# Natural History

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Shown actual size.
The Hummel Spice Jar Collection

The beloved art of Sister M.I. Hummel, now for the first time on a series of collector spice jars

Sister Maria Innocentia Hummel. Generations have delighted in her art.

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Discover the joyful art of Sister M.I. Hummel... send in your Reservation Application today!

&

The Danbury Mint

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Norwalk, Conn. 06857

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*Plus $2 per jar for shipping and handling.

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  ☐ VISA ☐ MasterCard

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Expiration Date

Name
Address
City

State Zip

Signature

Allow 8 to 12 weeks after payment for initial shipment.

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Cover: A snail kite, an endangered native of the Florida Everglades, feeds
the body of an apple snail to one of its brood. Photograph by James A. Kern. Story
on page 42.
Gullah Roots

Reading Theodore Rosengarten’s review (September 1987) of *When Roots Die*, by Patricia Jones-Jackson, gave poignant reminder to me of a wonderful opportunity to record personal history that I have lost forever. My maternal grandmother was born on Johns Island in the Carolinas and was a Gullah. The uniqueness of her background and heritage did not become apparent to me until I was in my late teens. It would be another ten years before I would begin to actively seek out my grandmother’s stories and anecdotes, her superstitions and wisdom, listening to the musical oddity of her speech.

I spent much time photographing Nana with her varied head wraps, but not nearly enough time recording her words or trying to document old family recipes that only she knew the secrets of. When I finally realized that I had to get her voice on tape because no one else in our family had retained the Gullah quality and way with words, it was too late: she died (at 80) as a result of an accident.

I applaud the late Ms. Jones-Jackson and others before her for their attempts to keep the Gullah culture alive. I will always regret missing my own special chance to do so.

Sandra Kitt
Brooklyn, New York

$6.45 an Acre

As articles in *Natural History* have noted many times, the extinction rate in tropical forests is rising precipitously and threatens to bring about the greatest biotic impoverishment since the end of the Cretaceous.

One tropical forest that could be saved is the Santa Elena Hacienda of Costa Rica, which until recently was the site of the CIA-sponsored airstrip for the support of insurgents in Nicaragua. This land, comprising 40,000 acres, is now available for incorporation into the Costa Rican national park system. Its purchase would join two pieces of a larger park comprising a total of 110,000 acres. The Santa Elena tract possesses great biological value in its own right. It is the driest part of Costa Rica and also the oldest above sea level. It contains elements of tropical dry forest, perhaps the most endangered of all terrestrial habitats, as well as many unique plant and animal species.

To purchase the land, $258,000 is needed, of which $100,000 has been pledged by the World Wildlife Fund—Conservation Foundation (1250 Twenty-Fourth Street, N.W., Suite 500, Washington, D.C. 20037), which is administering the attempt to raise the remaining $158,000. The Costa Rican government does not have the financial resources for the purchase but is prepared to incorporate the land into its already splendid national park system. Time is short. Our purpose here is to call the Santa Elena Project to the attention of a broader audience in the hopes that it might be brought to a successful completion.

Thomas Eisner
Cornell University
Ithaca, New York

Peter Raven
Missouri Botanical Gardens
St. Louis, Missouri

Edward O. Wilson
Harvard University
Cambridge, Massachusetts

Nana (Mrs. Lottie Wright)
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Atomic Secrets of the Nautilus

The only surviving member of a once-flourishing group of shelled cephalopods, the chambered nautilus has concealed many of the simple facts of its life history in the deep Pacific waters where it dwells. Little was known about its life span and growth rate when Neil Landman wrote about it for *Natural History* ("Not To Be or To Be?" August 1984).

Now, because of the carbon 14 deposited in the oceans by atomic-weapons testing over the last thirty years, researchers have begun to solve both mysteries. Landman, associate curator of invertebrates at the American Museum of Natural History, headed the team of scientists that came up with the answers.

Since the occurrence of atmospheric weapons testing in the late 1950s and early 1960s, the amount of C-14 in the world's oceans increased greatly, and yearly variations of the isotope are detectable in marine shells. A study of Australia's Great Barrier Reef, which measured carbon 14 levels in the new bands of corals that appear each year, served as a reference point for the nautilus study.

Landman and his colleagues analyzed a fully grown nautilus that had been captured off New Caledonia, measuring the concentrations of C-14 in its shell and septa (the walls that divide the animal's interior chambers) and comparing the results with those in the barrier reef. A chambered nautilus, they concluded, reaches maturity at about ten to twelve years of age. When the nautilus is young and small, it forms a new and ever larger
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chamber about every month; near maturity, a chamber is formed every year.

Another researcher, who captured a mature nautilus, marked it, released it, and recaptured it four years later, reported that the animal lives at least four years past its maturity, bringing the estimated nautiloid life span to at least sixteen years.

Grebes at the Vanishing Point

"Can a flightless water bird found only on one lake in the Guatemalan highlands survive guerrilla warfare, condominium fever, and Indian reed cutters?" This was the subtitle of "Goodbye, Giant Grebe?" an article that appeared in the February 1983 Natural History. The bird was the giant pied-billed grebe, the lake was Lake Atitlán, and the probable answer was no.

The author was Anne LaBastille, writer and wildlife ecologist, who first saw the giant pied-billed grebe (now called the Atitlán grebe) in 1960 and studied the bird and the ecology of the lake on and off over the succeeding twenty-two years. Perhaps the rarest water bird in the Western Hemisphere, the Atitlán grebe is closely related to the common pied-billed grebe (now called simply the pied-billed grebe), which also lives on Lake Atitlán. From a distance they might have easily been confused with each other even though the Atitlán was about twice the size and weight of its congener. The main behavioral difference between the two species is that the pied-billed grebe can fly. It is found at many locations in the Western Hemisphere, including Lake Atitlán and other Guatemalan lakes.

On each of her field studies at Lake Atitlán, a volcanic lake one mile high and 1,200 feet deep in the Guatemalan southwest, LaBastille surveyed the Atitlán grebe population. In 1960, she estimated its numbers at about 200; by 1980 the figure had dropped to about 80. The population "will probably continue declining," she predicted in her article. And so it did. One major reason was the introduction of largemouth bass to the benefit of tourist fishermen. Ornithologist Laurie A. Hunter, who reported on the fate of the bird at the annual meeting of the American Ornithologists' Union last August, says the bass consume the birds' food.

Hunter did fieldwork at Lake Atitlán and a second smaller Guatemalan lake, Laguna del Pino, used as a control, from March 1986 to June 1987 under the sponsorship of an international program to conserve the Atitlán grebe. She measured the grebes she found at both lakes, noted their mating habits, weighed their eggs, recorded the amount of time parents spent with chicks, and tape-recorded the birds' calls. Her data conformed with known information about the pied-billed grebes. In addition, on five occasions she saw grebes flying at Lake Atitlán. She has therefore concluded that the Atitlán grebe no longer exists and that the grebes now on Lake Atitlán are probably the pied-billed species. LaBastille concedes that even if a few of the rarer birds were still at Atitlán, there would not be enough of them to keep the species alive much longer.
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On the Road to America

Ice Age sites in Siberia provide glimpses of the Asians who may have crossed the Bering land bridge

by Nikolai N. Dikov

In 1961, I was lucky enough to find five archeological sites on the shore of Lake Ushki, in the center of the Kamchatka Peninsula, that were rich in paleolithic (Old Stone Age) artifacts. Traveling in a double-boat catamaran of poplar, my small survey team had been searching along the Kamchatka River, to which

This is the thirteenth in a series of articles exploring archeological sites and other lines of evidence that bear on the peopling of the New World.

Lake Ushki is connected by a narrow channel. Our exploratory pits revealed that the lake’s southern shore was archeologically rich, and a wedge-shaped stone core from which flakes had been struck was our first sign that excavations might reveal material of paleolithic age. The core was found in a pit dwelling of more recent age, into which, we concluded, it must have been introduced when the dwelling was originally dug out.

Summer was at its height, however, and as the ground water level was very high, we could not dig deeply. (Originally located on a terrace twenty to forty feet above the level of Lake Ushki, the sites had sunk considerably as a result of tectonic movement.) We returned the following year and found, six feet down, an undisturbed paleolithic layer containing many wedge-shaped cores. And in 1964, when the water level was very low, we reached the bottommost paleolithic level. Since then, we have worked at the sites nearly every year in the late fall, when the lower levels are free from ground water and the mosquitoes are not as wicked as they are in summer.

There are three paleolithic layers, which lie in sandy clay loam sediments at a depth of five to eight feet; above them are four neolithic layers and six bands of volcanic ash. Although the excavations are not yet complete—the sites are large and contain numerous dwellings—we can already see the outlines of two successive paleolithic cultures (Early Ushki and Late Ushki) of people who hunted bison, reindeer, and mammoth and, to some extent, consumed a large species of salmon, abundant in the lake even today. Analysis of pollen tells us the ancient inhabitants lived in a more rigorous climate than prevails now in Kamchatka: instead of trees there was a stony tundra.

The Early Ushki finds, which come from two of the five sites, include traces of several dwellings with very large (about 900 square feet) dumbbell-shaped floor plans, each containing six or seven unbordered hearths. The remains of the foundations suggest that these dwellings were double-walled tents or wigwams.
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whose wooden framework was covered with skins. The large living areas enclosed in this way probably accommodated several related families, each with its own hearth.

A pit burial filled to the top with red ochre (often a magical substitute for fire or blood) occupied the center of one camp. The deep grave, five feet in diameter, had been hollowed out in pebble conglomerate. Because of penetration by water, only traces of human bones were preserved. What remained, however, were about one thousand beads and pendants of soft pyrophyllite, which had decorated the clothes of the deceased. Some amber beads were also found. A 150-square-foot area around the burial was powdered with the same ochre that filled the grave. Perhaps this rich burial was a kind of mausoleum to the forefather of the tribal settlement, and afterward the dwellings were built around this sanctuary.

The stone tools discovered in the dwellings of this camp include bifacial leaf-shaped knives and spear points (shaped by flaking on both faces); abrasive chalcedony gravers for the manufacture of beads and pendants; and small, stemmed points for darts or arrows, made of various siliceous rocks and more or less thoroughly retouched from both sides. The forty or so stemmed points resemble, I believe, a type identified in the northwestern United States by Canadian archeologist Alan L. Bryan, who places them 13,000 to 11,000 years ago in the Great Basin (before Clovis, the first undisputed culture in the Americas) and later (up to 8,000 years ago) on a wider territory. Similar points have been discovered in the intermediate territory as well: by me at Ul’kmum, a model site near Cape Chaplin on the Chukchi Peninsula; and by the late Danish archeologist Helge Larsen at Trail Creek Cave, Alaska.

Materials associated with the Early Ushki culture have been dated by the radiocarbon method to between 14,300 ± 200 and 13,600 ± 250 years ago, but saturation with ground water in spring and summer seems to have resulted in an underestimation of their age. Based on our estimate of the age of the subsequent Late Ushki culture, for which archeomagnetic dating is available, we believe that Early Ushki is at least 1,500 to 2,000 years older than the radiocarbon determinations.

The Early Ushki discoveries may be contrasted with those from Dyuktai Cave and other paleolithic sites along the Aldan River, a tributary of the Lena, which are perhaps the most widely reported discoveries in eastern Siberia that may relate to an early human presence in the New World. Characteristic artifacts at the latter sites include bifacial leaf-shaped spear or dart points and wedge-shaped cores from which small blades were struck. Both types of artifacts are found at sites in Alaska and western Canada and in intermediate areas on the Asian side of the Bering Strait. Yuri A. Mochanov, who excavated and described the Dyuktai sites, believes that this culture persisted from 35,000 to 10,000 years ago. The most reliable dated evidence, however, indicates that the oldest finds are no more than 18,000 years old and that the bifacial points are a maximum of 15,000 years old.

The younger of our paleolithic cultures, Late Ushki, is found at four of the five sites. Radiocarbon dating suggests an age of 10,000 or 11,000 years, but the actual age seems to be older, since archeomagnetic dating yields a result of 12,300 ± 300 years ago. The Late Ushki culture differs from the earlier one both in dwellings and in technology. The settlements contain a greater number of dwellings—one partly excavated site includes more than twenty-five. Although also covered with skins, the dwellings were smaller (150 square feet or less, probably for one family) and quite different in construction. Many of them have a floor surface one to one and one-half feet below the ground level, a mushroomlike floor plan (the “stem” being an entrance corridor), and one stone-encircled hearth in the center, close to the entrance. These features probably minimized drafts, securing greater comfort for the occupants than the earlier type of dwelling. The family may have slept around the hearth, with either their feet or their heads turned to the fire.

In one especially small dwelling, we found the buried remains of a huskylike dog. For a number of reasons, we think this was the dwelling of some kind of shaman, or medicine man. It could have accommodated only one or two people (we think the shaman and his wife). In addition, it was reconstructed at the same place three times, perhaps because of its ritual significance, and the two later ringlike hearths were each composed of seven stones. A green stone was placed at the entrance during the last reconstruction, possibly for protection, while close to the center, we found a bison’s shoulder blade that had been burned. (Herodotus tells how the Scythians told fortunes based on the fissures in burnt shoulder blades of bulls.) Finally, the dog’s burial adds another special element to this dwelling.

The Late Ushki culture is typified by bifacial stone tools. The projectile points are not stemmed, as in the Early Ushki culture, but are an elongated leaf shape. A
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certain type of wedge-shaped core (from which small blades were struck), which is totally lacking in the Early Ushki culture, is quite common. Other artifacts include skillelike spalls detached from wedge-shaped cores; burins made from flakes; large, scraperlike knives ("screbloes"); scrapers; and roughly worked pounding tools (occasionally made from pebbles). There are objects that appear to be labrets (ornaments worn in a hole pierced through the lip) and primitive works of art: a flat piece of sandstone with an engraved image of a tentlike dwelling and, drawn on the earthen floor of one of the dwellings, an image of a fish. The bones of bison, horse, lemming, and salmon were also found.

While in some respects the Late Ushki culture is similar to the Dyuktai culture (notably in the wedge-shaped cores and leaf-shaped bifaces), in many other characteristics it differs. The presence of fishing alongside hunting, the peculiar dwellings, the use of labrets, and other specifics are not known for Dyuktai. The availability of labrets and the character of the stone industry, which resembles certain finds in Alaska and British Columbia (known to archeologists under the terms Denali, Akmak, and Namu), lead me to conclude that the Late Ushki paleolithic culture penetrated to Alaska and probably to British Columbia. Together with some other cultures (including Dyuktai), it might have contributed to the formation of early Aleut-Eskimo culture as well as to the ancestral Northwest Coast Indian culture, which included post-Ice Age traditions of microblades and labrets.

Various recently discovered archeological sites resembling Late Ushki may be interpreted as transitional on the way to North America. One is close to Cape Chaplin, about a mile from the present Bering Sea. In the surface there, among numerous chert flakes, artifacts typical of the Late Ushki have been found: bifacially worked leaf-shaped knives and points; burins made from flakes; endscrapers; and wedge-shaped cores. One of the cores is very primitively worked and falls in the category of "butted" cores (wedge-shaped cores made of unworked flakes, from which longitudinal spalls were detached from the butt).

Such butted cores are particularly common at another of these sites, on the west side of the Kurupka River, which flows from the mountains into the Bering Strait about sixty miles west of Cape Chaplin. Burins, scrapers, and fragments of leaf-shaped bifaces were also preserved there on the fine crushed rock surface, both on the shore and higher up on the sixty-five-foot river terrace. In general, the stone industry of this site resembles that of the U'khum site, the mixed site near Cape Chaplin that also contains Early Ushki-like artifacts. Wedge-shaped cores, including butted ones, and fragments of bifaces were found at four other paleolithic sites on the Chukchi Peninsula and two others farther southwest.

These eight intermediate sites also have similarities to the Dyuktai culture. They mark the dispersal of people from extreme northeastern Asia to Alaska 13,000 to 10,000 years ago, that is, at the time when the Bering land bridge was giving way to the Bering Strait.

Another site, which I discovered in 1985 on the southeastern Chukchi Peninsula in the Puturak Pass (three to nine miles away from the Bering Sea and its fiords), relates to a quite different and perhaps later migration. Abundant remains of stone working lie on the surface of fine crushed rock and sandy loam. Pale gray and yellow chert was used for manufacturing numerous blades and bladelets of various sizes, as well as knives, scrapers, and gravers made from them. Various cylindrical and other cores (but not wedge-shaped ones) were the technological basis for this blade industry. Besides hundreds of blades worked unifacially and unworked blades, thousands of flakes were discovered. The remains were concentrated where there was charcoal, possibly the site of some dwelling with a hearth.

The Puturak archeological material has no analogies elsewhere in northeastern Asia, but in its technology it is very similar to the complex of artifacts of Gallagher Flint Station, Locality I, located on the northern slope of the Brooks Range in Alaska. The latter, radiocarbon dated to 10,540 ± 150 years ago, has been related in turn to somewhat more recent finds in Alaska, including Anangula in the Aleutians. Thus Puturak may be an initial link in the formation of the coastal culture of the region of the Bering Sea.

With the possible exception of Early Ushki, therefore, sites found so far in eastern Siberia appear related to the peopling of mainland Alaska, the Aleutians, and western Canada, but not to more southerly portions of the New World. And none, including Early Ushki, challenges the conservative view that the significant population movements from Asia occurred after the peak of the last glaciation, which was some 18,000 years ago. The search continues for early sites in northeastern Siberia, especially in and near the Chukchi Peninsula, however, and so we are far from any final answers.
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The Case of the Creeping Fox Terrier Clone

Or why Henry Fairfield Osborn's ghost continues to reappear in our high schools

by Stephen Jay Gould

When Asta the fox terrier exhumed the body of the Thin Man, his delightfully tipsy detective master, Nick Charles, exclaimed, "You're not a terrier, you're a police dog" (The Thin Man, MGM 1934 original with William Powell and Myrna Loy). May I now generalize for Asta's breed in the case of the telltale textbook.

The wisdom of our culture abounds with mottoes that instruct us to acknowledge the faults within ourselves before we criticize the failings of others. These words range from clichés about what pots and kettles call each other to various sayings of Jesus: "And why beholdest thou the mote that is in thy brother's eye, but perceivest not the beam that is in thine own eye?" (Luke 6:41); "He that is without sin among you, let him first cast a stone at her" (John 8:7). I shall follow this wisdom in trying to express what I find so desperately wrong about the basic tool of American teaching, the textbook.

In March 1987, I spent several hours in the exhibit hall of the National Science Teachers Association convention in Washington, D.C. There I made an informal, but reasonably complete, survey of how (or if) evolution was treated in all major high-school science textbooks. I did find some evidence of adulteration, pussy-footing, and other forms of capitulation to creationist pressure. One book, Life Science, by L.K. Bierer, V.F. Liem, and E.P. Silberstein (Heath, 1987), in an accommodation that at least makes you laugh while you weep for lost integrity in education, qualifies every statement about the ages of fossils—usually in the most barbarous of English constructions, the passive infinitive. We discover that trilobites are "believed to have lived 500-600 million years ago," while frozen mammoths are "thought to have roamed the tundra 22,000 years ago." But of one poor bird, we learn with terrible finality, "There are no more dodos living today." Their extinction occurred within the bounds of biblical literalism and need not be hedged.

But I was surprised and pleased to note that most books contained material at reasonable length about evolution and with no explicit signs of tampering to appease creationists. Sins imposed by others were minimal. But I then found the beam in our own eye and became, if anything, more distressed than by any capitulation to the Yahoos. The problem does not lie in what others are doing to us, but in what we are doing to ourselves. In book after book, the evolution section is virtually cloned. Almost all authors treat the same topics, usually in the same sequence, and often with illustrations changed only enough to avoid suits for plagiarism. Obviously, authors of textbooks are copying material on a massive scale and passing along to students an ill-considered and virtually Xeroxed version with a rationale lost in the mists of time.

Just two months after making this depressing observation, I read Diane B. Paul's fascinating article "The Nine Lives of Discredited Data" (The Sciences, May 1987). Paul analyzed the sections on heritability of IQ from twenty-eight textbooks on introductory genetics published between 1978 and 1984. She paid particular attention to their treatment of Sir Cyril Burt's data on identical twins raised separately. We now know that these "studies" represent one of the most striking cases of fraud in twentieth-century science—for Burt invented both data and co-workers. His sad story had been well publicized, and all authors of texts published since 1978 surely knew that Burt's data had been discredited and could not be used. Several texts even included discussions of the Burt scandal as a warning about caution and scrutiny in science.

