologists such as B. Heuvelmans (R1) and G. McEvan (R3) have sorted out and distilled this mass of raw and often unreliable data into terse vignettes in their respective books. It is from their summaries that we construct our even-shorter catalog descriptions.

Of course, abundant observations do not prove the reality of sea serpent-like mammals any more than the vast corpus of UFO sightings demonstrates that UFOs are real. Most mainstream scientists ignore sea serpents completely, leaving the field to the cryptozoologists, many of whom do have academic credentials. Many of the sea-serpent books, for example, have been written by scientifically qualified investigators. So, although mammalian sea serpents may not be "scientifically correct," there have enough observations of sufficient quality to impel us to catalog five of the most believable mammalian "sea serpents."

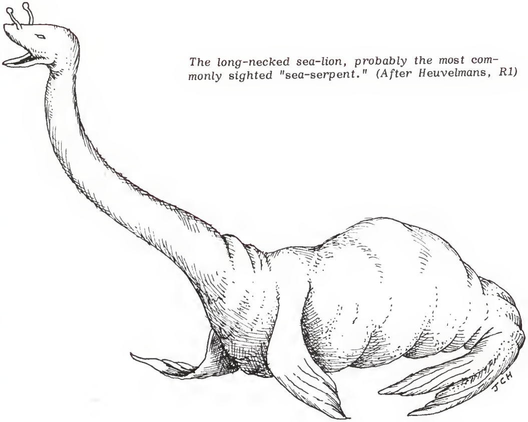
X1. "Sea serpents" that seem to be pinnipeds. The pinnipeds (seals and sea lions) are familiar to everyone. Their dog-like faces and prominent foreflippers identify them immediately. The absence of a dorsal fin and the propulsive tail of the cetaceans help confirm the categorization. Each of the two animals cataloged below has been observed scores, even hundreds, of times---so many times that cryptozoologists have even attached Latin binomials to them. We will add Heuvelmans' Latin designations, but we warn the reader that these do not confer scientific legitimacy.

The long-necked sea lion. (Megalotaria longicollis) Translation: "big sea lion with a long neck." If zoologists accepted this animal, they would term it "cosmopolitan," for it is seen in all of the world's oceans as well as in Loch Ness and other inland waters, particularly those in the Northern Hemisphere. It is speculated that they may have been trapped in waters now land-locked when sea levels fell thousands of years ago. This putative pinniped has even been seen ashore hunching along just like the scientifically acceptable sea lions. It is certainly the most common of all the unrecognized mammalian "sea serpents." If any of them are real, this is the most likely one.

The multitude of sightings available place this giant's length at between 10 and 20 meters---whale-size! The long-necked sea lion swims rapidly and, like other pinnipeds, sometimes leaves a "greasy" wake. In appearance, the animal lives up to its name: a seal-like head bearing small eyes is perched atop a neck that considerably longer than that seen on recognized sea lions. The stout body is wrinkled with a thick layer of fat, much like Steller's sea cow (BMD13) The foreflippers are readily visible. The most unusual feature reported for this creature is a pair of "horns" on the head. These are actually thought to be fleshy protuberances instead of bony structures. Their purpose is unknown.

The many hundred sightings of the much-ridiculed Loch Ness Monster amassed by Heuvelmans (R1) and Bauer (R5) strongly suggest that this controversial creature, if it exists at all, is probably a long-necked sea lion. Nessie doubters, who are legion, dismiss all sightings as misidentified ordinary otters, seals, floating logs, and hoaxes. Unfortunately, there have been many of the latter. (R1, R3)

The waterhorse or merhorse. (Halshippus olaimagni) Translation: the "sea-horse of Olaus Magnus." (R6) The waterhorse is configured like a seal or sea lion, with the usual foreflippers and fat-corrugated body. It is reputed to be even larger than the long-necked sea lion: 12 to 30 meters in length. Its neck, though, is proportionately shorter, and the head is more horse-like than seal-like. The eyes are very large, so

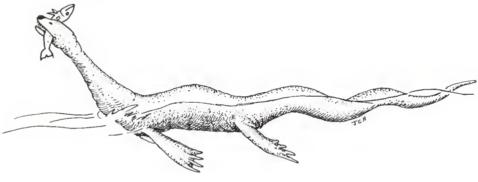


The long-necked sea-lion, probably the most commonly sighted "sea-serpent." (After Heuvelmans, R1)

large that it is speculated that the waterhorse hunts in deep waters where light levels are low. A key field mark is a strange reddish "mane" that makes the animal even more horse-like. This "mane" may be either hair or fleshy filaments; purpose, if any, unknown. The waterhorse swims with marked verticle undulations. It is rarely seen in the open ocean, preferring instead the warmer coastal waters. It is very rare in the Indian Ocean and never seen in polar waters. (R1, R3)

X2. "Sea serpents that are probably related to the cetaceans. Modern whales and dolphins are generally sleek and fast, with blowholes atop their heads, and with two foreflippers instead of the land mammal's four feet. As the fossil record shows (BME1-X4), cetaceans were not always so completely adapted to the marine environment. Some of our unrecognized sea mammals are large enough to be classified as whales, and some possess features such that they might be likened to those land-to-sea transitional forms that evolutionists assure us must have existed at one time. Some certainly appear to be animals still surviving from the distant past, like creatures out of a marine Jurassic Park!

The super-otter. (Hyperhydra egedei) Translation: "Egede's super-otter." (R6) This creature is more serpent-like than the two potential pinnipeds sketched above. It is long, 18 to 30 meters, as long as the largest modern whale. It is unwhale-like in its extreme flexibility, sinuous motion, and pointed tail. When swimming, several "humps" rise like coils out of the water. When it rolls over or raises itself out of the water, two pairs of webbed feet prove beyond doubt that it is not a serpent. Rather, except for its great length, it is more



The super-otter, which may be large enough to warrant the sea-serpent label. (After Heuvelmans, R1)

like an otter. The super-otter's head is small, flattish on top, a little seal-like, with small eyes. The body is uniformly gray, with rough, wrinkled skin. H. Egede, the source of the creature's Latin name, once saw the super-otter expel its breath into extremely cold air. The steamy mist emerged from two nostrils on its snout, not a blowhole on top of the head.

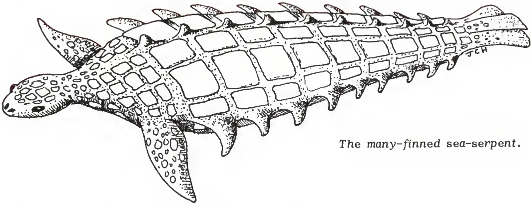
Despite the otter-like feet and lack of blowhole, we catalog this mammal with the whale-like "sea serpents." Size is one reason. In addition, the long, flexible spine is very much like that of the extinct Zeuglodon, one of the ancient whales or Archaeoceti. These primitive whales displayed no external feet, but the super-otter might represent an even more primitive cetacean---an earlier, but still surviving, transitional form between land and sea mammals---a form that has not yet discarded those feet.

The thirty-or-so probable sightings of the super-otter come mainly from Scandanavian waters, where sailors dub it the "sea worm." The super-otter has not been seen since 1848. It may now be extinct. (R1, R3)

The many-humped sea serpent. (Plurigibbosus novaeangliae) Translation: "the many-humped [animal] of New England." (R6) Famous for a large number of well-publicized sightings off the New England coast in the early 1800s, this, the "American sea serpent," is actually well-distributed all across the North Atlantic. Given its great size (15 to 30 meters) and its humps and vertical undulations, the many-humped deserves its sea-serpent appellation. Nevertheless, its tail is horizontal and strongly bilobate, a distinguishing feature of whales. There is also a pair of foreflippers that are easily seen when the animal rears itself out of the water. The many-humped is, therefore, sufficiently whale-like to be placed in this section of the catalog.

The "humps" along the back present a puzzle. They are not serpent-like coils but rather knobby protrusions, something like the bumps along the spine of the sperm whale but much more pronounced. Just like many cetaceans, the many-humped's back is dark, and its underside, white. Some observers report a small dorsal fin just in back of the neck, further heightening its cetacean affinity. Heuvelmans suggests that the many-humped is another primitive cetacean. It does seems much more whale-like than the super-otter which still retains those webbed feet. (R1, R3)

The many-finned sea serpent. (Cetiscolopendra aeliani). Translation: "Aelian's cetacean centipede." (R6) In contrast to the super-otter and many-humped, the many-finned "sea serpent" is a warm-water mammal. The Vietnamese call it the "con rit" or "millipede." Any marine mammal that is compared to an arthropod must indeed be strange! The arthropod allusions are borne out upon closer inspection, which tell of a flattish body covered with segmented, jointed armor, much like that employed by armadillos. (This armor was apparently useful in 1897, when the gunboat Avalanche fired at a many-finned without any appreciable effect!) Improbable

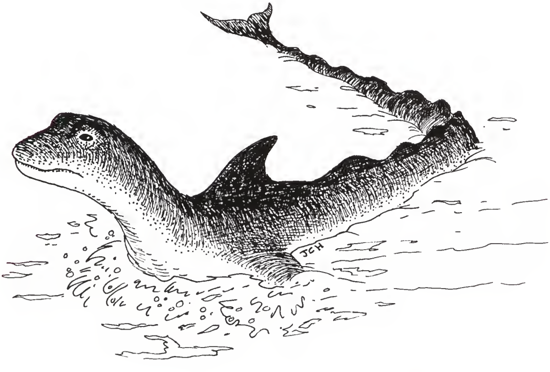


The many-finned sea-serpent.

as the many-finned seems, it remains whale-like, because the ancient whales also carried bony, plate-like armor.