But Paul then found that nearly half these books continued to cite and use Burt's data, probably unconsciously. Of nineteen textbooks that devoted more than a paragraph to the subject of genetics and IQ, eleven based their conclusions about high heritability on a review article published in Science in 1963. This review featured a figure that ten of these textbooks reproduced either directly or in slightly altered and simplified form. This figure includes, as a prominent feature, the results of Sir Cyril Burt (not yet suspect in 1963). We must conclude that the authors of these texts had either not read the 1963 article carefully or had not consulted it at all. Paul infers (correctly, I am sure) that this carelessness arises because authors of textbooks copy from other texts and often do not read original sources. How else to explain the several books that discussed the Burt scandal explicitly and then, unbeknown to their authors, used the same discredited data in a figure?

Paul argues that the increasing commercialization of textbooks has engendered this virtual cloning of contents. Textbook publishing is a big business, replete with market surveys, fancy art pro-
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programs, and subsidiary materials in the form of slide sets, teachers' guides, even test-making and grading services. The actual text of the book can become secondary and standardized; any departure from a conventional set of topics could derail an entire industry of supporting materials. Teachers are also locked into a largely set curriculum based on this flood of accouterments. Paul concludes: "Today's textbooks are thicker, slicker, more elaborate, and more expensive than they used to be. They are also more alike. Indeed, many are virtual clones, both stylistic and substantive, of a market leader."

The marketplace rules. Most publishing houses are now owned by conglomerates—CBS, Raytheon, and Coca-Cola among them— with managers who never raise their eyes from the financial bottom line, know little or nothing about books, and view the publishing arm of their diversified empire as but one more item for the ultimate balance. I received a dramatic reminder of this trend last week when I looked at the back cover of my score for Mozart's Coronation Mass, now under rehearsal in my chorus. It read: "Kalmus Score. Belwin Mills Publishing Company, distributed by Columbia Pictures Publication, a unit of the Coca-Cola Company." I don't say that Bill Cosby or Michael Jackson or whoever advertises the stuff doesn't like Mozart; I merely suspect that Don Giovanni can't be high on the executive agenda when the big boys must worry about such really important issues as whether or not to market Cherry Coke (a resounding "yes" vote from this old New York soda fountain junkie).

Paul quotes a leading industry analyst from the 1984 Book Publishing Annual. Future textbooks, the analyst argues, will have "more elaborate designs and greater use of color and the ancillary packages will become more comprehensive. New, more aggressive marketing plans will be needed just to maintain a company's position. The quality of marketing will make the difference." Do note the conspicuous absence of any mention whatsoever about the quality of the text itself.

Paul is obviously correct in arguing that this tendency to cloning has accelerated remarkably as concerns of the market overwhelm scholarly criteria in the composition of textbooks. But I believe that the basic tendency has always been present and has a human as well as a corporate face. Independent thought has always been more difficult than borrowing, and authors of textbooks have almost always taken the easier way out. Of course I have no objection to the similar recording of information by textbooks. No author can know all the byways of a profession, and all must therefore rely on written sources for areas not enlightened by personal expertise. I speak instead of the thoughtless, senseless, and often false copying of phrase, anecdote, style of argument, and sequence of topics that perpetuates itself by degraded repetition from text to text and thereby loses its anchor in nature.

I present an example that may seem tiny and peripheral in import. Nevertheless, and perhaps paradoxically, such cases provide our best evidence for thoughtless copying. When a truly important and well-known fact graces several texts in the same form, we cannot know whether it has been copied from previous sources or independently extracted from any expert's general knowledge. But when a quirky little senseless item attains the frequency of the proverbial bad penny, copying from text to text is the only reasonable interpretation. There is no other source. My method is no different from the standard technique of bibliographic scholars, who establish lineages of texts by tracing errors (particularly for documents spread by copyists before the invention of printing).

When textbooks choose to illustrate evolution with an example from the fossil record, they almost invariably trot out that greatest warhorse among case studies—the history of horses themselves (see my column of April 1987 for fallacies of the usual tale). The standard story begins with an animal informally called Eohippus (the dawn horse), or more properly, Hyracotherium. Since evolutionary increase in size is a major component of the traditional tale, all texts report the diminutive stature of ancestral Hyracotherium. A few give actual estimates or measurements, but most rely upon a simile with some modern organism. For years, I have been much amused (and mildly bothered) that the great majority of texts report Hyracotherium as "like a fox-terrier" in size. I was jolted into action when I found myself writing the same line, and then stopped. "Wait a minute," said my inner voice, "beyond some vague memories of Asta last time I watched a Thin Man movie, I haven't the slightest idea what a fox terrier is. I can't believe that the community of textbook authors includes only dog fanciers—so if I don't know, I'll bet most of them don't either." Clearly, the classical line has been copied from text to text. Where did it begin? What has been its history? Is the claim even correct?

My immediate spur to action came from a most welcome and unexpected source. I made a parenthetical remark about the fox terrier issue in my April 1987 column, ending with a serious point: "I also wonder what the textbook tradition of endless and thoughtless copying has done to retard the spread of original ideas."

I have, over the years, maintained a correspondence about our mutually favorite subject with Roger Angell of The New Yorker, who is, among other things, the greatest baseball writer ever. I assumed that his letter of early April would be a scouting report for the beginning of a new season. But I found that Roger Angell is a man of even more dimensions than I had realized; he is also a fox terrier fancier. He had read my parenthetical comment and wrote, "I am filled with excitement and trepidation at the prospect of writing you a letter about science instead of baseball."

Angell went on to suggest a fascinating and plausible explanation for the origin of the fox terrier simile (no excuse, of course, for its later cloning). Fox terriers were bred "to dig out foxes from their burrows, when a fox had gone to earth during a traditional British hunt." Apparently, generations of fox-hunting gentlemen selected fox terriers not only for their functional role in the hunt but also under a breeder's artifice to make them look as much like horses as possible. Angell continues, "The dogs rode up on the saddle during the hunt, and it was a pretty conceit for the owner-horseman to appear to put down a little simulacrum of a horse when the pack of hounds and the pink-coated throng had arrived at an earth where the animal was to do his work." He also pointed out that fox terriers tend to develop varied patches of color on a basically white coat and that a "saddle" along the back is "considered desirable and handsome." Thus, Angell proposed his solution: "Wouldn't it seem possible that some early horse geologist, in casting about for the right size animal to fit his elicite-to-be, might have settled, quite unconsciously, on a breed of dog that fitted the specifications in looks as well as size?"

This interesting conjecture led me to devise the following, loosely controlled experiment. I asked David Backus, my research assistant, to record every simile for Hyracotherium that he could find in the secondary literature of texts and popular books during more than a century since O.C. Marsh first recognized this animal as a "dawn horse." We would then use these patterns in attempting to locate original sources for favored similes in the primary literature of vertebrate paleontology. We consulted the books in my personal library as a sample, and compiled a total of eighty-six descriptions. The story turns
"... what makes the bordello of extraordinary interest is the way it mirrors the society in which it exists ... We find the whore who becomes empress; an empress a whore. And queens of the stage aspire to whorehouses of their own, too. Courtesans who model for immortality and trollops who set the course of nations ... masterful thieves, mass murderers and suicides galore. They're a variegated lot, as perverse and evil, as righteous and noble as the whole of mankind."

The quotation above is from Great Bordellos of the World, an illustrated history. Some readers, we imagine, might be shocked. We chose it because it illustrates a point: intellectual curiosity can be satisfied anywhere—in any time, any place, any subject.

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out to be much more ascertainable and revealing than I had imagined.

The tradition of simile begins at the very beginning. Richard Owen, the great British anatomist and paleontologist (see my column of October 1986), described the genus *Hyracotherium* in 1841. He did not recognize its relationship with horses (he considered this animal, as his chosen name implies, to be a possible relative of hyraxes, a small group of Afro-Asian mammals, the "conyes" of the Bible). In this original article, Owen likened his fossil to a hare in one passage and to something between a hog and a hyrax in another. Owen's simile plays no role in later history because other traditions of comparison had been long established before scientists realized that Owen's older discovery represented the same animal that Marsh later named *Eohippus*. (Hence, under the rules of taxonomy, Owen's inappropriate and unephonious name takes unfortunate precedence over Marsh's lovely *Eohippus*.)

The modern story begins with Marsh's description of the earliest horses in 1874. Marsh pressed "go" on the simile machine by writing, "This species was about as large as a fox." He also described the larger descendant *Miohippus* as sheeplike in size.

Throughout the nineteenth century all sources that we have found (eight references, including such major figures as Joseph Le Conte, Archibald Geikie, and even Marsh's bitter enemy E.D. Cope), copy Marsh's favored simile—they all describe *Eohippus* as fox sized. We are confident that Marsh's original description is the source because most references also repeat his statement that *Miohippus* is the size of a sheep. How, then, did fox terriers replace their prey?

The first decade of our century ushered in a mighty Darwinian competition among three alternatives and led to triumph for fox terriers. By 1910, three similes were battling for survival. Marsh's original fox suffered greatly from competition, but managed to retain a share of the market at about 25 percent (five of twenty citations between 1900 and 1925 in our sample)—a frequency that has been maintained ever since (see accompanying figure). Competition came from two stiff sources, however—both from the Museum that sponsors this magazine.

First, in 1903, W.D. Matthew, vertebrate paleontologist at the American Museum of Natural History, published his famous pamphlet *The Evolution of the Horse* (it remained in print for fifty years, and was still being sold at the Museum shop when I was a child). Matthew wrote: "The earliest known ancestors of the horse were small animals not larger than the domestic cat." Several secondary sources picked up Matthew's simile during this quarter century (also five of twenty references between 1900 and 1925), but felines have since faded (only one of fifteen references since 1975), and I do not know why.

Second, the three-way carnivorous competition of vulpine, feline, and canine began in earnest when man's best friend made his belated appearance in 1904 under the sponsorship of Matthew's boss, American Museum president and eminent vertebrate paleontologist Henry Fairfield Osborn. Remember that no nineteenth-century source (known to us) had advocated a canine simile, so Osborn's last entry suffered a temporal handicap. But Osborn was as commanding (and enigmatic) a figure as American natural history has ever produced—a powerful patriarch in science and politics, imperious but kind, prolific and pompous, crusader for natural history and for other causes of opposite merit (Osborn wrote, for example, a glowing preface to the most influential tract of American scientific racism, *The Passing of the Great Race*, by his friend Madison Grant).

In the *Century Magazine* for November 1904, Osborn published a popular article, "The Evolution of the Horse in America." (Given Osborn's almost obsessively prolific spate of publications, we would not be surprised if we have missed an earlier citation.) His first statement about *Eohippus* introduces the comparison that would later win the competition:

We may imagine the earliest herds of horses in the Lower Eocene (*Eohippus*, or "dawn horse" stage) as resembling a lot of small fox-terriers in size. . . . As in the terrier, the wrist (knee) was near the ground, the hand was still short, terminating in four hoofs, with a part of the fifth toe (thumb) dangling at the side.

Osborn provides no rationale for his choice of breeds. Perhaps he simply carried Marsh's old fox comparison unconsciously in his head and chose the dog most similar in name to the former standard. Perhaps Roger Angell's conjecture is correct. Osborn certainly came from a social set that knew about fox hunting. Moreover, as the quotation indicates, Osborn extended the similarity of *Eohippus* and fox terrier beyond mere size to other horselike attributes of this canine breed (although, in other sources, Osborn treated the whippet as even more horselike, and even mounted a whippet's skeleton for an explicit comparison with *Eohippus*). Roger Angell described his fox terrier to me: "The back is long and straight, the tail is held jauntily upward like a trotter's, the nose is elongated and equine, and the forelegs are strikingly thin and straight. In motion, the dog comes down on these forelegs in a rapid and distinctive, stiff, flashy style, and the dog appears to walk on his tiptoes—on hooves, that is."

In any case, we can trace the steady rise to domination of dog similes in general, and fox terriers in particular, ever since. Dogs reached nearly 50 percent of citations (nine of twenty) between 1900 and 1925, but have now risen to 60 percent (nine of fifteen) since 1975. Meanwhile, the percentage of fox terrier citations among dog similes had also climbed steadily, from one-third (three of nine) between 1900 and 1925 to one-half (eight of sixteen) between 1925 and 1975, to two-thirds (six of nine) since 1975. Osborn's simile has been victorious.

The only credible source for these shifts of popularity is copying: first from experts; then from other secondary sources. Shifts in fashion cannot reflect independent insights based on observation of specimens. *Eohippus* could not, by itself, say "fox" to every nineteenth-century observer and "dog" to most twentieth-century writers. Nor can I believe that two-thirds of all dog-inclined modern writers would independently say, "aha, fox terrier" when contemplating the dawn horse.
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The breed is no longer so popular, and I suspect that most writers, like me, have only the vaguest impression about fox terriers when they copy the venerable simile.

In fact, we can trace the rise to dominance of fox terriers in our references. The first post-Osborn citation that we can find (Ernest Ingersoll, The Life of Animals, MacMillan, 1906) credits Osborn explicitly as author of the comparison with fox terriers. Thereafter, no one cites the original, and I assume that the process of typing text had begun.

Two processes seem to have seeded the domination of fox terriers. First, experts began to line up behind Osborn's choice. The great vertebrate paleontologist W.B. Scott, for example, stood in loyal opposition in 1913, 1919, and 1929 when he cited both alternatives of fox and cat. But by 1937, he had switched: "Hyracotherium was a little animal about the size of a fox-terrier, but horse-like in all parts." Second, dogs became firmly ensconced in major textbooks. Both leading American geology textbooks of the early twentieth century (Chamberlin and Salisbury, 1909 edition, and Pirson and Schuchert, 1924 edition) opt for canines, as does Hegner's zoology text (1912) and W. Maxwell Read's fine children's book (a mainstay of my youth) The Earth for Sam (1930 edition).

Fox terriers have only firméd up their position ever since. Experts cite this simple, as in A.S. Romer's leading text Vertebrate Paleontology (3d edition, 1966): "Eohippus was a small form, some specimens no larger than a fox terrier." They have also edited the two leading high-school texts: (1) Otto and Towle (descendant of Moon, Mann, and Otto, the dominant text for most of the past fifty years): "This horse is called Eohippus. It had four toes and was about the size of a fox-terrier" (1977 edition); (2) the Biological Sciences Curriculum Study, Blue Edition (1968): "The fossil of a small four-toed animal about the size of a fox-terrier was found preserved in layers of rock." College texts also comply. W.T. Keeton, in his Biological Science, the Hertz of the profession, writes (1980 edition): "It was a small animal, only about the size of a fox-terrier." Baker and Allen's Study of Biology, a strong Avis, agrees (1982 edition): "This small animal Eohippus was not much bigger than a fox-terrier."

You may care little for dawn horses or fox terriers and might feel that I have made much of nothing in this essay. But I cite the ease of the creeping fox terrier clone not for itself, but rather as a particularly clear example of a pervasive and serious disease—the debasement of our textbooks, the basic tool of written education, by endless, thoughtless copying.

My younger son started high school last month. For a biology text, he is using the 4th edition of Biology: Living Systems, by R.F. Oram, with consultants P.J. Hummer and R.C. Smoot (Charles E. Merrill, 1983, but listed on the title page, following our modern reality of conglomerating, as a Bell and Howell Company). I was sad and angered to find several disgraceful passages of capitulation to creationist pressure. Page one of the chapter on evolution proclaims in a blue sidebar: "The theory of evolution is the most widely accepted scientific explanation of the origin of life and changes in living things. You may wish to investigate other theories." Similar invitations are not issued for any other well-established theory. Students are not told that "most folks accept gravitation, but you might want to check out levitation" or that "most people view the earth as a sphere, but you might want to consider the possibility of a plane." When the text reaches human history, it doesn't even grant majority status to our evolutionary consensus: "Humans are indeed unique, but because they are also organisms, many scientists believe that humans have an evolutionary history."

Yet, as I argued at the outset, I find these compromises to outside pressure, disgraceful though they be, less serious than the internal disease of cloning from text to text. There is virtually only one chapter on evolution in all high-school biology texts, copied and degraded, then copied and degraded again. My son's book is no exception. This chapter begins with a discussion of Lamarck and the inheritance of acquired characters. It then moves to Darwin and natural selection and follows this basic contrast with a picture of a giraffe and a disquisition on Lamarckian and Darwinian explanations for long necks. A bit later, we reach industrial melanism in moths and dawn horses of you-know-what size.

What is the point of all this? I could understand this development if Lamarckism were a folk notion that must be dispelled before introducing Darwin or if Lamarck were a household name. But I will lay 100 to 1 that few high-school students have ever heard of Lamarck. Why begin teaching evolution by explicating a false theory that is causing no confusion? False notions are often wonderful tools in pedagogy, but not when they are unknown, are provoking no trouble, and make the grasp of an accepted theory more difficult. I would not teach more sophisticated college students this way; I simply can't believe that this sequence works in high school. I can only conclude that someone once wrote the material this way for a reason lost in the mists of time, and that authors of textbooks have been dutifully copying "Lamarck . . . Darwin . . . giraffe necks" ever since.

(The giraffe necks, by the way, make even less sense. This venerable example rests upon no data at all for the superiority of Darwinian explanation. Lamarck offered no evidence for his interpretation and only introduced the case in a few lines of speculation. We have no proof that the long neck evolved by natural selection for eating leaves at the tops of acacia trees. We only prefer this explanation because it matches current orthodoxy. Giraffes do munch the topmost leaves, and this habit obviously helps them to thrive, but who knows how their necks elongated? They may have lengthened for other reasons and then been fortuitously suited for acacia leaves.)

If textbook cloning represented the discovery of a true educational optimum, and its further honing and propagation, then I would not object. But all evidence—from my little story of fox terriers to the larger issue of a senseless but nearly universal sequence of Lamarck, Darwin, and giraffe necks—indicates that cloning bears an opposite and discouraging message. It is the easy way out, a substitute for thinking and striving to improve. Somehow I must believe—for it is essential to my notion of scholarship—that good teaching requires fresh thought and genuine excitement and that rote copying can only indite boredom and slipshod practice. A carelessly cloned work will not excite students, however pretty the pictures. As an antidote, we need only the most basic virtue of integrity—not only the usual, figurative meaning of honorable practice but the less familiar, literal definition of wholeness. We will not have great texts if authors cannot shape content but must serve a commercial master as one cog in an ultimately powerless consortium with other packagers.

To end with a simpler point amid all this tendentiousness and generality: thoughtlessly cloned "eternal verities" are often wrong. The latest estimate I have seen for the body size of Hyracotherium, challenging previous reconstructions congenial with the standard simile of fox terriers, cites a weight of some twenty-five kilograms, or fifty-five pounds (B.J. MacFadden, Paleobiology, Fall 1986).

Lassie come home!

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.
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Annapurna I (left) and Annapurna South tower more than 10,000 feet above the grass meadows and glacial moraines of the sacred Annapurna Sanctuary of central Nepal.

Jon O'Neill
Sacred and Profaned Himalayas

In the high mountains of central Nepal, tourists trespass on the abode of the gods

by Stan Stevens

At the heart of the Himalayas of central Nepal is the Annapurna Range: thirty-five miles of high peaks; sixteen summits of more than 20,000 feet unbroken by a single pass. The mountains rise abruptly from subtropical forests of poinsettia, bougainvillea, and banana. Five of these peaks are the Annapurnas from which the range takes its name. The highest, Annapurna I, at 26,545 feet, is the tenth highest mountain in the world. Annapurna South, at a height of 23,607 feet the lowest of the peaks, is still higher than any mountain outside of Asia.

For two thousand years pilgrims have come to the Annapurnas from the lowlands of India and the far corners of Nepal. For Hindus the Himalayas are the abode of the gods. For the Gurung people, who share the lower slopes with several other peoples, the gods dwell on the snow peaks. The Gurungs tell of seeing columns of smoke rising from the nearby 22,942-foot summit of Machapuchare—incense being offered by the meditating Shiva.

The mountains can be approached by a single trail that winds through the narrow gorge of the Modi Khola River. The trail rises 6,000 feet in five miles, alongside white water and between walls never more than half a mile apart or less than 3,000 feet high. Above the last rhododendron and bamboo forests the trail traverses high meadows and reaches a portal cut between Machapuchare and Hiunchuli. At 13,000 feet the climb ends and the world widens into a vista of sharp ridges, white walls, and shattered icefalls. This alpine basin, a four-by-two-mile pocket of meadows, moraines, and glaciers, is the Annapurna Sanctuary.

The most powerful of all the Gurung guardian spirits, Pujinin Barahar, protects the approach to Annapurna Sanctuary. At a point where the gorge narrows to thirty yards and a waterfall drapes one wall, the Gurungs have built a small wayside shrine to the Barahar. Each summer Gurung shepherds bound for the sanctuary pastures stop here to petition for safe passage, good grass, and good luck. Strict taboos once preserved the purity of the place. Beyond the shrine no impure person could pass: no one of low caste, no woman,
no one who had not made the proper prayers. No polluting foods were allowed: no pig, chicken, cow, or water buffalo; no eggs, no garlic. Violations invited disaster, for the Barahar, who lives in forests and pools and is worshiped with sacrifices, prayers, and flowers, would send famine, destroying crops with hail.

Gurungs trace their origins to Tibet but have combined Tibetan Buddhist beliefs with Hinduism and belief in spirits. Gurung morning prayers combine offerings to Hindu gods with ancestor veneration. Rites to insure reincarnation can require not only the services of a Buddhist lama but also that of a shaman to conduct goat and sheep sacrifices. According to legend, twenty-five generations have passed since the Gurungs first crossed west into the Modi Khola valley seeking new hunting grounds. The valley then was wilderness and unbroken forest with plenty of game—bog deer, leopards, tigers, and the now-endangered red panda. Pheasant and musk deer lived in the alpine woods. In the tree-line country and the high snow-line meadows, herds of the antelope-like goral and Himalayan tahr grazed, while snow leopards roamed the heights. The abundance so impressed the first hunting party that they returned to found a settlement of round wattle-and-daub, thatch-roofed huts that grew into Ghandruk, then, as now, the major village of the valley. A collection of seven hamlets and about five hundred houses overlooking the Modi Khola, Ghandruk nestles in the shadows of Machapuchare, Hiunchuli, and Annapurna South less than ten miles to the north.

For centuries Ghandruk was a village of swidden cultivators practicing a form of forest agriculture that was once widespread in the Himalayas. Each spring Gurungs cut and burned a section of forest, then sowed seed in the fertile ash. Families planted barley, millet, and wheat on the steep slopes. After a single harvest
the fields were allowed to return to forest. Regeneration was rapid (the lower valley receives about 220 inches of precipitation per year, the upper valley about 125 inches), and after a decade or so, secondary forest was mature enough to provide abundant ash for another crop.

In the last hundred years, the basis of Gurung subsistence has shifted. As the population increased, the length of time a plot went unfarmed was shortened. By the turn of the century Gurungs were allowing vegetation to regenerate for only a single year before cutting and burning it. As yields declined, Gurungs began to experiment, to mix farming and herding and adopt new crops. From lowland neighbors, Gurungs learned to grow rice on irrigated paddy terraces. New World crops such as maize and potatoes became staples. Millet, the last crop grown extensively in swidden fields, is now grown on terraces.

With permanent cultivation, burned forest no longer provided ash for fertilizer. The need for grazing land placed an added demand on remaining woodland. Livestock were now kept as much for nurture as for milk, meat, or wool. This economic transformation rapidly altered the ecology and landscape of the Modi Khola valley. In the past, swidden farming had conserved forest, but in the last hundred years tiers of terraces have replaced vast forests. In the Ghandruk area, terraces cascade across the mountainsides. From 2,000 feet to 7,000 feet the only forest that remains is either relict woods on steep, marginal land or sacred groves protected out of fear and respect for the guardian spirits of the villages. For another thousand feet the mountain slopes are scarred by the cumulative impacts of fodder and fuelwood gathering, grazing, and logging. Large herds of sheep and goats graze at elevations as high as 17,000 feet on the rich bunch grass pastures of the Annapurna Sanctuary. Degraded scrub alternates with bare slopes of grass. And in the high forests the losses have recently been exacerbated by a new development in the Modi Khola valley—tourism.

Like most of Nepal, the entire Annapurna Range was off-limits to foreign travelers until 1950, when the government began to relax its restrictions. When Col. J.O.M. “Jimmie” Roberts appeared in Ghandruk in 1956 he was the first foreigner to enter the village. Roberts, an Englishman, had come looking for food, porters, and a trail to Machapuchare. He intended to scout the north side of the mountain for a climbing route for a British expedition he planned to co-lead the following year. The Gurungs gave Roberts an unfriendly reception. They told him no outsider could go into the upper valley, refused to sell him food, and only grudgingly admitted they knew of a path up the gorge. Giving up on finding help in Ghandruk, Roberts went on the next day to Chumro, the last Gurung settlement before the uninhabited gorge.

Chumro villagers eventually agreed to help. They would take him upriver to the sanctuary. But if he was going to go he would have to go as Gurungs went: taboos
The rhododendron is the national flower of Nepal, but few of the rhododendron forests of the Modi Khola gorge, below, remain pristine. Many have been hacked away for firewood or burned for agriculture. At sunset a glow illuminates the west face of Machapuchare, right, one of the mountains flanking the portal to the Annapurna Sanctuary.

Both photographs by Jon Ottmer

must be respected; offerings must be made. When they reached the shrine in the gorge the Gurungs insisted that Roberts leave behind all impure foods. Although he chafed at what he thought were simple superstitions, at the shrine Roberts abandoned four dozen eggs to satisfy the spirits and the Gurungs.

The next year Roberts returned to guide a small expedition up the Modi Khola. This time the Ghandruk Gurungs told Roberts he could not continue on to the sanctuary because the spirits would surely punish the Gurungs with storms. Roberts replied that he would look after the spirits. He also mentioned that as the Gurkha army recruiter for the region, he controlled the precious positions with the British army and that in the future, few Ghandruk men might find places. At this the elders spat on the ground and turned away. But the expedition continued up the valley unhindered.

No hail destroyed the Gurung crops that spring. The British had bad luck, though. One expedition member came down with polio and had to be evacuated. The summit team ran out of time just two hundred feet below the top, calling the climb to a halt with dark coming on and a final pitch of steep ice still ahead. No one has been closer to the summit since. A few years later when one Nepalese peak was to be set aside as inviolate, Roberts suggested Machapuchare, and it is no longer open to mountaineers.

Before 1970, few visitors other than shepherds came to the Annapurnas. But independent adventurers discovered the mountains, and soon commercial agencies began to bring catered camping tours, offering the charms of simple teahouses and of staying in local homes. Relatively easy access and spectacular terrain made the Annapurna Range the most popular trekking region in Nepal. Soon three times as many tourists were visiting the Annapurnas as were going to the Mount Everest area. The Gurungs began to try their hand at hostelry. The first lodges prospered and others soon opened. By spring of 1987 sixteen lodges were operating in Ghandruk, eleven in Chumro, twenty in the gorge, and six in the sanctuary itself. Most are small one-story structures with very basic facilities. But the early bamboo huts are rapidly being upgraded, and the new, two-story hotels are built of stone, with fifteen double rooms, shower houses, and menus that offer spaghetti, chop suey, and pizza, as well as chocolate pudding.

Uncontrolled development has brought further environmental and cultural impacts to the Modi Khola valley. The new demand for fuel and timber by lodge operators and trekking groups has lowered the tree line several hundred feet. No trees are left within the sanctuary itself, only shrubs and stumps. The grove of moss-hung birches, some a foot and a half in diameter, which has long shaded the entrance to the sanctuary, is getting smaller each trekking season. The trail is lined with the hulks of these venerable trees, some standing with all limbs amputated.

At elevations of 6,000 to 10,000 feet,
where five years ago entire ridges were cloaked in rhododendron (Nepal’s national flower), large areas, especially along the lower gorge trail, have been clear-cut to build and fuel lodges. The bamboo left behind is much sought after as building material, and Gurungs from as far off as Ghandruk come here for the grass. Although in the Modi Khola valley’s mild climate new grass and bamboo soon cover the rhododendron stumps, the growth is nothing like that of the uncut forest that remains higher up the gorge, where the massive rhododendrons still dominate, and in whose shadows ferns and flowers still flourish. This is the forest of the spirit of the gorge, Pujinim Barahar, kept inviolate by Gurung respect. In the upper valley, it is the only substantial pocket of pristine forest left.

Wildlife has fared no better than forest. Gurungs no longer hunt for subsistence, but sport hunting is an important social convention. The most popular game animals—goral, tahr, pheasant, and hog deer—are declining. Hunting pressure has been increased by the appeal of the new profits to be made selling game to lodges. Ghoral steak or roast pheasant is often the only sign that tourists see of scarce Modi Khola wildlife. Deforestation is destroying the remaining habitat of the musk deer and the rare Himalayan red panda and snow leopard.

Tourism takes a cultural toll as well. Few Gurungs profit from the new economy. Gurungs spurn work as porters or guides, and the only families directly involved with tourism are those with lodges or shops, less than one percent of local households. Inflation has made fruits, vegetables, and eggs so expensive that some local people can no longer afford them. Gurung parents are concerned that tourism will lead young Gurungs to lose interest in their culture and their traditional livelihood of farming and herding. And many Gurungs are convinced that tourism conflicts with
the values and practices that insured harmony between Gurungs and the spirits of the Modi Khola valley. They believe that the guardian Barahar has been angered by tourists who violate the sanctity of Annapurna Sanctuary. Although villagers no longer try to bar tourists or enforce the old food taboos, devout Gurungs are outraged by tourists eating chicken, pork, and eggs in the sanctuary, by foreign women going where Gurung women have always been forbidden, and by visitors befouling the sanctuary with toilet paper and garbage. They resent the erosion of religious customs, which they feel has brought bad luck, bad harvests, and increasingly frequent and severe hailstorms.

In 1985, with the environmental degradation beginning to worry foreign conservationists and tour promoters (Jimmie Roberts, who founded the first trekking agency, urged restricting the numbers of tourists allowed to visit the sanctuary and closing the area altogether for five years to allow the forest to recover), the Annapurna Range suddenly became one of Nepal’s top conservation priorities. King Birendra Bir Bikram Shad Dev issued directives to establish a protected area along the Modi Khola valley and Annapurna Sanctuary.

Annapurna Conservation Area headquarters was set up in Ghandruk in December 1986. By the spring of 1987 Gurungs had set up local management committees to regulate lodge development and forest use. By April a kerosene depot was set up at Chhumro, and all lodges in the upper gorge and the sanctuary had converted from cooking with wood to using kerosene stoves. A nursery was established at Ghandruk and village land donated for a fuelwood plantation. Moreover, Ghandruk villagers decided to ban tree cutting for fuelwood within a two-hour walk from the settlement. The Conservation Area, in return, has provided funds to support the school, establish the first clinic in the region, set up the fuelwood nursery, train Gurungs for park posts and lodgekeepers in more sophisticated hostelry techniques, and has granted loans to upgrade inns. Conservation Area administrators have also appealed to tourists to be more responsible: to avoid the use of fuelwood, dispose of waste carefully, and respect local customs and beliefs. A plan is under study to implement a carrying-capacity-based quota on visitors to the sanctuary.

Lodgekeepers from the sanctuary and the upper gorge devised a new ceremony. Gathering at the shrine in the gorge as they head home after closing their lodges for the monsoon, they offer prayers to the Barahar, as a way of atoning for offenses their guests might have caused in crossing the threshold between the ordinary universe and a sacred realm.

In the tropical climes at the base of the Himalayas, rice, bananas, mustard plants, tobacco, chilies, and mangoes are grown in terraced plots that rise up the steep hillside, below. The walls of the Modi Khola gorge, right, form the pass through which the Annapurna Sanctuary is approached. Some five miles and still a half day’s trek to the sanctuary, the trail tunnels through thick temperate forests of maple, oak, birch, and hemlock.

Both photographs by Jimmie Roberts
Caterpillars on Ice

Methuselahs of the insect world, arctic woolly bears spend most of their long lives in a deep freeze

by Olga Kukal

Alexandra Fiord lies some eight hundred miles from the North Pole, on the eastern shore of Ellesmere Island in northern Canada. In 1981, I spent my first summer in this part of the High Arctic as a member of a scientific expedition. A few weeks before I arrived, the sun had stopped dipping below the horizon of crags and ice fields, and three summer months of midnight sun had begun. In early June, when the first patches of open ground appeared, I set off on skis to investigate them. The heat of the midday sun was intense, but temperatures still dropped below freezing during the dusky “night,” locking the day’s snowmelt into a glassy coat that covered the tundra. On the more elevated, drier patches, this coat was very thin, enclosing the life below in a kind of natural greenhouse. The higher temperature and humidity under the ice helped stir the plants and animals from their long winter dormancy.

The only creatures I found on the snow-free tundra were thumb-sized caterpillars with long, orange-brown hair. These larvae were basking in the sun, oriented to allow the largest possible body surface to trap the sun’s rays. Occasionally, one would stir and start to nibble on a low-growing plant still devoid of green shoots. In the total stillness of the fiord, the chewing was audible. I began to wonder what secrets these caterpillars could reveal to a biologist; in particular, how they survived in the Arctic. For the past six summers, I have returned north to find out.

Most of the High Arctic is a barren, windswept desert, but a few areas sustain life. These oases vary in size and are usually separated by great distances. The larger oases, such as Lake Hazen on the northern tip of Ellesmere Island or True-love lowland on Devon Island, have expanses of sedge meadows that provide forage for musk oxen and caribou. These herbivores, in turn, are the prey of the top carnivore, the arctic wolf. At approximately seven square miles, Alexandra Fiord lowland is too small to sustain any of the larger mammals, and even smaller ones, such as lemmings and foxes, are relatively scarce, as are most common arctic birds. Uncontested by higher-level consumers, the lush carpet of plants is a readily available source of food for invertebrates such as woolly bear caterpillars, in this case a lymantrid moth species, Gynaephora groenlandica, found only in the High Arctic archipelago and Greenland and abundant at the Alexandra Fiord lowland.

The topography of Alexandra Fiord lowland promotes the growth of tundra plants such as the dwarfed arctic willow, purple saxifrage, arctic heather, arctic poppies, and a multitude of grasses and sedges. Nestled into the south shore of the fiord, the bowl-shaped lowland is rimmed by glacier-laden mountain ridges. The glacial ice, acting as a parabolic reflector, focuses the sun’s rays on the lowland, melting the snow and uncovering the plants beneath. Once exposed, the mat of vegetation acts as an absorbent heat sink. Eventually the heat radiates upward, preventing cloud formation and consequently minimizing local precipitation. At the same time, the melting glaciers spill rivulets of water into the sedge meadows, irrigating the plants. Without this meltwater, the lowland would be as much of a desert as the surrounding areas.

Having made the acquaintance of arctic woolly bears, I prepared to launch a scientific study of the caterpillars at what I believed to be an ideal time, mid-June. But showing no regard for my carefully planned schedule, the hundreds of larvae I had found prior to the summer solstice suddenly vanished, well before the full bloom of the arctic summer. Why did the larvae go into hiding? Why did they curtail their already very brief period of feeding and growth? With that summer’s fieldwork cut short, I left the Arctic with more questions than I had come with.

I decided to resume my investigation by trying to establish the outlines of the woolly bear’s life cycle, and the following summer I returned at the beginning of June for an intensive three-week caterpillar watch. I collected, photographed, counted, dissected, measured, weighed, fed, and timed. But the full story emerged only after I used the data to figure out the number of larval stages (from the distribution of larva head-capsule measurements)
The arctic woolly bear's handsome pelt gathers heat on sunny days.
Raymond A. Mendez
and the duration of each stage, or instar. I derived instar length from the frequency of molts—the shedding of the hard exoskeleton to allow further growth—within each larval stage.

Arctic woolly bears, I discovered, live at least fourteen years, an extremely long span for an insect. I determined that each one would have to molt six times before becoming a pupa, the stage prior to that of the adult moth. A few days after being laid, the eggs hatch into tiny first instars, all of which soon molt into the next larval stage, which overwinters. The next summer, the second instars all molt into the third larval stage. At this phase of development the pattern of molting changes; the period required for growth between the shedding of cuticle is extended. Although all first- and second-instar larvae molt simultaneously, only about one-third of the third-, fourth-, and fifth-instar larvae and one-quarter of the sixth-stage larvae molt in a single summer season. Thus the third, fourth, and fifth larval stage each require three years to complete development; another four years takes the sixth larval stage through pupation to a new generation of first-instar larvae. The life cycle then repeats itself for yet another fourteen years. The arctic moth spends less than 6 percent of its lifetime as an egg, young first-stage larva, pupa, and adult. The lengthy remainder is spent as a slowly developing second- to sixth-stage larva—active and growing for only a fraction of the arctic summer and locked in ice for the winter. Since the adults do not feed and are sensitive to freezing temperatures, the food and solar energy gathered by larvae in fourteen summers must insure the adult moths’ brief survival and rapid reproduction.

My investigation of the woolly bear life cycle failed to explain why the caterpillars abruptly stopped feeding and disappeared from the tundra surface before the peak of summer. I found the answer inside their bodies. In more than half of the larvae and pupae I had collected, I found parasitoids, insects that feed upon specific hosts and ultimately kill them. The larvae of a solitary ichneumon wasp were living off many of the young caterpillars, from which the wasps emerged each summer; the wasps then overwintered as adults. Also, two to sixteen individuals of an undescribed bristle fly species were parasitizing many of the older caterpillar larvae and pupae. The flies probably overwinter as larvae within the host, taking several years to reach adulthood. Overall, these two parasitoids killed more than two-thirds of each host generation—more than five times the number of caterpillars that we estimated die during the winter. In one respect, our findings contested a truism about which factors control population in harsh environments. Unlike most other arctic organisms, our caterpillars were being regulated by a biological factor—the parasitoids—rather than by low temperature. Together with Peter Kavan, an arctic pollution biologist, I wrote a computer program simulating the insect’s life cycle. The program predicts summer versus winter mortality. Interestingly, the figures indicated that only 13 percent of woolly bears die during the long, harsh winters of their fourteen-year life cycle. Summer is the risky season for these animals.

Woolly bears avoid annihilation by becoming active on the tundra surface only at the onset of summer, when very few adult parasitoids have yet emerged. Before the peak of parasitoid emergence, the caterpillars disappear. The vanishing act is most likely an adaptation to avoid parasitoids, since synchrony with the parasitoids’ life cycle might lead to the permanent disappearance of the host species.

I then focused on how the larvae that escape the parasitoids manage to survive thirteen frigid winters. With winter temperatures often plunging as low as −90° F, extreme cold hardiness is essential to the survival of any organism in the High Arctic. Warmblooded animals, such as birds and mammals, prevent damage to their tissues by maintaining high body temperatures. Most creatures also seek out sheltered hibernation sites that buffer them from ambient temperatures. But arctic woolly bears take a more drastic approach: they freeze while exposed near the windswept ground surface.

Nearly 250 years ago, the first pioneers in the area discovered that, unlike their frozen toes, frozen woolly bears could be brought back to life by thawing. James Ross (1800–1862), the renowned arctic explorer and naturalist, wrote:

About thirty of the caterpillars were put into a box in the middle of September, and after being exposed to the severe winter temperature of the next three months, they

Alexandra Fiord’s first snowmelt in early June finds a woolly bear basking in a miniature “solarium,” turning its body so that the largest possible area is exposed to the sun’s rays, below. An arctic woolly bear undergoes many molts; the cuticle and its overlying hairs are shed to allow for the caterpillar’s growth, right, top. After thirteen years as a larva, the woolly bear spins a cocoon and graduates to the pupa stage, right, bottom. If the threads of the cocoon are not firmly anchored to rock and the tips of nearby low-lying plants, the pupa may be blown away by fierce winds.
were brought into a warm cabin; where in less than two hours, every one of them returned to life, and continued for a whole day walking about; they were again exposed to the air at a temperature of 40° below zero, and became immediately frozen; in this state they remained a week, and on being brought again into the cabin, only twenty-three came to life; these were at the end of four hours put out once more into the air, and again hard frozen; after another week they were brought in, when only eleven were restored to life; a fourth time they were exposed to the winter temperature, and only two returned to life on being brought into the cabin; these two survived the winter, and in May an imperfect Laria [Gynaephora] was produced from one, and six flies [likely the bristle fly parasitoids] from the other.

Insects, in general, adopt one of two modes of winter survival. Some are freeze sensitive; they avoid freezing by lowering the freezing point of their tissues with compounds such as glycerol or even ethylene glycol, the ingredient in common automobile antifreeze. Other insects are freeze tolerant and actually induce freezing in parts of their bodies. The key to surviving freezing is to prevent dehydration and ice formation inside cells while ice slowly fills the rest of the body, including the contents of the gut, the blood, and the spaces between cells. Freeze-tolerant insects synthesize and manufacture "cryoprotectants," chemicals that allow body tissue to survive freezing by reducing the proportion of bodily water locked up in ice. The same compound, such as glycerol, can function as an antifreeze in a freeze-sensitive insect and as a cryoprotectant in a freeze-tolerant one.

Arctic woolly bears are a perfect model for the study of freeze tolerance: extremely hardy in the winter, they withstand temperatures of −95° F and perhaps lower. Furthermore, they remain freeze tolerant to about 5° F while active in the summer. Virtually all other insects lose their ability to tolerate freezing in the summer when they lose their ability to manufacture cryoprotectants.