The fleshy fins protruding from the sides of the animal give it its name. They do not seem to be true fins which contain bones to add rigidity. However they are constituted. they could well be useful for stabilization in the water and, when the animal flexes vertically, they could help propel it forward. Again surprisingly, some of the ancient whales are also thought to have had such horizontally-protruding fins.

Less startling is the many-finned's head. It is small, seal-like, with promi-



The many-humped sea-serpent. This is the famous New England sea-serpent of the 1800s. (After Heuvelmans, R1) nent eyes. The neck is short. Those who have watched the creature say that it spouts like a whale but out of nostrils on its snout rather than from a whale's blowhole on top of the head. The tail is short, horizontal, and shaped a bit like that of a lobster. Overall length is 15 to 21 meters, shorter than the super-otter and many-humped, but still in the size range of modern whales. Even so, the sketch does not look much like a whale, a "cetacean centipede," maybe!

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R1. Heuvelmans, Bernard; In the Wake of the Sea-Serpents, New York, 1968. (X1, X2)
R2. Costello, Peter; In Search of Lake Monsters, New York, 1974. (X1)
R3. McEvan, Graham; Sea Serpents, Sailors & Skeptics, London, 1978. (X1, X2)
R4. Eberhart, George M.; Monsters, New York, 1983. (X1)
R5. Bauer, Henry H.; The Enigma of Loch Ness, Urbana, 1986. (X1)
R6. Heuvelmans, Bernard; "Annotated Checklist of Apparently Unknown Animals with Which Cryptozoology Is Concerned," Cryptozoology, 5:1, 1986. (X1, X2)

BMU12 Cetaceans with Two Dorsal Fins

Description. The existence of cetaceans with two dorsal fins. This remarkable additional fin has been seen on both a toothed whale (Odontoceti) and a baleen whale (Mysticeti). Both animals would have to be new species.

Data Evaluation. We have only two substantive observations in our file; and both are over a century old. Their value, however, is greatly enhanced by the fact that they were made by recognized naturalists attending scientific expeditions. Both accounts were duly published in scientific journals of the period. This said, there have been no confirming sightings in modern times. Rating: 3.

Anomaly Evaluation. The presence of single dorsal fins on cetaceans is in itself considered somewhat anomalous. (BMA46 in Mammals I) However, the addition of a second dorsal fin would not seem to challenge evolutionary theory any more than a single fin. To an anomalist, the only significance of a two-finned whale is that a new species has been discovered---hardly anomalous at all in the context of 30 million or so estimated species on earth! Rating: 3.

Possible Exlanations. None required.

Similar and Related Phenomena. All other unrecognized mammals mentioned in this chapter (BMU). The evolution of the dorsal fin (BMA46 in Mammals I).

Entries

X0. Background. A single dorsal fin is characteristic of most cetaceans. Valuable though this dorsal fin may be hydrodynamically, not all dolphins and whales are so endowed. By way of illustration, among the toothed whales, we find the finless dolphin of the Indo-Pacific region and the right whale dolphin. (See BMA46 in Mammals I.) The right whale, a baleen whale and thus only distantly related to the right whale dolphin, also swims sans dorsal fin. Then, there are those cetaceans that substitute a ridge of bumps for the dorsal fin. The sperm whales and the California gray whale represent the toothed and baleen whales, respectively, in this respect.

Such variety encourages the thought that perhaps some cetaceans might possess two or more dorsal fins. After all, fish display a great variety of dorsal fins. But, mammals are not fish, and their dorsal fins are constructed of tissue only. There are no bones to add rigidity like there are in most fish dorsal fins. Embryologically, the two types of fins are quite different. Despite this fundamental difference, two-finned cetaceans have been reported---very rarely---among both toothed and baleen whales.

X1. The toothed whales. The best observation of a toothed whale with two dorsal fins was made by two French naturalists, J.-R. C. Quoy and J.P. Gaimard, who accompanied the 1819 expedition of the vessels Physicienne and Uranie. An excerpt from their report follows:

> In the month of October 1819, in going from Sandwich Islands [Hawaii] to New South Wales [Australia], we saw, by 5°28' N. latitude, many dolphins, performing in troops, round the vessel, their rapid evolutions: everyone on board was as surprised as we were, to see on their front a horn or a fin bent backwards, the same as that on their backs. The volume of the animal was about double that of the common porpoise, and on the upper part of its body, to the dorsal fin, was spotted black and white. (R2)

Quoy and Gaimard christened this apparently new dolphin species Delphinius rhinoceros.

The sight of an entire school of two-finned dolphins assures us that the extra fin was not a deformity or idiosyncracy of an individual animal, but instead was of taxonomic and evolutionary significance.

It is possible that the Italian scientist, A. Mongitore, also saw this possible new species near Sicily in September 1741. (R1-R3) There are no modern sightings that we know of.

X2. The baleen whales. The best report of a two-finned baleen whale came from another Italian naturalist, E.H. Giglioli. Giglioli was sailing on a scientific expedition aboard the Magenta. The vessel was off the South American coast, between Calloa, Peru, and Vaparaiso, Chili, on September 4, 1867. First, Giglioli

The rhinoceros dolphin with its two dorsal fins. (R2) heard a noise. This was followed by a spout of condensed vapor---a whale was obviously close by.

> At the same time, the greenish back of a large cetacean appeared, which, very remarkable a thing, showed two dorsal fins, well developed, erect, triangular, and separated by a large, apparently smooth space...It remained about a quarter of an hour on the side of the Magenta, so that I could estimate exactly enough its length, which should not exceed much, I think, 18 metres, from the tip of the muzzle to the extremity of the tail. The distance between the two dorsal fins was about 2 metres. Its head was not wider than its body, and it became gradually slender to the anterior extremity, but its muzzle was relatively large and blunt; its lower jaw was slightly longer. (R2)

This is the only convincing record of this whale. But Giglioni was able to provide a detailed description as well as a Latin name: Amphiptera pacifica. Here, too, the are no recent sightings of this animal.

References

R1. Heuvelmans, Bernard; In the Wake of the Sea-Serpents, New York, 1968. (X1)

R2. Raynal, Michel; "Do Two-Finned Cetaceans Really Exist?" INFO Journal, no. 70, p. 7, January 1994. INFO = International Fortean Organization. (X1, X2)

R3. Bille, Matthew A.; Rumors of Existence, Blaine, 1995. (X1, X2)

BMX MAMMAL INTERFACE PHENOMENA

Key to Phenomena

BMX0 Introduction

In the short run, the most important interfaces that mammals-in-general have with other species are those with their prey and predators. In the long run, though, it is probably that interface they share with humans that is the most significant, because humans exert such a powerful influence on the terrestrial environment and the life forms occupying it. Most such human-mammal connections are cataloged in BHX in Humans III.

In this chapter, the interest is directed toward unusual associations of mammals with other mammals and nonmammals. Most of these associations are more curious than anomalous, such as woodchucks and foxes occupying the same burrow, and the cooperative hunting of badgers and coyotes. Such associations, while not exactly amicable seem to offer advantages to both species---enough so to call a truce. At the other end of the spectrum, we find a few mammals, like the African rheboks, that are extraordinarily aggressive toward their own kind and innocent bystanders. Finally, when we hear of rats attacking and nibbling on cats, we know we have a curiosity worth recording.

BMX1 Curious Associations of Mammals

Description. Associations of mammals with other species of animals, not necessarily mammals which, to humans at least, seem incongruous. In other words, we do not quite understand why these associations exist.

Data Evaluation. The examples below are drawn from a wide range of sources: scientific journals to popular books. The latter, especially, seem to be tainted with anthropomorphic interpretations. Most observations, however, have been made and verified by experienced naturalists. Rating: 2.

Anomaly Evaluation. To humans, some of the strange associations cataloged here seem to be stupid, at least for one of the species in the association, and therefore contrary to the forces of natural selection, which are supposed to eliminate the unfit. In other associations that appear to be examples of altruism, strict reductionists have to be perplexed because altruism is not generally considered to be a trait present among non-humans. Actually, the core of the problem seems to lie in our incomplete knowledge about the real value of the various associations cataloged here for all of the participants involved. Although the subject associations do have curiosity value, they seem to be only marginally anomalous. Rating: 3.

Possible Explanations. Probably most of these curious associations will turn out to be cases of symbiosis; that is, they are really mutually beneficial to all species involved in ways we do not yet understand. Others may be fortuitous or unintentional and without any biological significance.

Similar and Related Phenomena. Unusual animal cooperation (BMX2).

Entries

X1. Red foxes and woodchucks living together. On occasion, naturalists have observed red foxes and woodchucks (Marmota monax) occupying the same burrow. Since red foxes are known to prey upon woodchucks, particularly young ones, this close association is incongruous to say the least. In fact, carrion at the mouth of one den occupied by both species contained bits of woodchuck pelt, confirming that the resident red foxes had not lost their taste for their unusual den mates.

Excavation of one such two-family den disclosed four separate nesting chambers. Separately, these held: a single male fox pup, an adult female woodchuck suckling four young, another single male fox pup, and a vixen with one male pup. (R1)

X2. Rodents and carnivores living and playing together. The young of the African ground squirrels and the young of the Viveridae family sometimes play together. The Viveridae family includes mongooses and civets, both with a taste for rodents. Nevertheless, these ill-matched mammals may even share the same burrow, according to reliable observers. To be more specific, mongooses, in particular, are known to have African ground squirrels on their menu. (R6)

X3. Coatis grooming tapirs. Interspecific grooming is rare among the mammals, except, of course, for humans and their pets and domesticated mammals. A most unusual case in the wild was reported by K.L. Overall in 1980. J.F. Eisenberg reviewed this puzzling instance.

Overall noted a remarkable association between a tapir and a male coati. Tapirs can become infested with ticks. In the case Overall described, the coati fed on the blood-gorged ticks by gleaning them from the tapir's body. The tapir, however, did not reciprocate. I have noted the same behavior when a tame tapir and peccary were associated at semiliberty in Panama. The peccary "cleaned" the tapir of ticks, but once again the tapir never reciprocated. Peccaries in groups are known to reciprocally groom each other, as do coatis. (R3)

Although unusual, this association is really symbiotic, since each animal gains something.

X4. Baboons warning and feeding bush bucks?

Baboons are the sentinels for the bush buck antelope in Africa. When leopards approach the watering holes where the bush buck drinks, the baboons will leap from tree to tree screaming a loud alarm. The baboons not only warn the bush bucks of impending danger, but also drop treetop leaves and fruits for the ground-locked bush buck to eat. (R4)

Here, one cannot be certain that the baboons are really altruistic. They may actually be warning each other about the leopard without giving a thought to the bush bucks feeding below. The same thought applies to the food they drop. Instead of being altruistic, the baboons may only be sloppy eaters. (See X5.)

X5. Langurs warning and feeding chitals? The Hanuman langurs of Asia are finicky eaters and habitually release a shower of rejected leaves from the trees where they are feeding. Chitals, India's spotted deer, often take advantage of this food from the sky, but one cannot say that the langurs are intentionally feeding the chitals. The two species do, though, seem to work together in detecting stalking tigers and leopards. The langurs have sharp eyesight, while the chitals possess good noses. Both species apparently understand the warning signals of the other. (R5)

Again, it is hard to read intention or symbiosis into this relationship.

X6. The curious dolphin-tuna connection. Scientists and fishermen have long realized that a school of feeding dolphins is often accompanied, far below, by a school of feeding tuna. This association is strong, with the tuna seeming to follow the dolphins wherever they go. The tuna fishermen, understandably, welcome the sight of a school of feeding dolphins and set their nets for the accompanying tuna. Unfortunately, they also unintentionally bag a lot of surface-level dolphins at the same time. (R7)

In the tropical Pacific, the species most frequently associated in this way are the spotted and spinner dolphins, sometimes in mixed schools, feeding below them are schools of yellow tuna and, less often, skipjack tuna. (R2)

This strong dolphin-tuna connection has been the subject of much debate. Although the mammals and fish feed at different levels, K.S. Norris opines that the dolphins are the fish finders, and the tuna just follow along to help with the harvest. (R7) Perhaps the dolphins find the tops of aggregations such as those described next.

X7. Multispecies aggregations. On the African plains, it is not rare to see wildebeest, zebra, and other herbivores feeding peacefully together. In the tropics, a column of army ants is usually accompanied by a wide range of bird species, all waiting to see what the ants flush out. The same sort of collective behavior occurs in the oceans, but the aggregations and the stimuli that engender them are a bit more obscure. K.S. Norris has written about these apparent extrapolations of the dolphin-tuna phenomenon mentioned in X6.

Some intrepid divers who have swum in the open sea report that sharks and schools of dolphins may not swim alone but instead can be parts of much larger retinues that include many kinds and sizes of animals, both above and below the water. Lacking a landscape of forests and mountains to spread them out and provide refuges, the dynamics of their collective lives can clump them in cadres. according to the speed at which the members habitually swim or fly. This clumping happens even though in doing so each animal takes its place in the hierarchy of predation and scavenging. (R7)

In a sense, the open-sea, multispecies aggregations are like a coral reef community without the reef---a floating, drifting ecosystem extending both horizontally and vertically.

References

R1. Merriam, H. Gray; " An Unusual Fox:Woodchuck Relationship," Journal of Mammalogy, 44:115, 1963. (X1)
R2. Leatherwood, Stephen, and Reeves, Randall R.; Whales and Dolphins, San Francisco, 1983. (X6)
R3. Eisenberg, John F.; Mammals of the Neotropics, vol. 1, Chicago, 1989. (X3)
R4. Thomas, Warren D., and Kaufman, Daniel; Dolphin Conferences, Elephant Midwives, and Other Astonishing Facts about Animals, Los Angeles, 1990. (X4)
R5. Editors of Time-Life; Amazing Animals, Alexandria, 1990. (X5)
R6. Nowak, Ronald M.; Walker's Mammals of the World, Baltimore, 1991. (X2)
R7. Norris, Kenneth S.; Dolphin Days, New York, 1991. (X6, X7)

BMX2 Interesting Interspecies Associations Involving Hunting

Description. The association of two distantly related species in a joint endeavor, usually hunting. We hesitate to call the relationships discussed here as "symbiotic" or even "cooperative", because one species may well be merely a tool of the other. Yet, these particular associations seem much more than opportunistic or fortuitous.

Data Evaluation. The associations collected and described below have been observed repeatedly by naturalists, who have duly reported them in journals and books. Rating: 1.

Anomaly Evaluation. Mammal-animal associations involving complex behavior and sophisticated interspecies communication directly challenge the reductionist's position that all animals (besides humans) are merely automatons incapable of thinking and planning ahead. Rating: 1.

Possible Explanations. Interspecies cooperation among animals other than humans is strictly fortuitous and does not involve intelligence or advance planning. Or, opposing the reigning paradigm, animals are intelligent and recognize the value of interspecies associations.

Similar and Related Phenomena. Unusual symbioses and parasitism involving mammals (BMX7 and BMX8, respectively). Human-animal interfaces (BHX in Humans III).

Entries

X1. The coyote-badger "partnership". Coyotes and badgers both make meals out of ground squirrels, prairie dogs, and other burrowing animals. The coyote has a good nose, and the badger is an accomplished excavator. Furthermore. neither can win a fight with the other. Conditions are thus ripe for a hunting partnership. Such joint efforts have been frequently observed and even filmed. However, questions remain: Is it really a fair "partnership"? Does the badger ever profit from this association?

Usually, the badger digs for its prey, while the coyote runs its quarry down above ground. Running down alert prairie dogs and ground squirrels is not easy for a single coyote, and two (sometimes more) will team up and rush a colony together and catch some meals in the general confusion.

There is at least one record where a coyote and a badger cooperated and "double rushed" a prairie-dog town. In the melee, the badger---not a fast runner---managed to run a dog down at a burrow's entrance. It promptly disappeared down the hole with its victim. The coyote got nothing. (R1) In this strategy, the badger can win.

But when nature writers describe the coyote-badger partnership, they refer to a different kind of hunting strategy. In one version, the coyote sniffs out the burrow containing prey, the badger then digs it out, and both share the meal. (R4) This sounds idealistic to anyone who has watched animals! Indeed, another writer tells a different (and more likely) story, one that is more one-sided.

> Much is made of the so-called hunting partnership between the badger and the coyote, in which the badger actually is more of a tool than a partner. Having discovered a badger trying to dig out a ground-burrowing creature, the coyote waits nearby. While the badger is busy digging in from the entrance to the burrow, its intended victim is likely to leave by another exit. As the rodent pops out, the coyote catches it before it reaches safety in another burrow. The trouble with this partnership is that the coyote never shares its catch with the badger. (R2)

The partnership may not be as one-sided as the above quotation suggests. The presence of the coyote above the ground may keep the ground squirrel or prairie dog in the burrow system, giving the badger a better chance to catch it. A recent study of the partnership indicates that both coyote and badger can gain by hunting together. (R3) It is not all opportunistic, yet it is hardly symbiosis. According to a TV documentary viewed in 1996, a very similar relationship exists between the ratel (honey badger) and a species of African kite.

The next partnership on our list is manifestly more symbiotic.

X2. Honeyguides enlist the help of mammals. African honeyguides, especially the greater honeyguide (*Indicator indicator*), as their English and scientific names both suggest, have the interesting trait of cooperating with mammalian honey-gatherers by leading them to bees' nests. It is also asserted, though denied by some naturalists, that the honeyguides will enlist the services of not only humans but also the ratel (honey badger) and perhaps even baboons in their raiding of bees' nests. The honeyguides require help because they cannot open up the nests by themselves in order to get at the larvae and wax. (Unlike most birds, honeyguides can digest the wax.) Humans and any other mammals the honeyguide can entice get the honey. (R5, R6)

So far, only humans, ratels, and baboons have apparently been successfully enticed by the honeyguides. The birds have tried to get mongooses and monkeys to follow them without success. (R6)

The antics and signals of the honeyguide as it solicits help are complex as well as amusing. Apparently, they even signal the direction and the distance of the hive. While the honeyguide has usually located a likely hive before it goes looking for a mammal to help it, human honey gatherers sometimes initiate the hunt by whistling for a honeyguide. The bird then joins the search.

Evidence of this bird's ability to adapt itself to changing conditions is seen in areas where commerical beekeeping has been established. In these places, humans no longer have any interest in following honeyguides, and the birds in turn ignore humans!

Honeyguides are hardly the automatons animal behaviorists would have us believe. Their adaptability as conditions change is remarkable. This is all particularly interesting to the ornithologists because most honeyguides are parasitic. Their young are raised by other species. Young honeyguides learn nothing from their parents about honey and the trick of enlisting other animals in searching for it. (R5)

We have barely touched this interesting problem in animal behavior. This human-honeyguide interface is dealt with in much more detail in BHX5-X2 in Humans III.