With the help of Tony Serianni, a chemist, and Jack Duman, a specialist in insect cold tolerance, I am probing the freeze-tolerance puzzle by studying freezing in arctic wooly bear tissue, as well as metabolism in live, unharmed caterpillars. Our findings so far show that our caterpillars can synthesize glycerol even at high temperatures, but can store glycerol only at low temperatures (less than 40° F) or when frozen (less than 20° F). Our metabolism studies indicated that glycerol accumulation is linked to reduced oxygen consumption at low temperatures. The reduced oxygen consumption is in turn related to adaptive changes in mitochondria—the tiny organelles responsible for cellular respiration—leading to reduced oxidative metabolism. Larvae are capable of glycerol production, even after being frozen, because the previous summer's energy stores are being channeled into glycerol synthesis.

Caterpillar behavior, as well as chemistry, plays a role in regulating body heat. Like most other insects, arctic wooly bears, being coldblooded, cannot generate body temperature from metabolic heat. Nevertheless, these larvae can raise their body temperatures as much as 75° above the temperature of the air by basking, orienting perpendicularly to the sun's rays. Over the course of twenty-four hours, the caterpillars track the sun's journey in a miniature circle of imperceptible motion. A larva's long, dark, dense hair
absorbs and retains heat. When the “dead-air barrier” along the hairy body is disrupted by motion or wind, the caterpillar’s body temperature drops. Consequently, each time larvae move or feed or are exposed to air currents, they suffer an energy loss. Essentially, they must compromise between gaining energy from sunshine and losing energy by moving and feeding. Since most of their time is spent basking and motion is limited to the search for new feeding sites, my conjecture is that raising body temperature is essential in aiding the assimilation of food and promoting growth.

The balance, however, is delicate. If body temperature is too high, the energy lost in respiration can exceed the energy obtained from food. In a series of feeding experiments, I found that the caterpillars digest their food more efficiently and use up less energy maintaining a high metabolic rate at 60° F than at the 85° F achieved by basking. According to plant physiologist Todd Dawson, early in the season, arctic willow buds and leaves—the woolly bears’ favorite food—are very high in nutrients and low in the potentially toxic tannins. Later in the season, when food quality worsens, the woolly bears slow down their metabolism. Instead of basking, they hide from the sun; this conserves energy for the winter.

Although the sun never sets during the arctic summer, air temperatures still fall at night and drop greatly during cloudy or snowy periods. How do the caterpillars deal with lower air temperatures while heat from the sun is inaccessible to them? They continue to bask but allow their body temperatures to drop. If body temperature falls below 40° F, the larvae start to accumulate cryoprotective glycerol, which guards them against freezing damage even if the ambient temperature continues to fall. In this way, the woolly bears maintain freeze tolerance in the arctic summer, even though this is the period of their greatest growth and activity.

The arctic woolly bear is one of the most cold hardy of all insect species, and I can only marvel at its physiology and behavior: During its fourteen-year life span, most of its time is spent frozen solid. The caterpillar awakens briefly during the arctic summer and seeks out sunshine to warm its body to 85° F. This is close to the temperature of the human body, which cannot deviate by more than 10° F without causing grave danger to life. In a sense, this insect has realized the human fantasy of suspended animation.
A Faithful, Fickle Hawk

The fluctuating Everglades influences the nesting behavior of an endangered bird

by Steven R. Beissinger

It was unusually warm and foggy at sunrise as we climbed from an airboat onto a cramped, four-by-four-foot observation platform. From this perch, fifteen feet above the cattail and sawgrass marsh of Florida's Lake Okeechobee, Noel Snyder—then an endangered species biologist with the U.S. Fish and Wildlife Service—and I began our daily observation of two pairs of snail kites at their nests, about a hundred yards away. With the goal of pinning down the factors that limited population growth in this endangered population, we had been focusing on the feeding and reproductive habits of these two pairs, using stopwatches to determine the time each parent bird spent flying in search of food or in nesting activities. It was April 1979, and we had already been at our dawn-to-dusk job for more than two months. In the open, nearly treeless habitat, we could easily follow the birds' movements with our spotting scopes and binoculars.

That morning, after the fog lifted, we first noted the absence of one of the females. Her young were about five weeks old, almost ready to leave the nest, but still five weeks from being able to feed themselves. So when she failed to reappear all that day or during our next visit, we assumed that she had somehow died. But then, about ten days later, the male at the neighboring nest also disappeared. Curious, we checked other snail kite nests on Lake Okeechobee that year and found that it was common to see only one parent bird caring for young at or near the time of fledging. We thought then that we had come upon something very unusual—regular mate desertion by either sex.

Most birds remain paired while they raise young, but in a sizable minority of species the males desert, leaving their original mates to care for young while they attempt to father other broods with other females. Rarely, as in phalaropes, the roles are reversed, and females depart, leaving the males to incubate the eggs and feed the young. In no species that we knew of was mate desertion leading to polygamy a characteristic of both sexes.

Intrigued by the unorthodoxy of what we saw, I decided to investigate the phenomenon. During the next four years, I studied the snail kite throughout southern Florida, looking for the ecological and behavioral factors that might correlate with ambisexual mate desertion. In all, I spent more than 3,000 hours observing 36 nests in detail. I also examined data that I helped collect on 300 nests for conservation and management purposes. During this time, I worked throughout southern Florida, following the major kite nesting concentrations from Lake Okeechobee to several lakes just south of Orlando (Kissimmee and Tohopekaliga) and finally back to the Everglades in State Water Conservation Area 3A, west of Miami.

The ecology of the snail kite revolves around its specialized diet, which consists almost exclusively of a genus of freshwater mollusk called Pomacea, or apple snails. Although in hard times the kites may dine occasionally on a small turtle, freshwater crab, or rodent, their dependence on the apple snail is almost absolute and confines them to freshwater marshes, lakes, and ponds.

The kite's long, thin, downwardly curving bill, relatively weak talons, and long
tarsi are adaptations for catching and eating snails. Apple snails must surface periodically to breathe and feed, and can be caught by kites when within six inches of the surface—the approximate reach of the bird's leg into the water. A kite hunts snails either by slowly flying into the wind in an almost buoyant fashion ten to fifteen feet above the marsh or by scanning from a perch. When it spots a snail, it hovers near the surface of the water, extends its foot, and plucks out the mollusk.

The three recognized subspecies of snail kite differ from one another only slightly in body proportions of bill and wing; one inhabits South America (from Ecuador and Venezuela to Argentina); another is found in Central America (southern Mexico to northern Panama). I was studying the third subspecies, which lives in Cuba and the United States, but the latter population is restricted to the few remaining wetlands in southern Florida. When developers began massive drainage of the Everglades for agriculture and housing, Florida's snail kite population declined rapidly. By the late 1960s and early 1970s, their numbers are believed to have fallen to as few as 50 or 60 individuals. Since then, kite numbers have risen rapidly in rainy years when water levels were high, reaching more than 650 in 1980 and again in 1984, and declined sharply during dry years. In 1981–82, only about 250 birds survived a severe drought that caused the species to disperse throughout the Florida peninsula in search of food.

Not only do many adults die in drought years, but few young fledge. Normally, snail kites nest in loose colonies and build their nests (each containing two or three eggs) in small shrubs growing above shallow water. But when waters recede, the birds build nests in cattails that grow in the deeper waters of the lake beds. Cattail nests, sticks piled sloppily atop the vegetation, are not as stable as nests in the shrubs and often collapse in strong winds. To increase nesting success during dry years, Rod Chandler, a National Audubon Society warden, began placing nests built in cattails in wire-frame baskets and suspending them on strong poles in their original positions in the marsh. The parent kites usually adjust to these modified nests within an hour, and Chandler and I found that nests placed in wire baskets were far more likely to fledge young successfully than those left undisturbed.

At both basketed and natural nests, mate desertion by kites was common, occurring at about three-quarters of the thirty-six nests that I studied in detail. Males and females deserted equally often in all years but one, when females were more often the deserters, perhaps because there were several unmaled males available nearby. Although nests were frequently abandoned by both parents before eggs were laid, these often seemed to be situations in which both adults were abandoning nesting altogether, perhaps due to poor environmental conditions.

Given that kite populations are prone to sudden crashes, how did we know that a missing parent hadn't simply died? First, the timing of the disappearances sug-
Once it has spotted an apple snail near the surface, the kite hovers until it can pluck the mollusk from the water with one foot. As the bird flies off, it usually transfers the snail from talon to beak.

Both photographs by James A. Kern

Suggested that they were desertions. Parents usually left their offspring very near the time of fledging when the young were three to five weeks of age, no longer in need of being brooded but still about three to six weeks from independence. If the adults’ disappearances were deaths, the desertions should have been more evenly spread out, with an equal proportion occurring during incubation or shortly after hatching. By the time of most desertions, however, chicks had reached (or even exceeded) their adult weight, although wing and feather growth were not complete and they could not feed themselves.

But the piece of evidence that seemed to make the death scenario especially unlikely was my finding that these disappearances were common only in good years, at the very times when the kite population was rapidly rising. In bad years, when populations fell, most pairs remained together. I found no cases of mate desertion in 1981, for instance, when a severe drought reduced nesting success as well as total nesting attempts. That year, both parents remained at the nest, even to care for a single chick, whereas in wet years, when populations were high, parents with up to three offspring often deserted their mates.

Since a drying-up of the marshland adversely affects the availability of snails, I hypothesized that food supply was an important factor affecting the “decision” of a snail kite to stay or abandon its mate. Although I was unable, after many attempts, to make a direct census of the apple snails, my hunch that food was the key to desertion was borne out indirectly by watching how far from the nests kites flew in search of snails, an inverse measure of food abundance. During the four years of my study, this distance was negatively related to the percentage of nests deserted in each year. In years when kites commonly flew less than one and a half miles, one parent deserted at nearly every nest. But when kites had to fly great distances in search of food (up to three and a half miles), fewer nests were deserted. This behavior, combined with the finding that water levels were high when kites didn’t fly far, strongly suggested that one kite parent was more likely to desert a nest during years when food was abundant. Such a nesting strategy contrasts sharply with that of animals that desert their young when food is scarce or when other environmental conditions jeopardize the survival of the parents.

Little is known about what happens to specific deserting parents after their departures. Snail kites are highly mobile and difficult to locate in the hundreds of square miles of Everglades habitat. We do know that individuals can successfully raise young at two nests in a year, and that successive nesting attempts may be as near as 100 yards from the previous site or as far as 100 miles. Interestingly, however, the only deserter I was able to follow after its disappearance from the nest area was a telemetered female that immediately re-mated, built a new nest with her new mate, and was incubating eggs two weeks before her former mate was finished caring for her first progeny.
A parent, probably a young male, delivers a snail, right. Both male and female perform all nesting duties, including incubation, as long as the pair remain together, but the mate that feeds the young less often is usually the one to desert the nest. Below: To extract a snail, the kite first rips off the operculum (the tough tissue that seals the entrance to the shell). Then the bird, with a quick stroke of its thin bill, cuts the muscle that attaches the snail's body to the shell. Extraction and consumption are usually accomplished in sixty to ninety seconds.

The long breeding season, from five to ten months of the year in Florida, offers individual kites the chance for three or, conceivably, four broods if they consistently desert and remate, but only two broods if they stay to care for the young. Mate desertion therefore gives a deserter a way to increase the number of young that it raises in a nesting season.

Deserters can usually leave without any cost to their reproductive success because tenders, or mates that stay behind, usually rear all young to independence. There are no costs to establishing a new territory since kites are not territorial. For males, finding and courting a new mate might take more time and energy than waiting and remating with the same female, but continuing to share the task of feeding a brood until it is independent is also costly, and individuals that hesitate to desert risk being deserted themselves.

Since natural selection should favor behavior that maximizes the number of surviving offspring produced, certainly the deserter should have the advantage, providing that the remaining bird stays to tend the young. The deserter has already produced one clutch that is likely to survive and it has the chance to produce more young. The tender is facing a less enviable situation because it is in what sociobiologist Robert Trivers called the "cruel bind." Desertion by a tender after its mate had already abandoned would doom the lives of the brood in hand in exchange for a future brood that does not yet exist. In other words, the tender, even with the best possible luck, could only exchange one brood for another. The cruel bind has some additional costs for tenders. They forfeit time and energy; not only do they lose three to five weeks, during which they must care for the young alone instead of renesting but they often must increase the number of daily trips to and from the nest with snails (up to sixty a day for a brood of three) in order to continue feeding the young at a rate equivalent to that previously attained by both parents.

Since the odds are that the mate that deserts will leave more descendants than the mate that stays, male and female should be in conflict over which one leaves. Some of the nests I observed seemed to illustrate the conflict. In one case both parents tried to desert. For a short time, neither parent fed the young very frequently and both stayed away from the nest area for long periods. At one point, I noticed that the male was bringing snails both to his two young and to a prospective new mate. But he dropped his heavy workload and reverted to feeding his young exclusively after his first mate deserted and immediately remated.

At another nest a predator had killed one nestling, and the other had jumped onto a branch dangerously near the water. The father of this brood soon began to display to a female a half mile away that was already being courted by another male. When I put the surviving nestling back in the nest, the male began feeding it again. Ten days later, however, he deserted for good. Did he "know" all along that he would desert as soon as possible?

To determine if there was any way of knowing beforehand which mate would be the one to desert, I examined my data on about half of the deserted nests to see if I
could find any objective differences between the behavior of deserters and tenders before a nest was abandoned.

The division of parenting duties was surprisingly variable from nest to nest. At some nests males did most of the incubating and feeding, at others females did more, and at still other nests the duties were shared more or less equally. Overall, deserters did not incubate, brood, or chase potential predators more or less often than tenders. But at all these nests deserters provided less food for the nestlings than did tenders.

The pattern established itself during the first two weeks after hatching. Feeding nestlings is the most energy-intensive phase of parental activity because finding food can require parents to fly great distances from the nest. We don't know, however, whether the deserting parent is somehow less “invested” in the nest or whether it is adjusting its efforts, say feeding rate, to test its mate's ability to care for the young alone. Either parent can desert as both sexes are equally capable of rearing the young alone. Therefore, differences in reproductive investments between mates may not be as important in determining which parent deserts as are factors that affect future nesting success, such as which mate recognizes the first chance to leave or has the best opportunity to remate.

While gathering data on the relative investments of male and female kites during nestling, I was intrigued by the intense courtship rituals performed by males.

Males make aerial displays to potential mates, usually a series of short, swooping dives in which they close their wings and descend steeply six to fifteen feet before opening their wings and rising again. Males also chase away competitors, do most of the nest building, and provide females with more than three-quarters of their food during the two to three weeks of pair formation and egg laying. Females do little more than sit near the nest site, taking it easy and converting snails brought to them by males into eggs. I observed the time spent by parents in various activities during pair formation and then converted these times to estimates of daily energy expended by using published studies of the metabolic costs of activities for similar birds. My bioenergetics models, including
Snail kites lay two to four eggs over several days but usually begin incubation as soon as the first egg is laid. Chicks therefore hatch asynchronously, and siblings within a brood may be as much as a week apart in age and dramatically different in size, below. Older chicks reach full size first and are less likely than younger nestmates to be eaten by raccoons or snakes. Staggered hatching dates may explain why small broods are usually deserted earlier than large broods: desertions may be timed to take place when the last hatched chick can survive. Right: On its first day out of the nest, a fledgling snail kite, perhaps eight weeks old, is able to fly, but it still cannot feed itself. Both photographs by James A. Kern

The cost to females of producing eggs, indicated that through the period of egg laying, males were investing more energy in reproduction than were females. The result is contrary to the expectations of some sociobiologists that females generally invest more reproductive effort than do males before fertilization, since they produce a few energy-rich eggs while males make many energetically cheap sperm. But males of many animals can make substantial investments before females lay eggs, namely, through the production of nutritious spermatophores (in insects), by presenting nuptial gifts of food (in arthropods and birds), and by guarding their mates from the advances of other males. No prior studies, however, had convincingly demonstrated greater investments before egg laying by males than females because they lacked complete estimates of metabolic activity or reproductive efforts by both parents.

So why should the mating habits of snail kites have evolved to be so unusual? An important factor influencing the behavior of this species is the very high nest-failure rate of 68 percent; in comparison, two-thirds of the nests of other raptors usually succeed. Kite nests fail most often because they are in unstable sites in shrubs, such as willows, or on emergent plants, such as cattails, where they are likely to fall or be blown apart. Predation by snakes, raccoons, grackles, and birds of prey also cause many nest failures, and kites, with their weak talons and relatively small bodies, do not appear to be able to fend off attacks by these predators. Breeding is particularly unsuccessful during dry years when food is less abundant and when the marsh dries out beneath nests, allowing predators to reach the eggs and nestlings more easily. Not only do kites compensate for the nest-failure rate by nesting more than once during a season but they also begin nesting at ten months of age, quite early for birds of prey, which commonly cannot breed before they are two or three years old.

These traits may be adaptations to, or results of, the very unpredictable environment of the Everglades. Rising and falling water levels affect the availability of suitable nest sites, the amount of food available for the young and adults, and therefore the overall population level of kites. Lake Okeechobee water levels vary unpredictably and follow a drought–flood cycle that during this century has shortened from a cycle of ten years or more to five or six years. In an unpredictable environment, natural selection is likely to favor individuals that have more nests. Since nest-failure rates high, more nests mean more chances of successfully completing at least one nesting attempt.

Some bird species facing fluctuating food resources gamble varying or decreasing or reducing the number of eggs laid in good and bad years. Others always lay several eggs but allow some hatchlings to die off in bad years. The snail kite, however, does not vary its clutch size. Instead it always has a small clutch, with fewer eggs than both parents could theoretically raise together in a good year. Its response to its changeable environment is behavioral flexibility—deserting and renesting when conditions are favorable. Fewer eggs in each nest means less wasted reproductive effort and possibly less time required by females to lay new clutches when nests fail.

Curiously, there is evidence that the clutch size of snail kites in Florida was once larger than it is today. Museum collections of bird eggs can serve as windows to the past. Egg collections were fashionable in the early part of the century and many natural history museums have now inherited these clutches. More than one-quarter of the clutches of kite eggs collected before 1925 contain four or more eggs (up to six). During my studies, clutch size never exceeded four eggs and these were rare, only 2 percent of the clutches. At present, the average kite clutch contains about half an egg less than those collected in the early 1900s.

The apparent decline in clutch size of the snail kites coincides with the timing of large-scale drainage of the Everglades and a decline in environmental quality. At the same time, the Florida snail kite population was plummeting from a thousand or more in the early 1900s to sixty or less by the 1960s. Although in a small population of kites any slightly adaptive behavior could cause large selective advantages, it is questionable whether a substantial decline in clutch size could have occurred in only a century of very direction to selective. We don't know if mate desertion was a way of life for snail kites before the Everglades was drained. Environmental
predictability was very low even before drainage began, so that selection for a smaller clutch size and mate desertion may already have been occurring, and the environmental degradation of the Everglades may simply have helped to accelerate the process. If changes caused by humans through water management are partly responsible for poor environmental quality in Florida, then a small clutch size and mate desertion might not be a characteristic of Central and South American snail kite populations. My present studies in Venezuela, however, show that mate desertion does occur there. But in Venezuela there is another variation on the theme of abandonment. Desertion is highly dependent on the number of young fledging: smaller broods are usually deserted; larger ones rarely.

Meanwhile, the Florida snail kite population continues to rise and fall with the Everglades' water levels. Currently numbering about 560 birds, the population concentrates in State Water Conservation Area 3A when it is flooded. Management of water levels in this area has become a critical concern of the overseeing agencies, the Corps of Engineers and the South Florida Water Management District. In spite of careful management, however, this area still dries out regularly because of periodic droughts at about five-year intervals. Perhaps at one time the large acreage of Everglades' waters buffered the effects of droughts, but drainage for agricultural and urban development has sharply reduced the water-storage capacity of the system.

To mitigate the effects of the population crashes that will continue to occur when kites disperse during dry-outs, smaller, more isolated wetlands throughout the east coast of Florida will have to be saved from the relentless pressures of development. But it is these same small wetlands that are rapidly being filled and developed as the human population continues to grow in the southern part of the state. For the kite to survive in Florida, compromises between development and conservation will be necessary—or one of our most remarkable animals may desert the Everglades.
An adult male flies over a marsh in the Florida Everglades. The snail kite is still endangered, and as the increasing human population of southern Florida encroaches on its wetland habitat, the bird's future is uncertain.