X3. Human-dolphin cooperation in fishing. In Brazil and East Africa, humans and dolphins have been fishing cooperatively for centuries. This symbiotic relationship is covered in BHX5-X1 in Humans III.

References

R1. Cahalane, Victor H.; "Badger-Coyote 'Partnerships'." Journal of Mammalogy, 31:354, 1950. (X1)

R2. Rue, Leonard Lee, III; Pictorial Guide to the Mammals of North America, New York, 1967. (X1)

R3. Minta, Steven C., et al; "Hunting Associations between Badgers (Taxidea taxus) and Coyotes (Canis latrans)," Journal of Mammalogy, 73: 814, 1992. (X1)

R4. Nowak, Ronald M.; Walker's Mammals of the World, Baltimore, 1991. (X1, X2)

R5. Wesson, Robert; Beyond Natural Selection, Cambridge, 1991. (X2)

R6. Griffin, Donald R.; Animal Minds, Chicago, 1992. (X2)

BMX3 Mammals Aiding Other Species in Distress

Description. The provision of aid or protection by one species of mammal to another species---not necessarily a mammal---in time of distress.

Data Evaluation. The scientific literature researched so far is mute as regards this claimed phenomenon. We have only one reference from a popular science magazine. Few details are provided. In particular, it is difficult to determine whether the apparent aid provided is intentional of accidental. Rating: 3.

Anomaly Evaluation. Even assuming that the cases presented below represent intention on the part of the dolphins, their aid of pilot whales involves a closely related species (both are "toothed whales"). Both of these cetaceans are highly intelligent and perceptive. Also pertinent is the fact that cetaceans usually show great concern for their kind and will aid injured companions. Furthermore, cetaceans often forage in the company of other closely related species. These facts, tend to reduce the anomalousness of the phenomena at hand. Rating: 3.

Possible Explanations. The phenomenon may be more apparent than real; that is, intent is not involved.

Similar and Related Phenomena. The stranding of cetaceans (BMB-X33 in Mammals I); anomalous altruism in mammals (BMB4 in Mammals I); feral children (BHB26 in Humans I); unusual animal succoring of humans (BHX3 in Humans III).

Entries

X0. Background and cross references. Here, we distinguish between inter-species "cooperation" (BMX2) and inter-species aid in times of distress. In the latter case, there is no question of mutual gain, as in the cooperative hunting of the coyote and badger. We look instead at cases when individuals of one species sees another species in danger or distress and (apparently) tries to help.

In other catalog volumes, we have cataloged several instances where humans have been succored or aided by other species. In BHB26, in Humans I, for example, we cover the subject of feral children, as in claims that human children have been suckled by wolves. In BHX3, in Humans III, we find dolphins protecting human swimmers from sharks. Those cases where domestic animals protect or otherwise aid their human masters are considered too prosaic to mention.

X1. Dolphins aiding other cetaceans. In September 1983, a herd of 80 pilot whales stranded themselves on Tokerau Beach, Northland, New Zealand. Many humans rushed to the beach to try to refloat the whales. And, when the tide had risen sufficiently, they were successful in wrestling 76 of the animals around and into deeper water. However, the whales still seemed navigationally confused. Fortunately, a school of dolphins that had been fishing offshore seemed to come to the aid of the pilot whales.

> Somehow apprehending the situation, the dolphins swam in and began to move around and among the whales. Then, taking their cue from the pilot whales' namesake, they guided the stranded animals to safety. Five years before, in Whangarei harbor, the same behavior was reported: a helicopter followed as common dolphins led a similar-sized herd of whales for several miles. It was clear that the dolphins were indeed leading the herd to safety.
>
> Aside from the obvious question of how the dolphins knew that the whales were in distress and what action was needed, there is also the puzzle of how the dolphins were able to help. One theory to explain strandings is that cetaceans may use a geomagnetic sense---an ability to detect changes in the earth's magnetic field---to determine their position and direction and use their sonar to locate specific features and obstacles. If this is true, then species that inhabit mostly deep water might get confused should geomagnetic navigation lead them close to shore where their sonar returns unfamiliar echoes. Deep-water whales are in fact statistically more likely to beach themselves than coastal ones.

The dolphins, then, familiar with the configuration of the sea floor near the land, would have had the specialized knowledge necessary to find their way---and show the way---to deeper water. (R1)

The above explanation is attractive, but even if true, we still do not know if the dolphins' action was intentional. They could have just beem curious and then returned to their usual haunts, with the pilot whales as unintended followers. It is easy to read anthropomorphic interpretations into such incidents.

Reference

R1. Anonymous; "Dolphin Pilots," Oceans, 17:50, 1984. (X1)

BMX4 Mammalian Mutualisms of More than Usual Interest

Description. The close, permanent association of a mammal with another species resulting in mutual benefit. Only a few of the many examples of mutualism observable in nature are cataloged here. Our selection criteria favor: (1) mutualisms that involve substantial morphological and/or behavioral adaptations of the species involved; and (2) mutualisms involving mammals and a wide spectrum of other life forms, particularly those that are very distantly related. Mutualisms differ from the looser associations cataloged in BMX1-3 mainly in the closeness and the permanent nature of mutualism.

Data Evaluation. The phenomenon at hand is widespread and fully accepted by mainstream science. The scientific literature devoted to mutualism is extensive. Here, we employ only a few references selected from many. Rating: 1.

Anomaly Evaluation. In those many instances where mutualism is not accompanied by special morphological adaptations, as with wart hogs and oxpeckers (X4), the prevailing evolutionary paradigm probably suffices. Elsewhere, though, as with the algae living in the specially grooved hairs of sloths (X2), anomalists must ask if evolution can properly account for one species evolving jointly with another to achieve situations that improve the fitness of both. Evolutionists apply the term "coevolution" to this phenomenon. In coevolution, both species accumulate random, favorable mutations which, with the help of natural selection, achieve the end result. This kind of explanation cannot, of course, be refuted; but it is doubly suspect here, because two different species are involved. Complicating the picture is the observation that often the adaptations are one-sided. (X1) Even so, in principle, the evolutionary paradigm can account for all observations. We never assign anomaly ratings in situations like this.

Possible Explanations. Although random mutation and natural selection can theoretically account for mutualisms, adapations may be accelerated by so-called "adaptive evolution," a process still without an accepted mechanism.

Similar and Related Phenomena. Human-symbiont relationships (BHX6 in Humans III); the greening of sloths (BMA15 in Mammals I); possible whale-barnacle symbiosis (BMO10-X2); other sections of this chapter.

Entries

X0. Introduction. Mutualism is a type of symbiosis in which two different species live together in a close and permanent association that provides benefits for both. In mutualism, one or both of the species often displays morphological and/or behavioral changes that enhance the value of the arrangement.

Presented below are a selection of some of the more interesting mutualisms involving mammals and a wide range of other life forms.

X1. Mammals and microorganisms. The stomachs of ruminants usually harbor bacteria that help break down plant cellulose for further digestion. In this classic example of mutualism, the bacteria help the mammal make more efficient use of food, and the bacteria have a perpetual source of food. (R1)

What is particularly fascinating here is the licking behavior of the mother cow that ensures that her calf will ingest the bacteria so vital to its future existence. (R4) In some other species of mammals, these vital bacteria are transferred by feeding feces to the young. The mammals, of course, are promoting not only their own welfare through such behavior but also the welfare of the bacteria.

In connection with the cow-calf example, L. Margulis and R. Fester write about the evolutionary significance of this sort of symbiosis.

> Neo-Darwinian evolutionary theorists claim that "individuals" behave to increase their inclusive fitness, the number of offspring left by them and relatives that share their genes. Analysts of symbioses retort that no individuals exist---with the exception of the unstudiable single bacterium. In spite of sociobiological dicta to the contrary, organisms behave to increase the fitness of symbionts with which they have very few genes in common.....The "standard" neo-Darwinian evolutionary theory claims that cows evolved by "gradual accumulation of favorable mutations" while it ignores the cellulytic activities of cow symbionts. The standard textbooks on evolution catechize all species and higher taxa (genera, families, phyla) as having evolved in the same way; by gradual accumulation of favorable mutations. Yet not a single example of the origin of such lower taxa (species) exists in the literature. Rather, the highest taxa (kingdoms and phyla) have evolved by acquisition of symbionts that have become hereditary. (R4)

This quotation also appears in BHX6 in Humans III, but it worth repeating in the present context.

X2. Mammals and plants.

Bats and plants. Some plants blossom only at night and are thereby specially adapted for pollination by bats. In fact, some plants have additional strategies that improve the efficiency of pollen transfer from plant-to-bat and, later, from bat-to-plant.

> "Chiropterophily" (literally, "bat loving") is the name given to the syndrome of bat-pollinated flowers. Chiropterophilous plants have flowers that open at night and are pale or reddish in color, and strong smelling. In many species, the odor resembles that of fermenting fruit. In plants

such as agave, the flowers may remain open for several nights, while the flowers of others such as baobab trees and African sausage trees are open for just one night. The flowers on bat-pollinated plants are easily accessible to a flying bat. In plants such as India trumpet-flower trees, the flowers are borne on long stalks that protrude well beyond the canopy of the tree. In African sausage trees, the flower stalks hang down below the canopy. (R5)

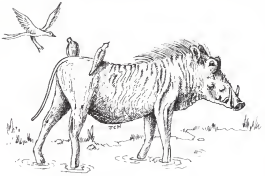
In these several ways, the plants make their pollen more readily available to night-flying bats. Of course, the bats are doubtless pleased to have their food more easily accessed.