Gordon Langsbury. Bruce Coleman Inc.
Metal Factories of the Deep Sea

Hot spot formations, complete with chimneys and smoky plumes, are producing lodes of copper and iron

by Peter A. Rona

In the summer of 1985, after fifteen years of searching, we lowered instruments deep into the Atlantic Ocean and discovered hot springs discharging from the sea floor. Around these springs, never before seen in the Atlantic, our cameras scanned thick deposits of metallic sulfides—copper, iron, and zinc—and thriving communities of animals—anemones, fish, crabs, and shrimps—all apparently specially adapted to living near sulfurous plumes of sea floor geysers. In May of 1986, I led a team of scientists from the National Oceanic and Atmospheric Administration, Woods Hole Oceanographic Institution, and the Massachusetts Institute of Technology on an expedition with the submersible Alvin to view firsthand this newly discovered world two miles beneath the Atlantic.

Our target was a mound about the size and shape of the Houston Astrodome, located on the sea floor 1,800 miles due east of Miami, Florida. The main topographic feature there is the Mid-Atlantic Ridge, itself part of the largest geographic feature on earth, the system of submerged volcanic mountain ranges that runs through the Atlantic, Indian, and Pacific oceans. Running north-south like a central spine down the entire Atlantic, the ridge is split by a valley five miles wide, with walls as high as those of the Grand Canyon. The rifted volcanic mountain range forms as molten volcanic rock rises from the earth’s interior, then cools, solidifies, and spreads. The Atlantic sea floor widens by about an inch each year, moving apart continents that were joined 200 million years ago.

Before our discoveries, the scientific consensus was that high-temperature venting was limited to the Pacific, where the sea floor is spreading up to ten times faster than in the Atlantic. Just south of the Gulf of California, pure, hot, metal-rich solutions discharge as sea floor geysers and precipitate instantly, forming a black smoke of metal-sulfide particles. Chimneylike formations created by these geysers rise as high as seventy-five feet. Wide mounds of chimney debris composed of sulfide minerals are similar to ancient ore deposits found on land.

With the Alvin’s mother ship Atlantis II in position, the pilots and technicians responsible for the submersible completed their predive checkout procedures. The weather was calm and clear. I crossed the catwalk to the submersible’s boarding position on the afterdeck of the Atlantis II, climbed over the bright orange sail, and lowered myself through the hatch of the six-foot-diameter titanium sphere. John Edmond, a professor of geochemistry from MIT, quickly followed through the hatch and down the ladder. We sat on mats with our legs drawn up and our arms drawn in to fit the small space; the pilot crouched between us. The ladder was lifted out, the pilot closed the watertight hatch, and through saucer-sized viewing ports, we saw the deck of the ship shift below us as the submersible was moved backward along a rail to the launching point—an A-frame at the stern of the ship. Once detached from the rail, the Alvin swung on its cable as it was lowered into the gentle swells of the sea surface. Swimmers released the cable and the submersible floated free from the mother ship.

When all systems were checked, the ship radioed that we were cleared to dive. The pilot opened the valves flooding the ballast tanks and at nine o’clock in the morning we began our 100-foot per minute trip to the sea floor 12,000 feet below. As we descended, the ocean darkened gradually from bright hues of blue to black. The fan drone, moving the air through a filter that removed the carbon dioxide; the air was replenished with a steady flow of oxygen to maintain atmosphere and pressure in the sphere. Every ten seconds we heard the pinging sound of signals sent back and forth to the mother ship to plot a track of our movements. The thought uppermost on our minds was whether we were descending on target. If deep currents carried us off course, we’d lose precious dive time searching the sea floor.

When the altimeter indicated that we were 300 feet from the bottom, the pilot released lead weights to slow our descent. With the submersible hovering nearly stationary in the water, Edmond and I bent down and turned our heads to get a look out the portholes on either side of the sphere. In the submersible’s floodlights we caught sight of the same kind of small gray shrimp that we had photographed the year before with our remotely towed cameras and recovered with our dredge. The shrimp are a new species, about two inches long, with a bright reflective patch on their backs. They have no eyes and the bright spot may be a sensory organ. As we descended farther, however, we saw only dark brown volcanic rocks and tan mud, the typical drab, desertlike landscape of the deep ocean bottom. We were afraid we might have missed our target. Then bright streaks across the glowing video tube of the side-scanning sonar indicated a steep slope one hundred feet ahead of us.

The pilot adjusted the thrusters and we moved slowly to the base of the slope. The scene changed abruptly as we began to ascend. Mud and volcanic rocks gave way to bright yellow, orange, and red rocks and irregular spires several feet high. These were the metal sulfide deposits, their surfaces rusted by seawater. We shouted in excitement. We had found the mound. In the light of our floodlamps the water emanating from the hot springs shimmered like heat waves over an asphalt highway. Clumps of bacteria drifted like snowflakes. Looking like daisies sprouting from a field of red soil, white anemones, with tentacles several inches long, were scattered on the rocks. White crabs crawled in and out of rock crevices. The food chain at hot springs on the deep sea floor is supported by bacteria that draw their nourishment from chemicals dissolved from the rocks by the water venting in the hot springs. The bacteria in turn, are eaten by the anemones and other organisms at the base of a food chain dependent on the internal heat and chemicals of the earth, and independent of the light of the sun, which drives the process of photosynthesis that supports life on land.

We continued to glide slowly upslope toward the center of the mound. The water soon became cloudy and enveloped us like a white fog. Through a clear patch we saw white and blue-white smoke emanating from several chimneylike forms, each
about ten feet high, on the sea floor. Edmund had seen such smoldering onion-shaped domes on the floor of the Pacific. Their white "smoke" was found to be composed of a calcium mineral that crystallizes from the hot springs at water temperatures approaching 400° F. The blue-white smoke had never been seen before. The submersible ascended past cliffs that looked like miniature white cliffs of Dover. They were more than twenty feet high and apparently composed of the same white calcium sulfate mineral.

As we approached the center of the mound, the water and the rocks beneath us darkened to shades of red and black. Particles of iron pyrite sparkled in our floodlights. This fool's gold crystallizes from metal-rich solutions that are discharged from the hottest of all sea floor hot springs, the black smoker. Ahead of us, columns of black smoke rose from cracks in the sea floor. Masses of the small gray shrimp we had seen on our descent wriggled over the chimneys. Gray, eellike fish, two to three feet long, were curled around rocks. Using the mechanical arm of the submersible we inserted a temperature sensor into one of the cracks from which black smoke was billowing and watched as the temperature gauge in the sphere rose from near freezing (the temperature of the surrounding water) to more than 600° F. Under the weight of the overlying column of water, the pressure is some 370 times that at the surface so that boiling is suppressed. The hot springs and black smokers were building a giant mineral deposit on the sea floor of a type known as polymetallic sulfide. When mined on land, polymetallic sulfide deposits are an economically important source of copper, zinc, silver and gold. These deposits on land were formed on the sea floor in the geologic past and subsequently up-

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**Mineral Formation at an Ocean Ridge**

Cold seawater sinks into fractures in the sea floor and encounters rocks heated by magma (molten rock). The hot water expands, rises, and leaches minerals from surrounding rocks. Near the sea floor and around the vents, metallic sulfides precipitate out of the hot water, forming thick deposits of minerals.
lifted by Earth forces to their present locations.

Ahead of us the sea floor was covered with bases of chimneys that peaked at the center of the mound. Shrimp swarmed by the thousands, as if in a feeding frenzy. Like bright eyes in the darkness, the curious patches on their backs reflected our floodlights. As we ascended, the clouds of black smoke became so dense that we could only get glimpses of the huge chimneys. In order to recover a sample of the chimney material, the pilot positioned the submersible in front of a small chimney at the periphery and drove forward. As we hit the chimney with the leading edge of a sample basket mounted at the front of the submersible, the chimney broke and fragments glittering with metallic crystals fell into the basket. For observation and sampling, the pilot attempted to maneuver into the group of chimneys at the very center of the mound but each time we had to retreat. The plexiglass viewing ports of the submersible melt at about 200°F, and we were coming dangerously close to the smokers. I recalled a prediction that anyone ever found an ore deposit being formed, the process would be so intense that it would defy direct observation.

This hidden world on the deep sea floor exists because, unlike swimming pools, which hold water, the basins that contain the oceans are leaky. Cold, heavy seawater flows downward through cracks in volcanic rocks underlying the sea floor of the ocean basins. In areas of volcanic activity, the descending seawater encounters hot rocks. It is heated, expands, becomes lighter, rises through the cracked volcanic rocks, and discharges at the sea floor as hot springs and geyserlike smokers. Most sea floor volcanic activity occurs along the midocean ridge system, the submerged volcanic mountain range that runs through all the ocean basins of the world.

When we returned to the surface after a two-hour ascent and reunited with the mother ship at six o’clock that evening, we were cold, tired, cramped, and elated. Prior to our discovery of this first site in the Atlantic Ocean, hot springs on the deep sea floor were only known at sites in the Red Sea and the Pacific Ocean. In the mid-1960s oceanographic research vessels of various nations, transiting the Red Sea en route from the Mediterranean Sea to the Indian Ocean during the International Indian Ocean Expedition, had noticed curious reflections in the water column from echo sounders that were only supposed to reflect from the sea floor. Subsequent investigation revealed that the reflections occurred at pools of salty, metal-rich hot water flowing from sea floor hot springs into deep basins of the Red Sea. The metals crystallizing from the hot water in a basin about 100 miles southwest of Mecca in Saudi Arabia have formed one of the largest polymetallic sulfide deposits in the world. Feasibility tests for mining this undersea deposit are being sponsored by a commission composed of Saudi Arabia and Sudan, the bordering coastal states. Yet the hot springs on the floor of the Red Sea have never been seen. Soviet scientists attempted to dive into this mile-deep basin in 1980, but the effort was thwarted when the submersible proved too buoyant to sink to the sea floor in the dense, salty seawater. Remote videotaping was also impossible, since salty water, murky with metal particles, would corrode cameras towed by a surface ship and veil their views.

Scientists considered the hot springs in the Red Sea a “special case” until our group found evidence for warm springs at the Mid-Atlantic Ridge in 1973. Four years later an expedition with Alvin to a submerged volcanic mountain range near the Galápagos Islands in the Pacific observed warm springs and a specially adapted animal community. In 1978, a French-American-Mexican research expedition diving with the French submersible, Cyana, encountered curious mounds about fifty feet high while crossing another submerged volcanic mountain range, the East Pacific Rise, near the tip of Baja California at the mouth of the Gulf of California. Their mound samples were laid out on a table in their laboratory when a visitor happened to recognize that they were polymetallic sulfides. Since such deposits only form from very hot water, they deduced that the Pacific floor must contain hotter springs than those that were already known. Those springs were found the next year. Within hundreds of feet of the polymetallic sulfide mounds sampled by the prior expedition, hot black smokers belched dark clouds of metal particles at water temperatures of more than 600°F.
Our recent discovery of hot black smokers, polymetallic sulfide deposits, and specially adapted animal communities in the Atlantic extended the known range of these features. They probably exist elsewhere as well, since hot volcanic rocks and deep sea floor hot springs can also be found at volcanically active islands, like Hawaii, and in island chains of the western Pacific, like Japan, the Philippines, and Indonesia. The worldwide range of sea floor hot springs and smokers—from the Red Sea to the Pacific to the Atlantic—means that these features have global effects. The annual flow of seawater driven by volcanic heat to circulate through rocks at midocean ridges is comparable to that of the world’s largest river, the Amazon. At this rate, all ocean waters circulate through deep seabed rocks every ten million years, fast enough for the oceans to have flowed through the rocks hundreds of times in the history of the earth.

Over geologic time, rocks formed on the sea floor are sometimes uplifted onto the continents. Ore deposits in eastern Quebec Province, for instance, are found in rocks 2.6 billion years old—half as old as the earth itself. They resemble the polymetallic sulfide deposits we observed forming on the Atlantic sea floor and were probably formed under similar conditions.

The ocean is a chemical soup containing nearly all known elements. Prior to the discovery of deep sea floor hot springs and smokers, the ingredients of seawater were thought to have been washed into the oceans by rivers. Analysis of the composition of the hot springs and smokers, however, showed that the circulation of seawater beneath the leaky ocean basins involves a two-way exchange of chemical elements between the seawater and the cracked volcanic rocks through which it flows. John Edmond’s studies of hot water recovered from black smokers in the Pacific showed that many of the chemical elements rising from sea floor hot springs were as important to the composition of seawater as the materials washed from the continents. Copper, iron, manganese, and zinc are dissolved from the volcanic rocks by the hot seawater. Some of these metals crystallize from the metal-rich, circulating seawater to form metal deposits beneath and on the sea floor. Observation of such actively forming metal deposits helps to guide exploration for economically important ancient deposits previously formed on the sea floor and subsequently uplifted onto land. The sea floor deposits themselves are resources for the future. Between five and ten times more lithium and rubidium and between one-third and one-half as much potassium, calcium, barium, and silica is dissolved from the ocean crust as is carried into the oceans by rivers. The amount of manganese dissolved from the ocean crust by the circulating solutions can account for all the manganese that occurs as nodules covering vast abyssal plains of the sea floor.

The discovery of the deep-sea vents has
revolutionized the once accepted notion that the chemical composition of the oceans has been constant. This theory has been replaced by the idea that the chemistry of the oceans has been changing throughout history in response to dynamic variations of volcanic and venting activity on the ocean floor. Deep-sea findings are spurring other theories as well. Since the hot water at the vents supports specially adapted microorganisms that are at the base of a complex web of life, some scientists have speculated that all life may have originated under such conditions. As natural laboratories where many of the secrets of our planet may be deciphered, the hot smokers, mineral deposits, and exotic animal communities of the deep sea floor will be the focus of scientific studies for years to come.
Everyone was working quietly when we arrived at midmorn. There were greets-
guding grunts from the student with the chip-
board and from the nearest baboons and a
few keen glances from under bushy eye-
brows at me, the stranger. The baboons
kept on foraging, the student kept on tak-
ing notes, and Shirley Strum, in a low
voice, pointed out some of the baboons I
had already read about. The open country
stretched about us in great folds under the
bright sun—clear, not shimmering be-
cause it was not yet hot. After a while, as
we all moved slowly forward, I realized
that the baboons had rearranged them-
selves slightly. There was a position for
me, too, in the apparently random scatter
of well-separated foragers: If I didn't
move at the expected time, my baboon
neighbors waited; if I moved ahead of my
place, eyebrows were raised. I felt greatly
honored. It was a moving experience. I
also reflected ruefully on how much te-
dious data collection and analysis it would
require, to demonstrate, to academic stan-
dards, the subtle readjustment of the ani-
mals' relative positions that I had per-
ceived. Perhaps it wouldn't be possible.
Does that mean it was not real?

I start with this fragment from my own
memory of a visit I made to the place
where Shirley Strum worked with her ba-
boons, Gilgil in the Great Rift Valley in
Kenya, partly to give a preview of the
extraordinary success of the author's field
method. When Strum started work, ba-
boons in Kenya were watched from vehi-
cles. Everyone assumed that the vehicle
was essential as a "hide" (and as protec-
tion for the observer in dangerous wild
Africa). But Strum got out and walked
with the baboons, and they didn't run
away. This simple step, which was at first
thought to be impossible but was later
 copied elsewhere and exploited by many
students at Gilgil, allowed for much more
detailed observation of social behavior.
The other purpose of my introduction is to
bring up the complexity of the route of
ideas from the field to the textbook.

To study the social behavior of animals
in the field is to take on the most chal-
enging of all scientific endeavors. By compari-
son, the unraveling of mere molecules is
simply itself, although it does require
some impressive technology. In a social
system you are faced not only with the
biological elaboration of animals as indi-
viduals but also with the interaction that
only becomes comprehensible in the con-
text of their habitat and their relations
with other group members. These con-
texts are in turn only comprehensible in
their historical perspectives.

We come to this task with the advan-
tage that the human mind is organized to
deal with the similar complexity of our
social behavior, and the disadvantage
that it is probably impossible to avoid
projecting expectations derived from our
own culture on to other social systems,
including that of humans. Different peo-
ple derive different expectations from
their experiences, and expectations also
change as the social and political ideas of a
society change. As Stephen Jay Gould
often points out in Natural History, the
expectations of a century ago now seem
laughably naïve. What will ours look like a
century hence?

Strum tells us that she went to Africa
with the formal expectations of current
anthropological theory and the (largely
incompatible) informal ones of 1960s
Berkeley. With unusual receptivity on her
part, and a lot of time, the baboons showed
her other, more interesting alternatives,
and Strum learned through a process of
comparing observation with expectation,
which is similar to the way an immigrant
in a new country learns. Being a sucker for
a soap opera, I could have read a lot more
of the baboon stories she uses to illustrate
her insights. The feeling of gaining those
insights is well conveyed. Usually, intel-
lectual excitement gets lost in the struggle
to present one's insights to skeptical col-
leagues, becoming reduced in the process
to little hard pellets of statistical differ-
cences. Some people manage to avoid such
insights altogether. The fashionable habit,

much encouraged by grant-giving agen-

almost Human, by Shirley Strum. Ran-
dom House, $22.50; 294 pp., illus.
Here I am, with my son Junior. Having some cool fun 'sledding' down a neighborhood glacier. I think that wonderful artist Michelle Emblem has captured us to a tee. Whee!

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cies, of formulating hypotheses and testing them in the field, if adhered to rigidly enough, may allow you to see only one of the two possibilities you thought of before starting. This method, which has been so effective in advancing the simpler field of molecular biology, leads to very boring studies of social behavior.

Perhaps Strum's most important finding has been that while adult male baboons appear, to us, as if they are designed to be fighting machines—all brawn and flashing canines—the ability to win fights does not gain success for a male. Aggressive, high-ranking males are not a social success with the females. Success in the biological sense, of gaining opportunities to sire offspring, comes instead with patient and subtle social maneuvering, described in the book in fascinating detail. Because Strum had the experience of having her observations disbelieved, she is ready with a convincing story.

Strum had recognized a new pattern, and her findings clearly contradicted ideas about the importance of dominance adhered to with quite irrational fervor by, for the most part (dare I say it?), the dominant adult males of an extraordinarily competitive society. I was shocked to discover for the first time that scientists, like other people, will ignore or reject whatever contradicts their comfortable, well-used mind tracks. And Strum was not a skilled academic politician. This experience is also vividly described in the book. The reaction to her work should be taken, in the long view, as a compliment to her innovativeness. I hope that eventually her insights will be accepted more widely, that she will be recognized as their originator, and that the insights themselves will survive the subtle distortion they will undergo as people try to push them into old molds in order to accept them.

The final section of the book concerns the author's efforts to intervene between her baboons and the smallholders who eventually came to live on part of the ranch, planting maize crops that the baboons were delighted to "help" harvest. Finally, Strum moved the baboons to a new area. On the way, she learned that the people of Africa have to be considered as well, a recognition that has eluded all too many biologists who have worked in Africa. Her achievement in moving the baboons successfully is astonishing. Written down, it sounds deceptively simple, but none of us thought it could be done. The move seemed like an act of sentimentality rather than a "suitable" scientific activity, yet it has actually opened up exciting and unexpected approaches and insights (not included in this book) that will hold our attention for some time to come.

Moving the baboons required applying political and social skills to both baboons and people. It would not have succeeded without the preceding fifteen years of research on baboon social behavior, and provides the clearest possible evidence that for effective management of wild animals, it is absolutely essential to study social behavior, as well as resource ecology.

This is an honest, in some ways an outrageous, book because it treats together things that happen together but that convention keeps apart: science and politics (in the widest sense) and the life of the scientist. I wish I had written it myself.

T. E. Rowell is a professor of zoology at the University of California at Berkeley. At present, she is in a forest in western Kenya watching blue monkeys.
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The bases of the water tupelo trees that grow in Cupola Pond, below, were exposed in the fall of 1987, following an extreme drought. Lower right: The pond in summer.

Dennis Brown
Cupola Pond, Missouri

by Robert H. Mohlenbrock

Some thirty-eight miles west of Poplar Bluff, Missouri, on the generally dry and somewhat monotonous Ozark Plateau, a ridge suddenly drops forty feet into a five-acre depression filled with water. This is Mark Twain National Forest's Cupola Pond, which was classified a Missouri Natural Area in 1981, a Society of American Forests Natural Area in 1983, and is currently being considered for a Forest Service Research Natural Area. These special designations acknowledge not only the rarity of a permanent source of water in the uplands but also the unexpected vegetation—a nearly pure stand of water tupelo trees. Water tupelos are normally found in lowland areas, growing in bald cypress swamps (the nearest to Cupola Pond being almost forty miles away). As a result of the draining, logging, and cultivation of southern Missouri's bottomland, even such swampy habitats are no longer common.