Sloths and algae. The curious symbiosis existing between sloths and algae is detailed in BMA15, in Mammals 1. In this example of mutualism, the algae acquire a substrate of specially designed hairs upon which to grow. The sloth gets a camouflage job, plus, some contend, a ready-made source of plant food. J.F. Eisenberg remarks that moths also attend this sloth-agla assemblage. It is not known if additional symbiosis is involved.

X3. Mammals and crustaceans. A certain species of barnacle attaches itself to humpback whales and may help this mammal echolocate by producing clicks. This helps the humpbacks and, of course, the barnacles themselves have a moving substrate in a plankton-rich sea. See BMO10-X2, where the remarkable physical modifications made by both whale and barnacle are described. (R3)

X4. Mammals and birds. In her masterful survey of biology, H. Curtis has a photograph of two oxpeckers resting on the back of a wart hog. She employs this association as an example of mutualism.

Oxpeckers live on the ticks they remove from their hosts. An oxpecker forms an association with one particular animal, such as the wart hog shown here, conducting most of its activities, including courtship and mating, on the back of its host. (R1)



Oxpeckers also "adopt" other large African mammals. The birds have the ticks and other insects stirred up by their hosts, and the mammals get parasites removed. No special morphological adaptations seem to be required. The two species simply tolerate one another, like fish at a cleaning station. This sort of mutualism, however, is much stronger and more permanent than the occasional grooming of tapirs by coatis (BMX1-X3). See also the honeyguide-badger association (BMX2-X2).

References

R1. Curtis, Helena; Biology, New York, 1979. (X1, X4)
R2. Eisenberg, John F.; Mammals of the Neotropics, vol. 1, Chicago, 1984. (X2)
R3. Dyer, Betsey Dexter; "Symbiosis and Organismal Boundaries," American Zoologist, 29:1085, 1989. (X3)
R4. Margulis, Lynn, and Fester, Renee; Symbiosis as a Source of Evolutionary Innovation, Cambridge, 1991. (X1)
R5. Fenton, M. Brock; Bats, New York, 1992. (X2)

BMX5 Do Predatory Mammals Kill the Unfit?

Description. The failure of predatory mammals to remove "unfit" animals from prey populations and thus improve the fitness of prey species.

Data Evaluation. The specific anecdotes presented below come from a creationist journal and are backed by full references to mainstream scientific journals. Additional support for the claimed phenomenon comes from a detailed paper in a prestigious biology journal. Rating: 2.

Anomaly Evaluation. Evolutionists usually assert that predation is an important facet of natural selection. Predation supposedly removes the sick, the weak, the old, and the less capable animals from a population and thereby improves the species' gene pool. Field data contradicting this position are highly anomalous. Rating: 1.

Possible Explanations. If predators instinctively prefer healthy, vigorous prey, this predilection would actually seem to support the evolutionary paradigm in one sense. Predators that eschew sick and parasitized animals are more apt to remain healthy, thereby improving their species.

Similar and Related Phenomena. See the Series-B catalog Subject Indexes under: Evolution, Natural selection.

Entries

X0. Introduction. A cornerstone of evolutionary theory states that the species are rendered increasingly fit because predators eliminate the sick, the weak, and the unfit. In this way, the gene pool of each species is constantly improved by "natural selection." Mammals are frequently important predators in some ecosystems (particularly those seen in television documentaries), and it is worthwhile inquiring whether their predation actually does weed out the less fit.

Although we do provide some anecdotes, the main thrust of this section is to be found in the overviews. (X4)

X1. Predators often single out healthy prey.

Wolves and cattle. In the spring of 1972, R. McBridge, a professional predator-trapper, was attempting to capture a wolf that was killing cattle in Durango, Mexico.

The wolf was killing weaning-sized steers and heifers of the 300-500 pound size. The ranchers weaned all the calves at the same time; and many in the herd were young, weak and in poor health. These weak steers tired quickly and could be easily thrown by one cowboy. Of the 96 steers and heifers reportedly killed by the wolf, McBride personally examined 55 kills before capturing the wolf. Without exception the wolf was "selecting" the top healthy animals in spite of the abundance of weak prey. The young weak calves remained unharmed. (R2)

X2. Predators avoid the sick and weak. Basically, this is the same as the phenomenon brought forward in X1!

Mountain lions and mule deer. McBride also recounted a case where four mule deer does were staying together on a hill near the Mexican border. Over a period of 90 days, a female mountain lion killed the three healthy deer in this group, leaving only the one that was afflicted with a shriveled front leg. (R2)

X3. Predatory mammals "enjoy" hunting healthy prey. Predators seem attracted preferentially to the more active (and presumably fitter) prey animals. The thrill of the chase seems important to them. Sick or unresponsive animals are often ignored, as in the case of an opossum feigning death. This supposed preference for the more active animals makes evolutionary sense, because the sluggish animals may be contagious or harbor parasites. (R2)

X4. Overviews. We now present the thoughts of two students of this claimed phenomenon. The first is by E.N. Smith, a creationist, and the author of the article from which the above anecdotes were taken. The second quotation is from biologist W.L. McAtee, who was ever ready to tackle controversial subjects.

E.N. Smith's summary.

> In summary, evidence and logic clearly indicate many predators are quite capable of catching and often prefer to catch healthy "top of the line" prey. Random selection plays a significant role in determining which animal is eaten. The evolutionary (or antievolutionary) implications are widespread and obvious. Predators have long been thought necessary to maintain density of prey species and to provide the mechanism for improvement of prey gene pools by selectively eliminating the inferior individuals. Both aspects of predator-prey relation permeate much of modern evolutionary dogma.
>
> If, then, fecund individuals are not selected for, and if predators (or herbivores) do not selectively harvest phenotypically inferior individuals, natural selection is a dogma without a mechanism. Clearly a critical reevaluation of the facts is warranted, and, indeed, needed. (R2)

W.L. McAtee's thoughts. McAtee wrote the following in 1937, when scientific opinions concerning evolution had not become so rigid. The scope of his inquiry is broad, but predation is a major factor in his analysis.

> Natural selection theory has been so frequently criticized that it seems well nigh impossible to bring forward an entirely new argument. Perhaps by presenting matters in a fresh light, however, and even by iteration alone, the attention of open minds may be focussed on some of the fatal weaknesses of the theory.
>
> The thesis of the present paper is not original but it was independently reached and has been the subject of reflection for years. I find it fairly well stated in a letter written in 1917 from which the following quotation is taken.
>
> "I am unable to put much faith in natural selection however, and none in that phase of it expressed by the phrase 'survival of the fittest.' It seems Quixotic to assert, that among the very large numbers of offspring, produced by most animals, only the fittest survive. Chance enters into the equation so largely that the fittest stands a proportional chance of being the first eliminated. It seems to me that the survivors will almost invariably come from the great median group of ordinary specimens, and not from either the small proportion of subnormal or of supernormal individuals. In other words, natural selection will usually leave typical specimens to reproduce a species, and is a conservative rather than a progressive process."
>
> About the only change I would make in that statement today would be to quote "natural selection" as well as "survival of the fittest," as both of these terms are mere slogans used almost invariably without the slightest analytical perception. A fair interpretation of typical assertions might read: "Mortality occurs; there are survivors; natural selection therefore has been effective, and the survivors are the fittest." As has been pointed out on the vari-

> ous occasions this is quite irrational, and means nothing but that survivors survive. (R1)

McAtee then follows with some fifteen pages of examples and analysis, reaching at the end the following conclusion.

> The evidence marshalled in this paper is to the effect that reproduction of species, on the whole, is carried on by ordinary individuals. They come from the great median mass of the population, and maintain the normal range of fluctuating variations. In the absence of other effective forces, propagation in this manner cannot change the character of the race nor produce evolution. (R1)

References

R1. McAtee, W.L.; "Survival of the Ordinary," Quarterly Review of Biology, 12:47, 1937. (X4)
R2. Smith, E. Norbert; "Which Animals Do Predators Really Eat?" Creation Research Society Quarterly, 13:79, 1976. (X1-X4)

BMX6 Unusual Aggression among Mammals

Description. Aggression by some mammals towards other mammals that "seems" to be excessive when hunger, breeding season, and other factors are discounted. The criteria for inclusion here are fuzzy and completely dependent upon what interests the compiler!

Data Evaluation. Most of the examples have been extracted from science journals, science magazines, and mammal guides. The single newspaper account is added only for curiosity purposes and background. Unquestionably, there are many additional, pertinent anecdotes that we have not yet collected. Rating: 2.

Anomaly Evaluation. Only curiosity value is claimed here, although one must wonder how red squirrels acquired their prescient behavior (X3). Rating: 3½.

Possible Explanations. None required.

Similar and Related Phenomena. Unusual animal assaults upon humans (BHX7 and BHX8 in Humans III).

Entries

X0. Introduction. Wolverines, water buffalo, javelinas, and Tasmanian devils are among those mammals notorious for being unusually aggressive and testy towards their own kind and/or other species of mammals. Of course, such aggression is variable and depends upon the individual animals involved. Furthermore, hunger, the presence of young, and the advent of the rutting season can change behavior considerably. These things said, our surveys have turned up several instances aggression so extreme and curious as to warrant cataloging.

X1. Extreme aggression during the rut. Male members of the deer family are normally highly aggressive during the breeding season, as are male elephants in musth. Usually, these animals are fearful of man, but a few hunters can testify that moose and even white-tail deer will sometimes attack humans during the rutting season. But one bovid is even more aggressive during the breeding season.

Rheboks. These relatively small (20-30 kilograms) South African bovids have straight, sharp horns are wield them fiercely during the rut.