Cupola Pond is a sinkhole, a depression caused by a dissolving of underlying rock, in this case limestone, followed by a collapse of the land surface. Paul Delcourt, Hazel Delcourt, and E. Newman Smith from the University of Tennessee have probed the center of Cupola Pond, removing core samples from a depth of forty
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The Old Dating Game
by Thomas D. Nicholson

When the 1988 New Year rings in, the year it ends will have been longer than 365 days, as will the year it begins. Nineteen eighty-eight is a 366-day leap year. Nineteen eighty-seven was an ordinary year, but as we reported last month, it was one leap second longer than 365 days. Not really a great difference: an ordinary year has 31,536,000 seconds, and 1987 had 31,536,001. Leap years, of course, are a whole day longer, and that’s another 86,400 seconds, a bit more significant.

If you think that implies a little uncertainty about the length of a year, you’re right. Our year is based on a calendar devised by the Romans in about the seventh century B.C. That calendar was crossbred with the still older Egyptian calendar by Julius Caesar in 46 B.C. and then adjusted by Pope Gregory XIII to its modern form in A.D. 1582. It has been as short as 354 days and as long as 445 days, with quite a bit of variation in between.

The calendar’s principal task is to keep track of the tropical year—the average time spent by the sun in moving from one vernal equinox to the next vernal equinox—about 365 days, 5 hours, 48 minutes, and 45.3 seconds. But a calendar has to have an exact number of days, and common sense dictates that most years should have 365 days. But some will have to have 366 to average out.

That’s all well and good until politics, religious practices, and tradition are factored in. One of the most perplexing problems has been reliance on the lunar cycle (a 19-year period during which the phases of the moon return to a particular date in the calendar year) in deciding how long the months should be and how many months should be in a year. The lunar month (the period from one new moon to the next, about 29 days, 12 hours, 44 minutes, and 3 seconds) doesn’t fit the 365-day year any better than the day fits the tropical year. Relying on it meant using some 29-day months and some 30-day months with some 12-month years and some 13-month years. We still find vestiges of this in religious calendars, such as the Christian rules for dating Easter, to wit, the first Sunday following the first full moon on or after the vernal equinox.

This struggle with the lunar month led to chaos in the older Roman calendar. Years of twelve months alternating between 29 and 30 days ordinarily averaged to 355 days. At more or less regular two-year periods, an extra month of 27 or 28 days was added after February 23, and then February’s remaining days were usually, but not always, dropped. The Roman year could have from 355 to 383 days, depending on how many days were added at regular intervals in what are called intercalations and whether the days following February 23 were dropped or not. The length of the Roman year could be 355, 377, 378, 382, or 383 days.

Even this confusing schedule could have worked if the rules of leap year and leap month had been properly regulated. But they weren’t, and the system slipped so badly that by the first century B.C., spring was coming in the calendar’s summer months. Julius Caesar called a halt then by abandoning the lunar cycle in favor of fixed months, introducing a four-year leap-year rule, and adding two extra months to the year 46 B.C. (already a leap year by the old rules) to bring the seasons back to where they belonged in the calendar. The year 46 B.C. became 445 days long as a result, the longest year on record.

By the sixteenth century the error was ten days, and the Christian rule for dating Easter was threatened. Pope Gregory XIII restored the seasons to where they were at the time of Caesar by changing October 5, 1582, to October 15, 1582. This made 1582 a year of 355 days, tying the old Roman ordinary years as the shortest in calendar history.

The Gregorian change wasn’t immediately accepted everywhere; resistance in predominantly Protestant countries delayed it by some centuries. In Britain (and the British-American colonies) the change was introduced in 1752, when the error had accumulated an additional day. That year, September 14 followed right after September 3, and September 4 through 13 were dropped, making 1752 a year of 354 days, the shortest year in history.

Variations in the year such as those will probably never occur again. Our leap year rule accumulates an extra day in about 3,300 years, and compensation for that may be made some day. Years should alternate between 365 and 366 days in a rhythm keeping us close enough to the tropical year to avoid the drastic changes of the past. But there will still be the minor annoyance of a leap second cropping up unpredictably now and then, sometimes being added, sometimes subtracted, to provide a little spice to calendar history.

Events described below are given in local time unless otherwise indicated.

January 1: The gibbous moon, in the sky from dusk until early morning hours, is in Taurus, moving to the left between the Bull’s bright Aldebaran below and Auriga’s Capella above.

January 2–4: Pollux and Castor are the two stars to the left of the moon as it moves through Gemini. The moon is full at 8:40 P.M., EST, on the 3d, and is in line with and below Gemini’s bright twin stars on the 4th.

January 3: The earth is at perihelion, nearer to the sun than it will be for the whole year.

January 6: The latest sunrise of the year

Oops! The anadema, described and illustrated in last month’s column, is a difficult concept, and perhaps repeating the first paragraph helped some readers understand the asymmetrical figure 8. But the repetition and garbled sentence were mistakes that occurred at the printer, after the column had left the author’s and editors’ hands. Sorry.
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occurs, although the shortest day of the winter was on December 21.

January 4: The third-best meteor shower of the year, the Quadrantids, is at maximum, but the morning moon will spoil after-midnight viewing. Expect to see fewer than the forty or so meteors that a dark sky would bring.

January 7: Apogee moon (farthest from the earth) occurs today. Leo's bright star Regulus is near it after moonrise. In conjunction with the star before rising at about 8:00 p.m., the moon pulls away toward the left as they climb the sky.

January 9: Regulus (higher and to the right) and Spica (lower) are the two bright stars bracketing the waning moon after midnight.

January 10–12: Rising later each night and closer to Spica, the moon finally occults (covers) the star over the Southern Hemisphere at their conjunction, at about 5:00 a.m., EST, on the 12th.

January 15: Mars, Antares, and the crescent moon are worth getting up to see before dawn. Look for them low in the southern sky, two reddish objects to the left and below the rising moon. Mars is the higher of the two. Later in the day the moon passes Mars (at about 11:00 a.m., EST) and Antares (at about 6:00 p.m., EST), occulting the latter over the southwest Pacific. Moonrise is at about 3:30 a.m. and the other two objects are up by 4:30 a.m. Saturn appears above the horizon during morning twilight. By the morning of the 16th, the moon is past Antares. Both reddish objects are above the crescent, with Saturn below it.

January 19: New moon is at 12:26 a.m., EST, and perigee moon (nearest the earth) occurs only sixteen hours later, building strong tides tonight and tomorrow. Should east-to-northeast storm winds blow along the eastern seaboard, flood conditions may arise.

January 20–21: A new crescent moon passes Mercury on the 20th and Venus on
January 12: January’s night is about as dissimilar as possible from December’s. The Pleiades, close to Aldebaran, don’t set so late this month. The greatest elongation of Mars (15°) occurs during this month, so the planet is bright enough to see during twilight hours.

January 17: The moon is in its first quarter and appears half illuminated. It is in the western part of the sky after sunset. The Pleiades are rising in the eastern part of the sky, ready to be seen after twilight.

January 22: The moon is near the Pleiades for the first time this month. The Pleiades are also near the center of the constellation Taurus, the Bull. Taurus is the first sign of the zodiac and is associated with the bull.

The winter Sky Map shows the sky for January, February, and March from 40° north latitude at the hours given below. To use the map, hold it vertically in front of you with south (S) at the bottom and match the lower half of the map with the stars you see when you face south. As you face in other directions, turn the map to bring the corresponding compass directions to the bottom. The stars move west continuously during the night. By morning (before dawn), stars on the western half of the map will have set, those on the eastern half will have moved into the west, and new stars (those of the spring evenings) will have risen in the east. The map shows the sky at about 2:00 A.M. on January 1; 1:00 A.M. on January 15; midnight on January 31; 11:00 P.M. on February 15; 10:00 P.M. on February 28; 9:00 P.M. on March 15; and 8:00 P.M. on March 31. It can also be used for an hour or more before and after those times.
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Stalking the Elusive Apricot

A good-tasting fruit is hard to find

by Raymond Sokolov

This is in memory of an apricot tree that went down in the freak blizzard that swept across the Northeast early last October. It was the earliest snow on record and caught everyone unawares, particularly the trees. Most of them still had their leaves, which each took on its burden of slush. The collective weight of all that wet snow on all those leaves was too much for thousands of trees. At our place in the mid-Hudson valley, we lost half of an ancient weeping willow and almost all of a big apricot that leaned down toward the driveway from a little rise next to the neighbor’s barnyard.

All along, this apricot had been a heartbreaker. In the early spring it sent out lots of white blossoms and even began to set fruit in little swelling green orbs at the base of the flowers, especially after we put in an apricot sapling nearby to keep it company and to give pollination and genetic vitality a better chance. But, as Waverley Root once said, the apricot exists “on the brink of viability.” It requires a real winter for dormancy, but blooms early in the season (its name does not derive from the Latin *praecox*, “precocious,” for nothing) and late frosts come to blast its young.

We never saw a fruit on our ill-fated tree until the summer of 1986. A half-dozen, fully developed, red-blushed orange apricots survived weather, birds, and neglect and ended up in the grass at the base of the tree, where I picked them up and ate them on the spot. Some were half-smashed; one or two were intact. They all were taste perfection and all the more delicious since good apricots were unobtainable in any other way short of flying thousands of miles.

Apricots stop ripening when they are picked. Commercial growers have to pick them as soon as they turn orange but before they get soft enough to spoil en route to market or develop their full taste. Every once in a while, decent-tasting apricots do get to New York markets, but the statistical likelihood of hitting on these anomalies is so low that anyone who really cares about apricots won’t bother to attempt to find them. The virtual certainty of disappointment is too great. This is why California growers sell only 5 percent of their crop as fresh fruit.

Apricots, commercially speaking, do better as processed fruit. Dried apricots are excellent. Apricot preserves are a fine thing. I like the condensed, glistening orange sheets called apricot leather. And I am willing to believe that the South African brine-and-sugar-cured apricots called mebos may be as delicious as the Cape gourmet C. Louis Leipoldt has said they are. But none of this can possibly match the miraculous taste of a fully ripe, fresh apricot found underneath its parent tree minutes or hours after it has fallen.

I can remember each of the four times I have eaten properly ripened apricots in the last thirty years. The first time was in Utah in the mid-seventies. Driving south from Salt Lake City on assignment for this magazine, I stopped at a roadside stand. Really, it was just a pickup truck parked on the shoulder. The proprietor was an old farmer in overalls, and his hand-lettered sign said APRICOTS [sic]. I bought a dozen and ate them in a euphoric burst that lasted maybe ten minutes. The exhilaration lasted somewhat longer and resulted in a speeding ticket. I thought of pleading guilty with an explanation but decided Utah chauvinism wouldn’t go so far as to persuade a traffic court judge that delirium caused by local apricots was a reasonable defense for going seventy miles an hour.

The second time was in Santa Fe, New Mexico (actually on the high road from Santa Fe to Taos). Another hand-lettered sign, another farmer. But this time the sign led to a little orchard and trees heavy with ripe fruit. I bought a lot and kept my eye on the speedometer.

The third time was that millennial moment when my own tree came through with fruit in 1986. And the fourth ... I thought the fourth was at hand last spring in Spain. It was just after Easter, and I was walking down a back street of Granada. Through the window of a little market I saw a pile of yellow-orange fruit about the size of apricots, maybe a bit lopsided, but what else could they be? Perhaps a special Spanish variety, one that came in very early. I bought a kilo.

Out on the street, I bit into one. Firm and acid, pleasantly acid. It was nice but it was no apricot. Instead of the hard-shelled central seed common to apricots and other stone fruits or drupes of the genus *Prunus* (peaches, plums), this fruit had several smaller black seeds. I inquired. The lady said it was a nispero. My pocket diction-
A Matter of Taste

ARY said that was a medlar, but this fruit was no medlar (Mespilus germanica). I was eating it happily out of hand, and the one thing I knew for sure about medlars, never having tasted one, was that they had to be “blotted” (a kind of controlled rotating) before they became worth eating.

So what was this nispero? Everywhere I went I saw them. They were the only fruit in stores. My friend, the food scholar Alicia Rios, served them to us in Madrid. I dunked into a big bookstore on the Gran Via. A French-Spanish dictionary translated nispero as nfele, which translates as medlar.

Back in New York, having planted several of the black seeds in a pot (Alicia Rios had a nispero flourishing in her city apartment; why couldn’t I?), I ransacked my library and found the answer. The mysterious fruit was a loquat, a.k.a. the Japanese medlar, el nispero del Madrid, la nespola giapponese, le nfele du Japon.

To avoid vernacular confusion between the nfele (medlar) and the nfele du japon (loquat), the French have very sensibly taken to calling the Japanese medlar le biibece, which stems from the Japanese name biwa. Me, I will happily settle for loquat, which is probably derived from the Chinese, and China seems to be the birthplace of this clever tree, which is known to science as Eriobotrya japonica.

In fact, the loquat is not so completely unrelated to the apricot as one might think. They both originated in China. Both are stone fruits in the rose, or Rosaceae, family. Both have spread to Europe. The loquat is now the early fruit around the Mediterranean. And it has been cultivated with success for some time in California and Florida.

So why don’t we see it in New York? According to Elizabeth Schneider in her book Uncommon Fruits and Vegetables, loquats blemish in transit, unless they are

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picked when so unripe that they would be inedible. Ms. Schneider would clearly be happy to take a few blemishes in return for eating loquats in Manhattan. She fulminated against the unnecessary suppression of a splendid fruit that could brighten everybody’s spring.

I agree, as usual, with Ms. Schneider, but I am more upset still about the dearth of edible apricots in the Big Apple. You could say that I was in the Slough of Despond when I noticed in early summer that the dozen green apricots that had swelled almost to full size on our tree had fallen prematurely to earth or simply vanished. The culprit was not the worm known as plum curculio, which a local fruit “consultant” had said might infest our tree. The fallen fruits were uninvaded.

I never did find a satisfactory explanation, but I did find apricots later in the summer. In Santa Fe, it was the height of the season, but for tourists, apricots were hard to find. No restaurant I ate in offered them. At the otherwise impeccable Santacafe, fruit falling off a bearing tree in the courtyard was swept away daily and tossed out. No doubt local folk were gobbling the apricot-filled empanadas traditional in the region, but no one offered me one. And I couldn’t seem to find fresh apricots in supermarkets. I did locate some passable specimens in an upscale natural-foods market. But I knew there had to be first-rate fruit somewhere.

By the side of a dirt road in the outlying village of Rio en Medio, my wife espied a little tree with telltale orange spots on it. They were small and fabulous, riotous in the underbrush below the tree. I removed my shirt and filled it with fruit.

The shirtful is the unit of measure of scrupulous foraging. There you are, unexpectedly in the great outdoors, face to face with a forest of chantrells or a lawn of fallen native persimmons. You are unprepared. You have no bags or baskets. You cope any way. You take off your shirt and fill it with treasure.

So that was my fourth time with apricots—a shirtful.

Two months later, sleet forced our tree to its knees. But maybe the nearby sapling will bear fruit next spring. Meanwhile, the nispero seeds have sprouted, with glistening green leaves. If they produce—good trees bear 200 pounds of loquats—I will give Alicia Rios and Elizabeth Schneider a shirtful.

Raymond Sokolov is a writer whose special interests are the history and preparation of food.

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### Loquats in Syrup

*(From Uncommon Fruits and Vegetables: A Commonsense Guide,* by Elizabeth Schneider, Harper and Row)

1. 1/2 cup sugar
2. 1 long strip lemon peel
3. 2 tablespoons lemon juice
4. 1 pound ripe loquats (weighed without stems)

1. Combine 1 cup water, sugar, lemon peel, and lemon juice in saucepan. Simmer, covered, three to four minutes. Turn off heat and let stand while you prepare loquats.
2. Rinse stemmed loquats, trim off blossom ends, then halve and pit them. Pull off skins (or do this first, as you prefer). If loquats are relatively large, cut into quarters. (Note: if you do not object to cooked fruit with pits, poach the fruits whole for more flavor.)
3. Add fruit to syrup and bring to simmer. Cover and poach gently on lowest heat, until fruit is tender to taste, about five minutes.
4. Uncover and cool in syrup. Pour into dish and chill thoroughly.

*Yield: 4 servings*

**Note:** After loquats have cooled in syrup, they can be packed into freezer containers and frozen for months.

### Ballymaloe Baked Breakfast Fruit

*(Slightly adapted from The Breakfast Book,* by Marion Cunningham, Knopf)

1. 1 cup dried pitted prunes
2. 1 cup dried apricots
3. 1/2 cup raisins
4. 3 bananas, sliced thick
5. 2 tablespoons honey

**Grated zest of 1/2 lemon**

### Apricot Bavarians with Nectarines, Pistachios, and Almonds

*(Slightly adapted from The Natural Cuisine of Georges Blanc, Stewart, Tabori, and Chang)*

1. 1 ounce sliced almonds
2. 1 ounce shelled unsalted pistachios
3. 1 cup orange juice

1. 2 tablespoons butter

1. Put the prunes and the apricots in a bowl and cover with hot water. Soak overnight.
2. Preheat oven to 350 degrees.
3. Drain, and put the prunes, apricots, raisins, and bananas in a baking dish. Dissolve the honey in 1/2 cup water. Sprinkle the lemon zest over the fruit and then pour on the honey. Dot with butter.
4. Bake for about thirty-five minutes. Add the orange juice and continue to bake long enough for the orange juice to get hot, about five more minutes. Serve warm. The fruit is nice with light cream poured over.

*Yield: 8 servings*

**Note:** To serve cold, follow the preceding directions, but omit the bananas and the orange juice. Reserve 1/4 cup of the water that the fruit soaked in, add it to the honey, and pour it over the fruit. Put into a baking dish, omit the butter, and bake as directed. Cool and refrigerate. Just before serving add a little fresh orange juice and some sliced bananas. This keeps for about ten days in the refrigerator.

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This young southern elephant seal sounded off on finding a welcoming committee of king penguins on the strand of remote Marion Island. Located in the stormy latitudes known as the roaring forties, the island is about midway between the Cape of Good Hope and Antarctica, and its beach-front property is seldom in dispute. With temperatures hovering around freezing, one hundred inches of rain annually, and winds often gusting to...
The Natural Moment

one hundred miles an hour, this subantarctic real estate is the province of a few scientists and meteorologists based at a weather station and the abundant wildlife of the surrounding turbulent seas.

Whether the approximately six-month-old seal is barking in anger, surprise, or merely youthful good spirits is not known, but the unperturbed penguins did not take it as a serious threat.

After all, elephant seals—even the four-ton adult males—don’t prey on penguins, but prefer to plumb the depths for fish and squid. Penguins also savor fish but pose no competition for the seals, which hunt at greater depths. Burney La Boeuf, an expert on the southern elephant seal’s cousin, the northern elephant seal, has monitored female northern elephant seals’ dives to a previously unsuspected record depth of 2,900 feet. —J.R.
The first chapter in the human history of the New World was written on the Asian side of the Bering Strait, from where, most scholars believe, the first Americans migrated. Among Soviet scientists probing the archeological record of eastern Siberia is Nikolai N. Dikov (page 10), whose interest in New World settlement helped draw him to work at the Chukchi District Local Museum in Anadyr and, as he describes in his article, to the discovery of Old Stone Age sites on the Kamchatka Peninsula. A corresponding member of the USSR Academy of Sciences, Dikov, who is now based in Magadan, is continuing his archeological survey of extreme eastern Siberia, especially the Chukchi Peninsula. For additional information on the archeology of Siberia, readers may consult “The ‘Dyuktai Culture’ and New World Origins,” by Seonbok Yi and Geoffrey Clark (Current Anthropology, February 1985, pp. 1–20), and “Siberian Paleolithic Archaeology: Approaches and Analytic Methods,” by Alexander B. Dolitsky (Current Anthropology, June 1985, pp. 361–78).

Olga Kukal (page 36) encountered the animals that launched her major research project by chance when she first visited Ellesmere Island in 1981. Although I was working in a research group of Pleistocene geologists, my interests in biology and insects drew me toward these arctic caterpillars.” Kukal grew up in Czechoslovakia, and her parents, both scientists, encouraged her interest in natural history from an early age. Soon to receive her doctorate in physiological ecology from the University of Notre Dame, Kukal, shown with a tropical amathusiid butterfly, has specialized in the cold adaptations of arctic insects. She has done fieldwork from the Antilles to Papua New Guinea and from the Rockies to the Caucasus. Kukal refers readers to Ecology of a High Arctic Oasis: Alexandra Fiord Lowland, Ellesmere Island, N.W.T., Canada, edited by J. Svoboda and B. Freedman (Toronto: University of Toronto Press, 1987), and Arctic Dreams: Imagination and Desire in a Northern Landscape, by Barry Lopez. (New York: Charles Scribner’s Sons, 1986).
“Sorry for the typos,” writes Stan Stevens (page 26), “but I’m running my computer on solar panels here in Namche Bazaar (twelve miles from Mount Everest), and we’ve been having a monsoon for the last week so my batteries are low.” Since beginning his story on the Annapurna Sanctuary we have had to track Stevens from Berkeley, California, where he is a doctoral candidate in geography, to remotest Nepal, where messages are best sent via trekkers. Stevens himself is an inveterate hiker and devotee of what he calls “high wilderness travel” in the Canadian and American Rockies. He figures he has walked more than 2,000 miles through Nepal and the Himalayas, conducting his research on land use in dozens of Indian, Nepalese, and Pakistani villages. For further reading on Nepalese villagers, he recommends Alan MacFarlane’s Resources and Population (Cambridge: Cambridge University Press, 1976).

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Unlike many ornithologists, Steven R. Beissinger (page 42) says he was never very interested in birds during his childhood, when his specialty was catching grasshoppers and fish. During his last year of college, however, he took a course in ornithology, and soon afterward, birds "became a passion." His first introduction to snail kites came ten years ago in Guyana, where he became intrigued by their highly specialized snail diet. Since then, Beissinger has been studying snail kites in the Florida Everglades and, more recently, on the llanos of Venezuela. Beissinger, until recently a National Science Foundation postdoctoral fellow at the National Zoo in Washington, D.C., is now an assistant professor of wildlife ecology in the Yale School of Forestry and Environmental Studies. For more background on conservation of the endangered snail kites in Florida, he refers the reader to "The Kite Hangs by a Thread," in the August-September 1984 issue of National Wildlife, and for those interested in the nesting ecology of raptors in general, he recommends Ian Newton's Population Ecology of Raptors (Vermillion: Buteo Books, 1979).

In 1987 Peter A. Rona (page 52) was awarded the U.S. Commerce Department's gold medal for distinguished service for his work in the study of undersea geology. Rona has been going out to sea in research ships since 1960 and has studied the sea floor from submersibles in the Atlantic, Pacific, and Indian oceans. As senior research geophysicist for the National Oceanic and Atmospheric Administration, his work now centers on the deep sea floor processes that create the great wealth of ocean mineral deposits. Rona is a trustee of the Miami Museum of Science and an adjunct professor at the University of Miami. Since 1970 he has served as a consultant to the United Nations on sea floor resources. The Mines of Neptune, by Elisabeth Borgese (New York: Harry N. Abrams, 1985), is a good source for further reading on deep-sea mining.

British ornithologist Michael Brooke (page 80) was braving the dismal weather of subantarctic Marion Island studying seabirds when, by "sheer good luck," he came upon the standoff in this month's "Natural Moment." Like many fine photographers, Brooke started out as a boy with a Brownie camera. A postdoctoral research assistant in the zoology department at Cambridge University, Brooke has also worked at the Edward Grey Institute of Ornithology at Oxford University. Although he has done fieldwork in both the subantarctic and subarctic, his specialty is the cuckoos of more temperate regions. In addition to photography, he enjoys writing and sometimes, after his travels, just staying at home, tending the goldfish in his backyard pond. He took this month's photo with a Canon A-1 using Agfa 50S film and a 70-210-mm zoom lens.
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Cover: All eyes left, three juvenile dwarf mongooses emerge from the safety of their den. Photograph by Bruce Davidson. Story on page 40.
Geofacts and Fancy

"If a man will begin with certainties, he shall end in doubts; but if he will be content to begin with doubts he shall end in certainties." —Francis Bacon

by C. Vance Haynes, Jr.

In the summer of 1959, while archeologist George Agogino and I were investigating sites at Hell Gap, near Guernsey, Wyoming, we received a call from H. Marie Womington, a leading authority on early human settlement in the New World. Womington, then at the Denver Museum of Natural History, wanted us to give José Cruxent, a visiting South American scholar, a firsthand view of an early North American site. Hell Gap was a logical choice because it was relatively close to Denver and contained a sequence of artifacts, in a stratified geological context, that revealed cultural development from about 11,000 to 8,000 years ago.

In those days, we all thought that the first occupation of the New World began before the last glaciation reached its peak between 20,000 and 17,000 years ago. Sandia Cave, in the mountains above Albuquerque, New Mexico, had yielded stone spear or dart points and other artifacts thought to be at least 20,000 years old. Clovis artifacts (named for a site near Clovis, New Mexico, and characterized by a distinctive type of fluted projectile point) were estimated to be between 11,000 and perhaps 15,000 years old. At Hell Gap, however, the earliest radiocarbon date associated with artifacts was a more modest 10,800 years ago, at the bottom of the archeological sequence. The artifacts were unfluted points that we attributed to the Folsom culture, a successor to Clovis. This culture, more normally represented by fluted points, was named for an important site near Folsom, New Mexico. There, for the first time, archeologists had unequivocally demonstrated that New World inhabitants had hunted now-extinct Ice Age animals.

Below the artifacts at Hell Gap, in alluvial sand that contained no evidence of human presence, we had a date of 13,000 years ago. Still farther below were gravel deposits consisting of chert and quartzite cobbles that Ice Age streams had washed down from natural outcrops to the northwest. We knew that Paleo-Indians had used flinty materials like chert and quartzite to manufacture stone projectile points and other tools, and that some had quarried chert from the nearby outcrops. But we had not thought about looking for artifacts in our gravel deposits.

In examining the gravel with Cruxent, however, we found several pieces of chert that appeared to have been worked into recognizable tool types such as scrapers, speksheaves, and beaked implements. The more we looked, the more we found; and the more we found, the more our excitement grew. Later in the day, in the uplands where the outcrops of chert were located, we found similar tools with flaked edges, although they seemed cruder. In addition, we found more familiar forms of stone tools, cores, and flakes, which we could confidently identify as products of prehistoric quarrying.

Evaluating the significance of our finds in light of what geological processes could do in the way of chipping and flaking stone, we realized we had been carried away by our enthusiasm. We unanimously concluded that everything we had found in the gravel deposits had been chipped naturally while being transported along the beds of streams from the outcrops in the uplands to the alluvial terraces below. Whenever we examined mixed gravels containing both chert and other stones, such as quartzite, that could have served as natural hammerstones, we seemed to also find pseudotools, regardless of the age of the gravel deposits. We also recognized that the battering of natural pieces of chert by the hoofs of grazing animals was probably responsible for some of the cruder "tools" we found on the slopes of the uplands. The entire experience alerted me, as an archeological geologist, to how often natural processes produce objects easily mistaken for the work of humans. For such products of geological processes I coined the term geofacts.

This lesson was brought home again in 1962, when I was invited by archeologist Richard Shutler to participate in a massive investigation of the Tule Springs site near Las Vegas, Nevada. At the time this was considered the oldest demonstrated site for early human presence in the New World: archeologists had reported finding bones of extinct mammals and artifacts in direct association with hearths loaded with charcoal, dated 28,000 years old by the radiocarbon method. The purpose of opening new excavations was to expand our knowledge of the culture and uncover more evidence in geological context. A blue-ribbon panel of experts from the fields of archeology, geology, chemistry, and physics, all sponsored by the National Science Foundation, monitored the objectivity of the effort.

From what I had read about the site, there was little doubt about the evidence for a 28,000-year-old human presence at Tule Springs. Therefore, as site geologist,
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I was surprised to find that what had been interpreted as charcoal hearths were in fact black deposits of incompletely fossilized plants associated with one-time spring feeders. And what had been interpreted as fire-reddened earth associated with the carbon turned out to be iron oxide stains produced by ground water. Furthermore, we concluded that the bones of horse, bison, camel, and mammoth, whose curved fractures had been interpreted as the result of human handiwork on fresh bone, were instead the product of trampling by animals that had been trapped in the spring feeders. The only indisputable artifacts were those found in younger alluvium above the older spring sediments, dated by the radiocarbon method to be between 10,000 and 11,000 years old.

Another object lesson in the pitfalls of interpretation came soon after, when Emil Haury, of the University of Arizona, and I examined the Calico site near the Calico Mountains of California. This dig is at a fan-shaped, chert-bearing deposit left by ancient streams. The surface of this alluvial fan is littered with chert cores, bifaces (stone tools shaped by flaking both faces), and flakes derived from quarrying and stone-knapping activities. These artifacts represent a considerable span of time, as indicated by the wide variation in their weathering and in their coating of desert varnish, a patina built up by bacteria in conjunction with windblown substances. One can also find historic traces ranging from nineteenth-century artifacts connected with the nearby gold mining town of Calico to modern litter left by rockhounds, who have found the Calico cherts to be a good source of agates.

At the time of the initial Folsom discovery in 1927, the late Louis Leakey predicted that evidence for pre-Folsom humans would be found in America of an age beyond the fondest dreams of American archeologists. In 1963, recognizing the problems with dating the artifacts on the surface of the Calico fan, Leakey suggested to archeologist Ruth Simpson that she trust in "Leakey's luck" and dig into the fan deposits proper. The minimum age of the alluvial fan itself is established because deposits of a lake that existed 18,000 years ago, during the last glacial period, are demonstrably much younger. William Bull, an authority on Mojave Desert geomorphology, believes the fan is at least one million years old.

Almost immediately, Simpson's dedicated crew found, below the surface, flaked pieces of chert that she considered to be artifacts, classifying them as possible, probable, or "mint specimen." These were saved until Leakey arrived once or
twice each year to pass judgment on the finds. All other pieces of chert were discarded until I, Haury, and others cautioned that, because of the subtle gradation between categories and the subjectivity of the selection process, all specimens of chert should be saved. The piles now cover several acres.

Critics of the Calico excavations see a distinct difference between most of the "mint specimens" and indisputable artifacts, like some of those found on the surface of the alluvial fan. Nevertheless, of the perhaps million or so pieces of chert excavated, a few have been recovered that would pass as artifacts if found in an otherwise indisputable archeological context. Even so we must ask, Are these not statistical flukes of nature, considering the great number of pieces from which they have been selected?

After pointing out several ways geofacts might have been produced at Calico, and to test the possibility of natural origin, I suggested checking to see whether equal numbers of such "artifacts" could be found in similar gravels anywhere one looked in the alluvial fan. Since one would not expect to find equally intense human occupation in every gravel deposit, the uniform presence of such "tools" would suggest they are geofacts. This experiment was never thoroughly carried out, but on the basis of archeological test pits at the site, a geological origin for the "artifacts" seems most likely—not proven, but most likely. This interpretation is unacceptable to most of those still digging the site because they are convinced that they have found artifacts.

Apart from the question of distinguishing artifacts and geofacts, there is the problem of dating purportedly early finds. During the mid-1950s, few Folsom or Clovis sites had been accurately dated by the relatively new radiocarbon technique. In addition, most of the results were based on bone or mollusk shell, materials with a reputation for yielding imprecise if not erroneous dates. To help rectify this situation, Agogino and I set out to find charcoal at as many of the critical sites as we could.

As a geologist, I wanted to obtain precise dates associated with Paleo-Indian cultures in geological contexts, and to use this information to compare stratigraphy over a wide geographical area.

At that time, as mentioned earlier, we thought that Clovis went back in time three or four thousand years beyond Folsom, which was almost 11,000 years old. The results soon indicated otherwise. The first reliable radiocarbon date for Clovis had already come from the Lehner site in Arizona, where Haury and his associates
found that charcoal from a hearth was 11,200 years old. We were a bit surprised, therefore, when we obtained a nearly identical date at Dent, Colorado, where the first Clovis artifacts had been unearthed (although not immediately recognized as distinct from Folsom). Our date was on bone, however, and so we felt the results could be in error and possibly too young.

We soon excavated a new mammoth find near Rawlings, Wyoming, and found tools that were probably Clovis, although they did not include the fluted projectile points. The tusks—so well preserved that we could have made piano keys of the ivory—dated to 11,280 years ago. Meanwhile the Domebo Clovis site in Oklahoma was found to be 11,000 years old based on wood from a rooted tree stump, and 11,200 years old based on an associated mammoth skeleton. And new discoveries were made at the original Clovis site while I was working in the radiocarbon dating laboratory at the University of Arizona. Agogino sent me charcoal from carbonized plants directly associated with one of five mammoth skeletons. It dated to 11,150 years ago. What were these dates telling us, and why couldn’t we find a Clovis site more than 11,500 years old?

In the course of examining the geological evidence to see if it was compatible with these radiocarbon dates, as well as with other evidence, such as the types of animals found and climate-induced environmental change, I found a marked uniformity in the way Clovis sites were related to alluvial deposits along streams throughout much of North America south of Canada. The very limited stratigraphic position of the buried Clovis sites is consistent with the remarkably short time range of the radiocarbon dates. At most sites, the Clovis level is associated with a stream bed that is puny in comparison with that of the stream preceding it; the ancestral stream can be attributed to the time when the continental glaciers were retreating at the end of the Ice Age.

In particular, the Clovis artifacts are concentrated either in the upper portion of their stream-bed deposits or on the surface of the eroded banks. Deeper portions of some of the same stream beds have yielded radiocarbon dates between 13,000 and 11,500 years ago, but no positive evidence of a human presence. Big game was every bit as plentiful during this preceding interval as during Clovis times, yet no evidence of humans has ever been found in these lower deposits despite several decades of searching.

A possible explanation for this tight clustering of Clovis dates emerged twenty-five years ago from geological evidence published by David Hopkins and other scholars. Research showed that Alaska and Siberia had been connected by a broad land mass between 22,000 and perhaps 11,000 years ago because continental glaciers had taken up ocean water and lowered the sea level. This bridge to America had been broad and clear for about 10,000 years. Any migrants reaching central Alaska during that period, however, were blocked from movement southward by the continental glacial ice covering Canada from coast to coast.

Between 16,000 and 7,000 years ago, the glaciers released their grip on Canada in a series of fluctuating retreats and readvances. Sometime during this period, ice covering the western mountains of Canada (the Cordilleras) is believed to have separated from the main mass to the east, known as the Laurentide ice sheet. The Two Creeks Interstade (or Two Creeksian Interstage, as it is now formally called) was a relatively warm interval that is a prime candidate for when this ice-free corridor opened up. (It is named for a fossil forest bed near the town of Two Creeks, Wisconsin, where trees grew during that time; they were then drowned by the rise of ancestral Lake Michigan, when readvancing glacial ice blocked an outlet through the Straits of Mackinac.)

Early radiocarbon dates on Two Creeks trees indicated that the warm interval occurred about 11,000 years ago, or perhaps a bit less—just a little later than Clovis times. In 1963, however, geochemist Wallace Broecker and geologist William Farrand published the results of new radiocarbon tests that indicated that several of the previous dates were too young: the Two Creeks trees persisted no later than 11,400 years ago, and the height of the warm interval must have been earlier.

How interesting! The abrupt appearance of the Clovis folks in the stratigraphic record could be explained by the opening, a few centuries earlier, of the first passable corridor through Canada in several thousand years. Taking a cue from David Hopkins, I proposed this as a working hypothesis to explain the geologically sudden appearance of Clovis artifacts over most of North America south of Canada. Soon after, I presented a conservative model of how a single band of twenty-five Clovis progenitors could have populated the continent in a few hundred years. Paul Martin took this idea further with his blitzkrieg model for Pleistocene “overkill”—the extinction of Ice Age mammals as a result of the expansion of a new predatory animal—the human hunter.

A model of what may have happened, devised by Martin, along with statistician
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James Mosimann, suggests that behind an advancing wave of superpredators there would have been regions left depopulated of both humans and large animals. This is not supported by the geoarchaeological record, however, which shows cultural diversity and human population increasing exponentially throughout the interior of North America, as the Clovis folk rapidly transformed to Folsom and several other cultural complexes.

I might add that neither climatic change at the end of the Ice Age nor human predation alone seem adequate to explain the extinction of the large Ice Age animals. More severe climate fluctuations earlier in the Ice Age had failed to produce similar results, and by themselves, humans probably could not have annihilated such a significant portion of the animal life. Because of the geological evidence for low stream flow and a reduction of watering places during Clovis times, I favor the view that the large mammals, already under duress, were preyed upon at water holes. But even this seems inadequate. The extinctions were every bit as sudden as the appearance of the Clovis folk, both events occurring at the same narrow stratigraphic position. For some yet undiscovered reason, the large mammals may have been on an irreversible decline before the Clovis population attained significant strength.

In any case, the abrupt appearance in the geological record of the Clovis culture, consisting of sophisticated stone and bone tools, seems to me to be most readily explained by an influx of their progenitors years ago. While a coastal route is feasible (as suggested by Knut R. Fladmark in the introduction to this series in November 1986), I find fewer problems with an ice-free corridor route. This model for Clovis origins, although speculative, is based upon an effort to test alternative hypotheses only to find them less supportable.

This conservative view has been challenged by a number of the sites described in this series on “First Americans.” But will their evidence stand up, as did that of Folsom, New Mexico, in 1927? Folsom, like the Tule Springs reexcavation, was witnessed by a group of leading authorities, including skeptics. Because of the unavoidably subjective nature of many archeological interpretations, skeptical inquiry is not only healthy for science, but it should be required at the more controversial sites. Alan Bryan, who has excavated such sites in both hemispheres of the Americas, has openly invited such inquiry, but there have been no takers because granting agencies are not supportive of such activities, and most archeologists are too busy to spare time from their own investigations.

Much of the evidence for pre-Clovis human presence involves either questionable artifacts or their association with localized cave or spring deposits that are isolated from regional stratigraphic sequences. Here the only criterion for age is radiocarbon dating. If I have learned one thing in a quarter century of direct involvement in radiocarbon dating, it is that radiocarbon dates can be wrong. Other evidence is needed for corroboration, such as stratigraphic correlation and consistency in cultural sequences and in associated fauna and flora.

J. M. Adovasio and Ronald Carlisle, for example, argued in this series (December 1986) that the early cultural levels of the Meadowcroft rock-shelter in Pennsylvania, with radiocarbon dates between 19,000 and 12,000 years ago, provide ample evidence for people being in Pennsylvania 8,000 years before Clovis. When I first learned of the deep stratigraphic record at Meadowcroft, with its consistent succession of radiocarbon dates on charcoal from hearths and the associated developmental sequence of artifacts, there was little doubt in my mind that this was the discovery that would break the ice and prove the pre-Clovis occupation of America south of Canada.

In scrutinizing the details of the site reports, however, I and others were puzzled by the evidence of post–Ice Age animal and plant life at the time the edge of the great continental glacier was only thirty-eight miles away. Also, 19,000 years of continuous sedimentation with no significant stratigraphic deviations bothered me, because most sedimentary processes show pronounced changes at the end of the Ice Age. Then I learned that the radiocarbon samples taken from lower levels of the site were very soluble in the caustic solution used, before analysis, to free all samples from contaminating humic acids. This was unusual. And upon testing, the humic acids turned out to be nearly two times older than the small residue (charcoal?) that survived the treatment. Normally we would have expected such contaminants to be younger. Because the site is in a coal mining district, we must ask, Is it possible that ancient organic matter derived from coal has contaminated the samples, making them appear older than they are? This question has not been adequately resolved by skeptical inquiry.

If we accept the South American evidence, including that presented in this series by Alan L. Bryan (June 1987), Tom D. Dillehay (April 1987), and Niéde Gui
Dordon (August 1987), we have: 32,000 years ago, pebble tools at Monte Verde in Chile and pebble tools and rock paintings at Pedra Furada in Brazil; 22,000 years ago, crude flake tools at Pikimachay in Peru; between 15,000 and 13,000 years ago, chopper-chopping tools at Pikimachay, unifacially retouched flake tools at El Abra rock-shelter in Colombia, bifacial leaf-shaped projectile points at Taima Taima in Venezuela, and essentially all of these traditions at Monte Verde. If we include Middle America, we can add Tlapacoya, in the Valley of Mexico, where sophisticated obsidian blades are believed to be associated with strata 24,000 years old. Taken all together, these sites provide an impressive display of cultural diversity going back as much as 20,000 years before Clovis.

This evidence needs better verification, however. If people have been in South America for 30,000 years, or even 20,000 years, why are there so few sites? In Europe, Africa, and Asia, artifacts are relatively common in Ice Age alluvium. The contrast with the Americas is striking. If there were pre-Clovis people in South America, we must also wonder why there is so little evidence to positively identify their counterparts in North America. One possible answer is that they were so few in number; another is that South America was somehow initially populated from directions other than north until Clovis appeared. In either case, none of the South American material appears to be a logical forerunner of Clovis, considering the whole range of Clovis artifacts. Why would everybody have dropped what they were doing 11,500 years ago and taken up the Clovis life style?