> Males are extraordinarily aggressive, often killing others of their sex during the rutting season and even attacking and killing sheep and goats. (R3)

X2. Turnabouts: predators become prey.

Cats and rats.

> A portent unparalleled in the annals of biology has become the talk of Palermo. The Sicilian city is home to over a million rats which have recently begun to dispatch the local cats by "tearing out their throats and nibbling at them." The rats of Palermo, which outnumber the humans three to one, are thought to consume some 200,000 tons of foodstuffs a year not counting the cats. (R2)

Such levity is rare in Nature, a usually circumspect science journal.

X3. Emasculation of competing species.

Red squirrels v.s. gray squirrels.

> It is not generally known that a large percentage of gray squirrels are emasculated annually by the pugnacious reds. In years past the writer has shot and trapped alive a large number of gray squirrels and close observation showed 98 percent mutilation. The technique used by the red squirrel is simple but most efficacious. Contact is made by leaping from a limb of a tree, a distance of fifteen feet or more, making a perfect landing on the back of the unsuspecting gray engaged in digging seeds. With a quick body twist the unfortunate victim is pinned on its side and in less than ten seconds emasculation is effected. (R1)

Mainstream biologists would never attribute foresight to the red squirrels in this unusual method of reducing future competition. How could such an indirect weapon be forged by random mutation and natural selection?

X4. Unusual aggression toward humans by cetaceans. In section BHX8 in the catalog volume Humans III, we catalog the apparently malicious attacks on humans by some primates (especially the hamadryads) and the African water buffalo. The cetaceans, though, are universally portrayed as totally friendly towards humankind and even solicitous of contact. Male dolphins, for example, even make amorous advances toward female human swimmers. (BHX8-X1) In 1994, however, this interest in humans turned deadly, when two human males, swimming with a woman, were attacked by a male dolphin off Sao Paulo, Brazil. One man ultimately died from his injuries. Evidently, the dolphin considered the men to be romantic competitors. (R5)

We can claim mitigating circumstances in the Brazilian incident, but there is one group of cetaceans that seems perpetually aggressive towards humans, despite all the friendliness shown by the dolphins and killer whales (orcas) we admire in the marine parks.

Transient killer whales. The so-called "transient" killer whales differ physically and behaviorally from the "resident" killer whales that frequent coastal waters and perform in marine parks. They live in deeper waters and, unlike the fish-eating resident killer whales, prey almost exclusively upon other mammals. They are not human-friendly!

Residents tolerate---even welcome---human propinquity. The photographs of kayakers lolling among orca dorsal fins commonly featured in Alaskan and British Columbian travel brochures portray resident whales. No similar photographs exist of transients, apparently because they are, at best, aloof. There have been no substantiated transient attacks on humans, but posturings that can be easily translated as aggressive are not uncommon. (R4)

At present, the transient killer whales are classified as belonging to the same species as the residents, but they seem to be diverging in both their behavior and (slightly) in physical appearance. Little is known about the transients because they avoid human contact. (BMA3-X1 in Mammals I)

References

R1. Jackson, Ralph C.; "Migration of Gray Squirrels," Science, 82:549, 1935. (X3)

R2. Anonymous; Nature, 225:784, 1970. (X2)

R3. Nowak, Ronald M.; Walker's Mammals of the World, Baltimore, 1991. (X1)

R4. Martin, Glen; "Killer Culture," Discover, 14:110, December 1993. (X4)

R5. Anonymous; "Dolphin Prefers Women, Kills Male Playmate," Washington Times, December 11, 1994. (X4)

BMX7 Unusual Mammal-Animal Psychological Interfaces

Description. The ability of mammals to affect the behavior of other animals by means of physical motions, eye contact, sound production, and general behavior. Such psychological techniques are variously called hypnotism, mesmerism, or fascination.

Data Evaluation. The sources employed here are over a century old and anecdotal in nature. There is probably some truth in the tales, but scientifically they are of little import. Rating: 3½.

Anomaly Evaluation. Humans are rather adept at hypnotizing other animals, especially chickens and snakes (BHX2 in Humans III), but apparently some other mammals have learned or know instinctively how to apply such psychological forces.

Given that many animal behaviorists maintain that all "other" animals are virtual automatons, the existence of this talent is at least surprising. However, there is no reason for considering it any more anomalous than stalking or ambushing prey. If there is anything anomalous about this phenomenon, it probably resides in the curious susceptibility of a wide variety of animals to hypnotic manipulation. Such weaknesses make a species less fit! Rating: 3.

Possible Explanations. Animals, including humans, are for some reason widely susceptible to hypnosis or fascination.

Similar and Related Phenomena. The ability of humans to hypnotize other animals (BHX2-X2 in Humans III). Snakes are reputed to fascinate birds and other creatures (BRX). Human hypnosis of other humans and similar psychological phenomena are treated in the Series-P catalogs.

Entries

X0. Introduction. Hypnotism, fascination, or mesmerism, whatever name you wish to employ, has been in vogue among humans for millennia. However, we rarely hear of humans fascinating other mammals, although we do collect a few examples under BHX2-X2 in Humans III and add one more rather questionable instance here. As for nonhuman mammals fascinating other animals of any kind, good anecdotes are scarce in the scientific literature. In fact, only two meet our minimal criteria, and even these are of little use to animal behaviorists!

X1. Humans fascinating wild mammals. Snakes seem to be enthralled by the physical motions and music of Asian snake charmers, but we have found only the following tale of success with mammals. It takes place in the Nineteenth Century.

> A new book called "Rifle and Spear with the Rajpoota," by Mrs. Alan Gardner, contains a very interesting account of some wild animals attracted by a conjurer. Mrs. Gardner and her party rode out on elephants to an endless uncultivated plain; the man told them to remain quiet, while he went forward a hundred yards and hid himself in a bush. He then began a muffled chuckling kind of call, which he kept up without ceasing. In about two minutes a fox came out of a little ravine close by, and, looking suspiciously about him, trotted towards the noise. Then came another, and presently two or three more ran in from different directions; soon four or five appeared in the distance, followed by several others; and, finally, two big jackals, quite half a mile away, came galloping up, as if afraid of being late for the fun. At last, there must have been thirty or forty foxes and jackals clustered like a pack of hounds not a hundred yards from the bush. They all looked frightened, and seemed to come against their will, and the instant the man stopped his chant, every one of the animals fled, as if the spell was broken. The Maharajah of Jaypoor was delighted. (R3)

In this vein, see BHX2-X3, in Humans III, for more curious effects of human music on some mammals.

X2. Stoat fascinating a rabbit. This anecdote was found in a delightful old journal, The Zoologist, which is full of curious field observations by amateur naturalists.

> As I was walking on the hill-side above West Creech Farm, in Penbeck (the down was scattered with very low furze bushes), my attention was arrested by a cry of distress; it proceeded from a rabbit which was cantering around in a ring, with a halting gait. I watched it for some minutes, but as the circle became

smaller and the rabbit more agitated I perceived a stoat turing its head with the rabbit's motion, and fixing its gaze upon it. I struck a blow at the stoat and missed it; its attention was thus withdrawn, and the rabbit ran away with great vigour in a straight direction. (R1)

X3. Cat fascinating a bird. We have found several reports of snakes fascinating birds (BRX), and evidently cats can turn the same trick!

Mr. J. McNair Wright, an American naturalist. has called attention to a case of "fascination" by a cat which came under his observation. The cat was sitting on the sill of his window near a pine tree, when a bird alighted on a tree. The cat fixed his eyes on the bird with a peculiar intensity of expression, and the fur on his head stood on end, but otherwise he remained motionless. The bird quivered, trembled, looked fixedly at the cat, and, finally, with a feeble shake of the wings, fell towards the cat, who pounced upon it. Mr. Wright regards such fascination of snakes and other animals as a form of hypnotism. (R2)

References

R1. Bond, Henry; "Rabbit Apparently Fascinated by a Stoat," Zoologist, 18:7273, 1859. (X2)
R2. Anonymous; "Fascination," English Mechanic, 56:34, 1892. (X3)
R3. Anonymous; "Fascination," English Mechanic, 62:269, 1895. (X1)

FIRST-AUTHOR INDEX

SOURCE INDEX

SUBJECT INDEX

BIOLOGY CATALOGS

BIOLOGICAL ANOMALIES: HUMANS I; A Catalog of Biological Anomalies

This volume, the first of three on human biological anomalies, looks at the "external" attributes of humans: (1) Their physical appearance; (2) Their anomalous behavior; and (3) Their unusual talents and faculties.

A Moi boy with a nine-inch tail

TYPICAL SUBJECTS COVERED
- Mirror-image twins
- The sacral spot
- The supposed human aura
- Baldness among musicians
- Human tails and horns
- Human behavior and aolar activity
- Cycles of religiousness
- Cyclicity of violent collective human behavior
- Handedness and longevity
- Wolf-children
- The "Mars Effect"
- Telescopic vision
- Dermo-optical perception
- Hearing under anesthesia
- Human navigation sense
- Asymmetry in locomotion
- Sex-ratio variations

COMMENTS FROM REVIEWS
All I can say to Corliss is carry on cataloging.
NEW SCIENTIST

304 pages, hardcover, $19.95
52 illus., 3 indexes, 1992
548 references, LC 91-68541
ISBN 0-915554-26-7, 7x10

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The second Catalog volume on human biological anomalies focuaes upon the "internal" machinery of the body: (1) Its major organs; (2) Its support atructure (the skeleton); and (3) Its vital subsystema (the central nervous system and the immune system).

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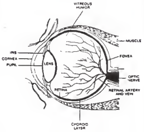
- Enigma of the fetal graft
- Phantom limbs
- Blood chimeras
- Anomalous human combustion
- Bone shedders
- Skin shedders
- "Perfection" of the eye
- Dearth of memory traces
- Sudden increase of hominid brain size
- Health and the weather
- Periodicity of epidemics
- Extreme longevity
- AIDS anomalies
- Cancer anomalies
- Human limb regeneration
- Nostril cycling
- Voluntary suspended animation
- Male menstruation



Is the complexity of the human eye anomalous?

297 pages, hardcover, $19.95
40 illus., 3 indexes, 1993
494 references, LC 91-68541
ISBN 0-915554-27-5, 7x10

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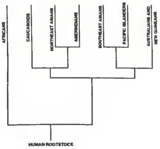
Completing our trilogy on human anomalies, this volume focuses on four areas: (1) the human fossil record; (2) biochemiatry and genetics; (3) possible unrecognized living hominids; and (4) human interactions with other species and "entities."



DNA analysis divides modern humans into these seven major groups.

TYPICAL SUBJECTS COVERED
- Neanderthal demise
- Giant skeletons
- Tiny skeletons
- Hominid gracilization
- Sudden brain expansion
- Human chimeras
- Sasquatch/Bigfoot, Alma, Yeti, and others
- Human-animal communication
- Humanity and Gaia
- Anomalous distribution of human lice

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311 references, LC 91-68541
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TYPICAL SUBJECTS COVERED

- Horizon-to-horizon sky flashes
- Episodes of luminous mists
- Mountain-top glows (Andes glow)
- Earthquake lights
- Ball lightning with tails
- Rocket lighting
- Lightning from s clear sky
- Ghost lights; Ignis fatuus
- Darting streaks of light (sleeks)
- The milky sea and light wheels
- Radar-stimulated phosphorescence of the sea
- Double ball lightning
- Luminous phenomena in tornados
- Black auroras

Luminous display over Mt. Noroshi during earthquake swarm.

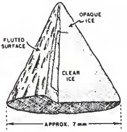
COMMENTS FROM REVIEWS

. . . the book is well-written and in places quite fascinating. SCIENCE BOOKS

248 pages, hardcover, $14.95
74 illustrations, 5 indexes, 1982
1070 references, LC 82-99902
ISBN 915554-09-7, 7 x 10 format

TORNADOS, DARK DAYS, ANOMALOUS PRECIPITATION; A Catalog of Geophysical Anomalies

Here is our "weather" Catalog. As everyone knows, our atmosphere is full of tricks, chunks of ice fall from the sky, tornado funnels glow at night. The TV weathermen rarely mention these "idiosyncracies".



Conical hailstones with fluted sides.

TYPICAL SUBJECTS COVERED

- Polar-aligned cloud rows
- Ice fogs (the Pogonip)
- Conical hail
- Gelatinous meteors
- Point rainfall
- Unusual incendiary phenomens
- Solar activity and thunderstorms
- Tornados and their association with electricity
- Multiwalled waterspouts
- Explosive onset of whirlwinds
- Dry fogs and dust fogs
- Effect of the moon on rslnfall
- Ozone in hurricanes
- Ice falls (hydrometeors)

COMMENTS FROM REVIEWS

. . . can be recommended to everyone who realizes that not everything in science has been properly explained. WEATHER

202 pages, hardcover, $14.95
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745 references, LC 82-63156
ISBN 915554-10-0, 7 x 10 format

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Quakes and monster, solitary waves and natural detonations; these are the consequences of solids, liquids, and gases in motion. In our modern technological cocoon, we are hardly aware of this rich spectrum of natural phenomena.

Sand craters created by earthquakes.

TYPICAL SUBJECTS COVERED

- Periodic wells and blowing caves
- Sun-dominated tides
- Immense, solitary waves
- Animal activity prior to earthquakes
- Earthquake geographic anomalies
- Earthquake electricity
- The sound of the aurora
- Musical sounds in nature
- Mysterious detonations
- Anomalous echos
- Slicks and calms on water surfaces
- Periodicities of earthquakes
- The vibrations of waterfalls
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TYPICAL SUBJECTS COVERED

- Rainbows with offset white arcs
- Sandbows
- Offset and skewed halos
- The Brocken Specter
- The Alpine Glow
- Unexplained features of the green flash at sunset
- Fata Morgana
- Telescopic mirages
- Long-delayed radio echos
- Eclipse shadow bands
- Geomagnetic effects of meteors
- Intersecting rainbows
- The Krakatoa sunsets
- Kaleidoscopic suns

Shadow of Adam's Peak with glory and radial rays.

COMMENTS FROM REVIEWS

...all in all it's a fascinating book. SKY AND TELESCOPE
...any student of the physical sciences will find it fascinating. SCIENCE BOOKS

244 pages, hardcover, $14.95
111 illustrations, 5 indexes, 1984
569 references, LC 84-50491
ISBN 915554-12-7, 7 x 10 format

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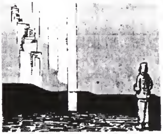
This is our first Handbook, as rewritten in a more popular style for publication by Doubleday in paperback form. It deals with most of the subjects mentioned in the preceding four Catalog volumes.



A low-level aurora descends below mountain peaks.

TYPICAL SUBJECTS COVERED

- Nocturnal lights and will o' the wisps
- Oceanic light wheels
- Non lunar tides
- Falls of ice, fish, grains, etc.
- Strange hums and hisses
- Unexplained mirages
- Low-level auroras
- Ball lightning
- Cloudless rain and snow
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- Dark days, yellow days, etc.
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COMMENTS FROM REVIEWS

...fascinating reading may be found at almost any point in the book. BOOKLIST
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431 pages, hardcover, $9.95
133 illustrations, index, 1983
References, LC 78-22625
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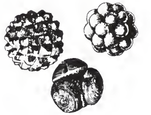
- Zimbabwe and Dhlo-dhlo
- Huge spheres in Costa Rica
- The Great Wall of Peru
- Ancient batteries and lenses
- Mysterious walls everywhere
- Pacific megalithic sites
- European stone circles and forts



Scottish carved stones from circa 1000 B. C.

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...a useful reference in undergraduate, public, and high school libraries. BOOKLIST

792 pages, hardcover, $21.95
240 illustrations, index, 1978
References, LC 77-99243
ISBN 915554-03-8, 6 x 9 format

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- Carolina Bays and oriented lakes
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- Immense craters
- Raised beaches
- Guyots (flat-topped seamounts)
- Island arcs
- Doubts about plate tectonics (continental drift)
- Mima mounds
- Drumlin anomalies
- Patterned ground
- Esker problems
- Lake walls and ramparts
- Crevicular structure
- Submarine canyons

Pyramid of frozen foam on the Bozenkill, New York State

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. . . enough terrestrial intrigue to keep us thinking for years.
PURSUIT

245 pages, hardcover, $17.95
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682 references, LC 87-63408
ISBN 915554-22-4, 7 x 10 format

ANOMALIES IN GEOLOGY: PHYSICAL, CHEMICAL, BIOLOGICAL; A Catalog of Geological Anomalies

Journey here into ice caves, exhume Siberian mammoths, see animals perish in gas-filled valleys---a little media hype is justified here. But more serious questions involve the origins of oil, coal, and natural gas.

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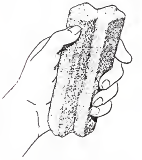
- Biological extinction events
- Musical sands, ringing rocks
- Anomalies of oil's origin
- Ice caves, frozen wells
- Natural fission reactors
- Marine organisms and fossils found far inland
- Siberia's frozen mammoths
- Radiometric dating problems
- Anchor ice, frazil ice
- Violent lake turnovers
- Flexible rocks
- Origin of ocean water
- Skipping in fossil record
- Valleys of death



Prismatic sandstone from Missouri

335 pages, hardcover, $18.95
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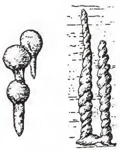
1260 references, LC 89-90680
ISBN 915554-23-2, 7 x 10 format

NEGLECTED GEOLOGICAL ANOMALIES; A Catalog of Geological Anomalies

Neglected but far from insignificant are the anomalies cataloged here. Do we really know how concretions and geodes form, where tektites come from, whence the immense deposits of superficial debris all over our globe?



Mace-shaped and sand-spike concretions from the Colorado delta.

TYPICAL SUBJECTS COVERED
- Concretions and geodes
- Tektites and microtektites
- Erratic boulders and gravels
- Polystrate fossils
- Bone caves and bone beds
- Giant basalt flows
- Natural glasses
- Surging glaciers
- Driftless regions
- Stretched pebbles
- Crystal inclusions
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- Elevated erratics
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333 pages, hardcover, $18.95
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1030 references, LC 90-60568
ISBN 915554-24-0, 7 x 10 format

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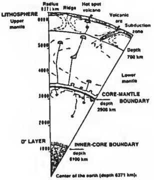
TYPICAL SUBJECTS COVERED

- Anomalous gravity signals
- Mid-plate volcanism
- Mysterious seismic reflectors
- Seismic velocity discontinuities
- Deep-focus earthquakes
- Incompleteness of the stratgraphic record
- Cyclothems and rhythmites
- Exotic terranes
- Compass anomalies
- Earth-current anomalies
- Problems of paleomagnetism
- Polarity reversals



Model of the earth's interior

230 pages, hardcover, $18.95
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619 references, LC 90-92347
ISBN 915554-25-9, 7 x 10 format

BIOLOGY HANDBOOK

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Even with its 1000-plus pages, this Handbook barely does justice to the immense number of biological anomalies in the scientific literature.

Crow "anting" with a lighted match

TYPICAL SUBJECTS COVERED

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- Yeti and Sasquatch
- DNA: the ultimate parasite
- Luminous plants
- Diseases from outer space
- The strange synchronous flowering of bamboos
- The problem of excess DNA
- Sea and lake serpents
- Unexplained senses of ants
- Water-breathing in mammals
- Life and thermodynamics
- Is evolution a tautology?
- Unusual behavior of animals
- Cryptobiosis or latent life

COMMENTS FROM REVIEWS

...the collection is endlessly fascinating. NATURE
...it certainly does pique the interest of the reader. LIBRARY J.

1024 pages, hardcover, $24.50
100 illustrations, index, 1981
References, LC 80-53971
ISBN 915554-07-0, 6x9

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Our Astronomy Handbook covers much the same ground as the three preceding Astronomy Catalogs, but in more detail. For example, the quotations are much more extensive.

Unexplained rift in the zodiacal light.

TYPICAL SUBJECTS COVERED

- The lost satellite of Venus
- Transient lunar phenomena
- Ephemeral earth satellites
- Venus' radial spoke system
- Relativity contradicted
- Cosmological paradoxes
- Changes in light's velocity
- Vulcan, the intramercurial planet
- Knots on Saturn's rings
- Bright objects near the sun
- The sun's problematical "companion star"
- "Sedimentary" meteorites
- Life chemistry in outer space
- Planet positions and sunspots

COMMENTS FROM REVIEWS

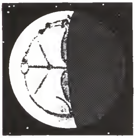
...highly recommended...excellent value for money. NATURE
(Astronomy Book Club selection)

716 pages, hardcover, $19.95
103 illustrations, index, 1979
References, LC 78-65616
ISBN 915554-05-4, 6 x 9 format

ASTRONOMY CATALOGS

THE MOON AND THE PLANETS; A Catalog of Astronomical Anomalies

From our own moon's cratered surface to the red, rock-strewn plains of Mars, the Solar System is a fertile field for scientific research. Despite centuries of observation, each new spacecraft and telescope provides us with new crops of anomalies.



One drawing of the Venusian radial spoke system.

TYPICAL SUBJECTS COVERED

- The ashen light of Venus
- The Martian 'pyramids'
- Kinks in Saturn's rings
- Continuing debate about the Voyager life-detection experiments
- Neptune's mysterious ring
- Evidence of water on Mars
- The strange grooves on Phobos
- The two faces of Mars
- Lunar clouds, mists, "weather"
- Ring of light around the new moon
- Dark transits of Jovian satellites
- Io's energetic volcanos
- Jupiter as a "failed star"
- Venus-earth resonance

COMMENTS FROM REVIEWS

The author is to be commended for his brilliantly conceived and researched volume. SCIENCE BOOKS

383 pages, hardcover, $18.95
80 illustrations, 4 indexes, 1985
988 references, LC 85-61380
ISBN 915554-19-4, 7 x 10 format

THE SUN AND SOLAR SYSTEM DEBRIS; A Catalog of Astronomical Anomalies

Our sun, powerhouse of the Solar System and an enigma itself, is orbited by clouds of asteroids, comets, meteors and space dust. These "minor objects" cause "major headaches to astronomers searching for explanations.

TYPICAL SUBJECTS COVERED

- Solar system resonances
- Bode's Law and other regularities
- Blackness of comet nuclei
- Cometary activity far from solar influences
- Unidentified objects crossing sun
- The 'missing' solar neutrinos
- Pendulum phenomena during solar eclipses
- Observations of Planet X
- Meteorite geographical anomalies
- Meteorites from the moon
- Long fireball processions
- Very long duration meteorites
- Zodiacal light brightness changes

One of the many possible modes of solar surface oscillation.

COMMENTS FROM REVIEWS

It is an unusual book, nicely executed, and I recommend it highly. . . ICARUS

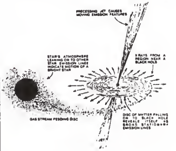
288 pages, hardcover, $17.95
66 illustrations, 4 indexes, 1986
874 references, LC 86-60231
ISBN 915554-20-8, 7 x 10 format

STARS, GALAXIES, COSMOS; A Catalog of Astronomical Anomalies

Did the Big Bang really begin the existence of all we know? Do we honestly know how the stars (and our sun) work? Can we rely on Newton's Law of Gravitation? According to this volume the answer seems to be: "Probably not!"

TYPICAL SUBJECTS COVERED

- Optical bursters and flare stars
- Historical color change of Sirius
- Infrared cirrus clouds
- Quasar-galaxy associations
- The red-shift controversy
- Quantization of red shifts
- The quasar energy paradox
- Apparent faster-than-light velocities in quasars and galaxies
- Evidence for universal rotation
- Swiss cheese structure of universe
- Is the "missing mass" really missing?
- Superluminous infrared galaxies
- Shells around elliptical galaxies



Model of the mysterious star SS 433.

COMMENTS FROM REVIEWS

. . . it never fails to be interesting, challenging and stimulating. NEW SCIENTIST

246 pages, hardcover, $17.95
50 illustrations, 4 indexes, 1987
817 references, LC 87-60007
ISBN 915554-21-6, 7 x 10 format

SOURCEBOOKS

The first publicstions of the Sourcebook Project appesred in the 1970s. These were loose-leaf notebooks called "Sourcebooks." In these notebooks were reproduced articles snd excerpts of articles dealing with anomalous phenomena. Although the Sourcebooks were superceded by the Handbooka and Catalogs, the continuing demand for them has encouraged us to keep most of them in print, aa detailed below.

STRANGE UNIVERSE: vol. A2
W.R. Corliss, 286 pp., 1977, $16.95
Astronomical snomalies. Xeroxed text, original printed binder.

STRANGE PLANET
W.R. Corliss, Geological anomalies
vol. E1, 289 pp., 1975, $9.95
Printed text, printed binder
vol. E2, 275 pp., 1978, $16.95
Xeroxed text, plain binder

STRANGE PHENOMENA
W.R. Corliss, Geophysical anomslies.
vol. G1, 277 pp., 1974, $16.95
Xeroxed text, plain binder.
vol. G2, 270 pp., 1974, $9.95
Printed text, plain binder.

STRANGE ARTIFACTS
W.R. Corliss, Archeological anomalies
vol. M1, 268 pp., 1974, $16.95
Xeroxed text, printed binder.
vol. M2, 293 pp., 1976, $16.95
Xeroxed text, printed binder.

STRANGE MINDS: vol. P1
W.R. Corliss, 291 pp., 1976, $9.95
Psychological anomalies. Printed text, plain binder.

PHOTOCOPIED CLASSICS

LEGENDARY ISLANDS OF THE ATLANTIC
W.H. Babcock, 196 pp., 1922, $12.95p

The title of this book immediately conjures up thoughts of Atlantis; but many other Atlantic islands were once thought to exist, were placed on maps, and then disappeared. The island of Brazil (or Hy Brazil) is one of these phantom islands. Babcock has written an engrossing, scholarly treatise, with many old maps, and hints of pre-Columbian contacts with the New World. Here follow some chapter titles: •Atlsntis; •The Island of the Seven Cities; •The Problem of Msyda; •Estotiland and the Other Islands of Zeno; •The Sunken Lsnd of Buss and Other Phantom Islands. This is a reprint of our xeroxed classic.

THE MAMMOTH AND THE FLOOD: An Attempt to Confront the Theory of Uniformity with the Facts of Recent Geology
H.H. Howorth, 1887, 498 pp., $19.95p

Sir Henry Howorth was one of the great synthesizers of acience in the late 1800a. In this book, he brought together all of the svailable evidence on recent catastrophic flooding on the earth: the bone caves, the Siberian mammoth carcasses, the masses of fresh moa bones in Australia, and a hoat of cther geological and biological puzzles. Most of Howorth's attention, however, is focusaed on the mammoths and their recent demiae. This book is one of the clsssics of catsstrophe literature. Our high-quslity xerox edition is bound with heavy covers.

ANCIENT MONUMENTS OF THE MISSISSIPPI VALLEY
E.G. Squier and E.H. Davia, 376 pp., 1848, xeroxed classic, $29.95p

One of the most remarkable archeological books ever published in America! This book was Volume 1 in the Smithsonian Contributions to Knowledge series. Its sppearsnce in 1848 created a sensation. For, as America moved west, the remnants of the great civilization of the Moundbuilders raised much speculation. Even today we marvel at their immense, flat-topped temple mounds, the huge earthen enclosures, and the meticulously wrought srtifacts of copper, mica, snd clsy. Squier snd Davis objectively described the features of this New World civilization in words and drawings. It is the drswings, though, that really capture the reader. They are superb, almost overwhelming. (Hardcover re-reprints of this book run over $80.)

DOUBT/FORTEAN SOCIETY MAGAZINE

During the 30s, 40s, and 50s, the work of Charles Fort was promoted by the Fortean Society. The Society initially published the Fortean Society Msgazine, later changing its name to Doubt. These publicstions are delightful collections of Fortesna of the period and also include reproductions of some of Fort's originsl notes. Curious snd fun to resd. All numbers are available in photocopied format bound as listed below.

Nos. 1-10	(152 pp.)	$16.95
Nos. 11-20	(160 pp.)	$16.95
Nos. 21-30	(160 pp.)	$18.95
Nos. 31-40	(160 pp.)	$16.95
Nos. 41-50	(160 pp.)	$16.95
Nos. 51-61	(184 pp.)	$18.95