Instead of searching for the oldest sites in the Americas, my approach is to investigate the 500 years immediately preceding 11,500 years ago, when positive evidence first appears in the geological record. By understanding what goes on archeologically during this critical period we will learn if Clovis evolved from a preexisting culture in the New World or if it arrived, as a highly developed culture, as suddenly as the record suggests, taking over what probably (but not necessarily) was uninhabited territory.

So far, there are only tantalizing clues concerning the origin of Clovis. In Alaska the oldest radiocarbon dated evidence for early human occupation is known as the Nenana complex, dating between 12,000 and 11,000 years ago. The assemblages (collections of artifacts found together), some of which predate the earliest Clovis dates, include projectile points that are not fluted and scrapers similar to Clovis forms. The Nenana complex is, therefore, a potential Clovis progenitor.

In the Old World, the most similar assemblages are from upper paleolithic (later Old Stone Age) sites in eastern Europe. Even though there are no fluted points, there are some remarkable similarities concerning the distances involved. In all of Siberia, instead, only the upper paleolithic site of Mal’ta near Lake Baikal has similarities to Clovis. Bone from the site is radiocarbon dated to 14,750 years ago. Some say the site is 18,000 years old, based on geological evidence. The site contains a human burial with red ocher; cylindrical, bevel-based bone points identical to a type known for Clovis; and stone bifacial forms. Except for its abundance of carved figurines and the absence of fluted points, Mal’ta is comparable to the Anzick site in Montana, a Clovis burial, where cylindrical bone shafts with beveled bases, large bifaces, well-made Clovis points, and other tools were found with the fragmentary remains of a child, all covered with red ocher. In contrast, most other upper paleolithic sites in Siberia are dominated by a microblade technology that does not appear in either Clovis sites or at Mal’ta.

Of all the Siberian samples of human teeth examined by Christy G. Turner II in his exhaustive survey, only those discovered in the Mal’ta burial appeared more European than Asian. This suggests that eastern Europeans had gone halfway across Siberia by 15,000 or even 18,000 years ago. Could Clovis progenitors have come from Mal’ta stock? On the basis of the New World samples, Turner thinks not, but his interpretations are subject to argument. Unfortunately, the best candidate for actual Clovis skeletal material, the few fragmental child remains from Anzick, proved to be too immature for Turner’s classification.

Despite decades of research, the origin of the first Americans remains one of the most intriguing of all archeological questions. Our objectives should not be to prove a particular theory, but to learn what occurred in the past. All potential candidates for pre-Clovis occupation of the Americas must be evaluated with as much objectivity as possible. Only when scholars can point to replicated findings at two or more sites—with similar cultural traits and similar pre-Clovis radiocarbon dates, all in a pre-Clovis stratigraphic context that is not isolated—will we be able to say for certain that there were pre-Clovis inhabitants in the New World. Such evidence will also reveal something of their lifeways and their relationship, if any, to the Clovis people.
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East of Costilla, New Mexico, just south of the Colorado border, a narrow forest service road climbs over the Sangre de Cristo Mountains, going past Clayton Pass, a 300-acre tract managed by the Carson National Forest as a Research Natural Area. Less than a mile from a small parking lot at the Clayton horse corral, which borders the southern edge of the natural area, the terrain ascends rapidly from 10,000 feet to an 11,000-foot ridgetop, which runs northeast. The lowest zone is occupied by a meadow of oat grass, Thurber fescue, and bluegrass, with an occasional bristlecone pine seedling. As the elevation increases, however, these bristlecones become more abundant, shading out the grasses. Finally, where the slope is extremely steep and rocky, a nearly pure stand of the trees dominates the landscape.

Bristlecone pines receive their common name from the often firm bristles that protrude from the cones. I have previously described the grotesquely twisted bristlecone pines that grow on bleak, windswept peaks in the White Mountains of eastern California (May 1985). One of those gnarled specimens, barely thirty-five feet tall, is 4,600 years old. Others, equally ancient, grow on Wheeler Peak, in eastern Nevada. Although botanists have known for more than a century that bristlecone pines also grow in the Rocky Mountains, from central Colorado to northern New Mexico, as well as in Utah and in an isolated stand on the San Francisco Peaks north of Flagstaff, Arizona, none of these other places seem to yield trees of such remarkable longevity.

William Dunmire and his colleagues from the New Mexico field office of the Nature Conservancy, for example, have determined that none of the trees at Clayton Pass are more than about 300 years old. Yet they found one noteworthy pine more than sixty feet tall, while another behemoth had a circumference of eleven feet, measured four and a half feet above the ground. Among the conditions supporting this vigorous growth are about thirty inches of annual rainfall, which comes mostly between May and October, and the relatively nourishing mixture of
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orange, chert-bearing sedimentary rock and loamy soil. Although temperatures are low—ranging from 54°F during July to a low 16°F in January—up to seventy inches of snowfall insulates the ground during the winter months.

Beginning in 1966, D. K. Bailey of the National Oceanic and Administrative Environmental Research Laboratory, whose interest is the dating of ancient trees, tried to locate bristlecone pines in Colorado that might approach the age of those in California. After searching for five years in vain, Bailey eventually went to Nevada to see some of the ancient bristlecones firsthand. In addition to the twisted growth of the Nevada trees, he noticed one other obvious difference from the Rocky Mountain specimens. The needles of the Nevada bristlecone pines lacked the white, sticky resin that covered the needles of the Colorado trees. This difference had never been detected before, since the resin is not obvious on dried specimens and apparently few botanists had ever compared living specimens of the Colorado and Nevada bristlecone pines.

Suspecting that perhaps the bristlecone pines from the two regions were not the same species, Bailey began looking for other consistent differences between them. He took detailed notes on every bristlecone pine stand known for Colorado, New Mexico, Utah, Nevada, and California and made several revealing observations. The needles of the Rocky Mountain trees (Colorado and New Mexico) have a single dark line extending the length of the underside, while the needles from Utah, Nevada, and California trees have two dark lines. After they are about two years old, the needles of the Rocky Mountain trees tend to curve outward, giving the branch a soft appearance; the needles from the western trees remain straight, so that the branches seem coarser. The needles of the Rocky Mountain trees stay on the trees for ten to fifteen years; those of the more western trees persist twenty-five to thirty years. When fresh, the needles of the Rocky Mountain trees have a pungent turpentine-like odor; needles from western trees lack this odor.

The cones of the Rocky Mountain trees are very sticky and resinous, and they are difficult to handle because their bristles are very prickly and point directly outward. The cones from the western trees are less sticky and the bristles turn downward and are less prickly. Bailey also noticed that cones from the Rocky Mountain trees can stand on end because their bases are flattened; western cones, which have very rounded bases, topple over.

Apart from compiling structural differences among bristlecone pines, Bailey checked their ranges and ecology. When he plotted the distribution of the hundreds of trees he had examined, he found that all of the trees with Rocky Mountain characteristics are confined to Colorado and New Mexico, along with the single stand in Arizona, while all the others are in Utah, Nevada, and California. There is no overlap. In fact, a distance of 160 miles separates the Rocky Mountain trees from the more western populations. Interestingly, all of the western trees grow in areas where limestone or dolomite lies under the soil; the Rocky Mountain trees live in more acid soils. And the western trees receive less than thirty inches of annual precipitation, most of it in winter, while the Rocky Mountain trees receive up to forty-five inches, mostly in summer.

Bailey found that the western trees are often more than 3,000 years old, while the Rocky Mountain trees never exceed 2,000 years. He concluded that there were two species of bristlecone pines that had distinguishing features and separate habitats. He thus named the longer-living western species *Pinus longaeva*, reserving the traditional name *P. aristata* for the Rocky Mountain populations.

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In matters of incubation, male mallee fowl prove to be parental paragons

by John Alcock

The ranger at Wyperfeld National Park tells me where to look for mallee fowl, a bird I very much wish to add to the list of Australian species I have seen and admired. I can pick up a short trail right to a nest mound, but the ranger warns me that the birds are diffident and my chances of more than a glimpse are slight at best.

A glimpse would be good enough for me, so I make for the trail, which slips into the mallee scrub forest, a uniform woodland in a land with virtually no topography. In the early morning the pendant leaves of the eucalyptus filter the bright sunlight. Three galahs pass overhead, flashing in and out of view. The sun accents their parrot pinks while their thin calls fall to earth.

Each mallee eucalyptus is a duplicate of all others, a fan of trunks only a few inches in diameter, spreading out and upward to a delicate crown of narrow, blade-shaped leaves that shade the forest from a height of ten to fifteen feet. The bark of the trees peels away from the trunk and dangles in curved strips that scrape in the wind before dropping to litter the barren ground.

I walk as quietly as possible through the absorbing woodland, stopping when I see a surprising mound, more than a yard high and five yards across, that stands like a miniature volcano in a little clearing by the trail. Two mallee fowl stand calmly in the pit of sand and forest humus they have excavated within the center of the mound. They are beautiful birds, the size of small turkeys, decked out in earth tones—grays, warm browns, and off-whites. Their brown backs are scalloped into a mosaic of large, leaf-shaped patches outlined in white.

I freeze as soon as I detect the mallee fowl, but as they show not the slightest sign of alarm, I move closer. And closer. They ignore me utterly as they face toward the center of the mound and propel their feet, shifting their feet of debris out of the pit with powerful, raking leg strokes. Puffs of dust accompany each sweep of a leg, enriching the metaphor of the mound as an active volcano.

Seeing how tame the birds are, I edge away slowly and then race back down the trail to the camper in which my camera has been left for safekeeping. By the time I return, the two birds have stopped excavating the mound and have begun to work at drawing material from the walls into the center, refilling the pit they had constructed earlier. (I later learned that the mound is opened up in order to permit the female to lay an egg, which is then covered with sand and debris.) But with the job less than half done the female walks up and out of the nest; she wanders slowly off over the hard-packed forest floor, stopping to peck here and there at cryptic food items.

The male remains behind, raking back five or six times in a row with one ponderous claw, then switching to the other for a new series of sweeps, moving along the rim of the now-diminishing mound. The trill of a daytime cricket accompanies the mallee fowl’s methodical work.

After many minutes of exertion, the male completely reconstructs a smooth mound that conceals his partner’s egg deep within. He stands on the top of the mound for a moment, then dips his head,
raising the plumes on his skull; while in
this peculiar stance he lifts his wings
slightly and utters a series of deep coos
that roll off through the mallee forest after
the departed female. I sit on the ground
nearby and applaud his efforts.

K. H. Bennett, an early student of
megapodes (mound-building birds, of
which the mallee fowl is but one repre-
sentative), appears to have been over-
whelmed by the silent, claustrophobic
mallee habitat and the tedious nature of
the mallee fowl’s routines. The Reader’s
Digest Complete Book of Australian
Birds quotes Bennett as writing that the
bird’s “actions are suggestive of melan-
choly, for it has none of the liveliness that
characterizes almost all other birds, but it
stalks along in a solemn manner as if the
dreary nature of its surroundings and its
solitary life weighed heavily on its spirits.”
For an evolutionary biologist, however,
mallee fowl are an absolute delight be-
cause their behavior poses many challeng-
ing questions. How did mound building
ever get started? What were the evolution-
ary steps that led from the typical nest-
building behavior of most birds to the gi-
ant compost heaps built by mallee fowl
and some other megapodes? And why do
male megapodes perform most of the
work of nest building and incubation with
essentially no help from their females,
when females of most other bird species
are full partners in these tasks?
The evolutionary sequence that led to
meganeasts is not easily reconstructed, for
there are no currently existing species
whose nests seem obviously intermediate
between a “typical” simple ground nest
and the immense and complex nests of
megapodes. But we do know that ground-

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nesting birds must contend with many egg-eating enemies, and one possible way for a parent to conceal eggs when it had to leave the nest unattended would be to cover them with forest litter. In tropical areas where leaf mulch is often moist, decaying mounds of debris would generate heat that could be used by incubating eggs. If a proto-megapode happened to bury its eggs deeply, the better to conceal them from predators, the eggs would also have been kept warm. What initially provided antipredator benefits to a parent could provide incidental incubation benefits as well.

Almost all currently living species of megapodes inhabit wet tropical forests where they have access to quantities of moist organic material perfectly suited for making compost-heap nests. Therefore the mallee fowl, the only megapode to inhabit cool, dry woodlands, probably evolved from a tropical ancestor. Despite their spartan environment and a scarcity of compost starter that would lead an organic gardener to despair, male mallee fowl have successfully retained the ancestral pattern of using heat generated by fermenting vegetation to warm their mate's eggs.

The male—and only the male—devotes himself to the tasks of building a mound and tending the eggs after they have been deposited in his nest. Although a female may help a little in opening a prepared mound before laying an egg, the male does the rest. The job begins in the cool Australian fall, when the male laboriously digs a deep hole in the ground into which he rakes mallee leaves and other debris needed for heat production. He also gathers a great quantity of sandy soil to cover the composting center. This is a task that takes several months and a staggering amount of plain hard work. H. J. Frith, a megapode observer par excellence, discovered that males attend their mounds for about ten hours each day during all but one or two months of the year. Each day a male spends an average of more than five hours digging and digging, using his megafeet to open or build up the giant tumulus.

Eventually a male's nest is ready to receive the eggs of his mate; she lays them in the zone of the fermenting compost, one at a time at four- to eight-day intervals. A single female may have thirty eggs to deposit over a period of several months. During all this time the male, on his own and with no help from the female, carefully regulates the temperature of the eggs, keeping them to within a degree or two of 90°F. This task requires that the male measure the temperature of the material surrounding the eggs, which he does by taking up beakfuls of the stuff. If he determines that the fermenting compost has heated up too much, he opens the mound to let some heat escape. But when the compost has lost its warmth, the male may open the mound in midday to let the sun toast the eggs to a temperature optimal for development. Even so, two months of careful incubation are needed before an egg hatches and the fluffy youngster, fully active and independent, burrows up through the mound to set off in a dangerous world, where it will be on its own from the moment it walks off the nest.

Once the compost-heap system of incubation had evolved, one way for a male to attract a female to him would be to demonstrate that he had a well-prepared heap of litter in which the eggs could be concealed and kept warm. Males of many bird species build display nests that show off the suitability of an area for nesting and the competence of the male to perform his parental duties. Females may use these display nests to make decisions about which male to select, thereby affecting the reproductive success of males. If the heat of the compost is sufficient to incubate the eggs in the female's absence, she could gain by abandoning the male with her egg(s) and devoting her time and energy to egg production rather than to incubation. Remember that a mallee fowl can lay thirty-plus eggs per year, a much greater number than produced by most birds.

A “deserted” male has two primary options: to abandon the eggs, in which case he will leave few or no descendants, or to care for them and attract his mate to return to the mound repeatedly to lay all her large clutch of eggs there, one by one. Obviously the latter route is more conducive to genetic donation—provided the male inseminates the female whose eggs he cares for. Frith noted that males usually copulated before permitting their partner to lay an egg in their nest; without this precaution their nest labor could be parasitized by males that fertilize females and leave the monumental job of egg care to the parental types in the population. The reproductive failure of those males would, however, shortly doom their genes and lead to the elimination of paternal behavior from the population. This has not happened. Instead, male mallee fowl work on, hour after hour, month after month, among the mallee eucalyptus in an ordeal they accept stoically, unaware of the genetic dividend derived from their paternal sacrifices.

John Alcock is a professor of zoology at Arizona State University.
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The Heart of Terminology

What has an abstruse debate over evolutionary logic got to do with Baby Fae?

by Stephen Jay Gould

Language can be such a mighty tool for communication that even the Lord himself feared the power of mutual understanding among people: "Behold, the people are one, and they have all one language ... and now nothing will be restrained from them ..." (Genesis 11:6). Thus, in the very next verse, He whacked the divine wrecking ball against the Tower of Babel, scattered the people abroad, and assured perpetual disunity by confounding the languages of the earth. Since then we have understood in sadness that language can sow division and confusion as often and as easily as it can foster unity and understanding.

We all know the problems of communicating with people who speak different languages. But even more frustrating, almost perversely so, are the severe misunderstandings that can arise among people who claim to speak the same language, but use identical words in disparate ways. A classical arena of confusion lies in differences between scientific and vernacular meanings of the same words.

Significance, to a statistician, may refer to established differences between two samples (a centimeter or two in average length of Tanzanian versus Kenyan elephant ears, for example) that have no conceivable significance (in the vernacular sense of importance) to either a biologist, an African farmer, or a tourist. Random, to a scientist, can have an import precisely opposite to the vernacular meaning of chaotic or unpredictable. (Random processes offer maximal predictability in large samples because each item has no individuality and therefore maintains the same probability in each trial. We cannot know the outcome of one coin flip, but we can unerringly predict the small range of departure from 50–50 in very large samples. Radioactive dating works with precision because samples of billions of atoms decay at random. Las Vegas gets richer and we lose our shirts because, for large volumes in a random world, casinos can know what they will win and lose with precision, and can set the odds accordingly to give themselves a slight but inevitable edge.)

But parochialism extends beyond differences between scientific and vernacular uses. Different subcommunities of scientists may also define the same word in contrary ways, thus promoting serious confusions within the world of professionals. Technical debates about the meanings of words might strike readers as a particularly unpropitious subject for a general essay. What could be more tedious, more dull, more devoid of meaning and importance for understanding the real world out there than debates about terminology? In general, I concur and have only once before in this series written a column on the meaning of a word—evolution itself. But the story of this essay does merit attention from general readers, both because it involves the central concept of evolutionary biology and because the confusion of different meanings can, in this case, have vital consequences.

Evolutionary biology is largely the analysis of similarity among organisms. Evolution advances the general postulate that degrees of similarity reflect closeness of genealogical relationship—for history is the tightest bond among organisms. Nature, however, is never unambiguously simple. If genealogical closeness could be judged directly by extent of overt similarity, we could plug thousands of measurements into our computers, press the appropriate button, and go home a few seconds later with an irrefutable chart of evolutionary relationships.

But similarity has two distinctly different and opposite meanings: one records genealogical relationship, but the other confounds descent. Thus the basic activity of evolutionary biology cannot be simple measurement of overall similarity, but must reside in the more complex task of distinguishing the two kinds of similarity, rigidly separating the features that confound descent, and basing evolutionary trees only on the similarities that do record genealogy.

Many similarities exist as legacies of history. Organisms share features by inheritance because their common ancestor possessed the traits in question. To cite the classic example, the same arrangement of arm and finger bones permits a dog to run, a seal to paddle, a bat to fly, and a cop to direct traffic. The current functions are so different that we cannot attribute similarity of structure to natural selection for the same mode of life. The similarities are, in this case, a result of genealogy: the common ancestor of mammals also carried bones in this topological arrangement, and mammals have retained this heritage ever since. Similarities due to descent from a common ancestor are called homologies.

But other similarities, often just as impressive, arise as separate evolutionary adaptations to common functions. Birds, bats, and pterodactyls all bear wings with common aerodynamic properties (flight is a hard taskmaster, and only certain con-
figurations can work), but each lineage evolved its wings separately. No common ancestor of any pair had wings. Separately evolved similarities are called analogies.

The central task of evolutionary biology is not the totting up of similarities but the separation of homologous from analogous likeness. Obviously, if we wish to reconstruct pathways of descent, we will make terrible mistakes if we use analogous similarity (as folk wisdom has done in classifying bats with birds or whales with fishes). Genealogical relationships must be based only upon homologies.

There is nothing either mysterious or conceptually difficult about such a procedure. (Practical application is another matter, for we cannot always separate homologies from analogies with ease.) Biologists have recognized and understood the need for such a methodology from the inception of their efforts to find a “natural” system of classification. The terms have an ancient pedigree, even predating Darwin. Richard Owen, the great British morphologist, coined them in the 1840s, defining homology as the same organ under different circumstances, and analogy as different organs under similar circumstances.

Our terminological problem has arisen from the new kid on the phylogenetic block—comparative biochemistry, or the molecular approach to phylogeny. These methods are powerful, in my view by far the best we have ever possessed. I will go further and argue that molecular techniques have finally solved, in principle, the problem of phylogeny—for they have finally provided a strong criterion for the separation of homologies and analogies.

Homology can, in the end, be depicted as a problem in mathematical probability. Analogy works in a limited domain. Separate evolution can produce striking overt similarities, technically called convergences, in the outward, highly functional form of such structures as wings—for the exigencies of design dictate that no other shape can work, and natural selection must converge on the same basic solution. But separate events are limited in their power to replicate intricate detail. The form and aerodynamic properties of wings may converge, but all the nuances of morphology cannot, thus betraying the analogy. (Bats stretch their wing membrane between several elongated fingers, pterodactyls from one finger. Only birds evolved feathers.)

The more complex, numerous, and independent the similarities, the less likely that they could arise by analogy in separate evolutionary lineages. We may finally reach a level of detailed concordance that precludes analogy and must indicate homology. Molecular data provide this adequate sample size for the first time. Genes aren’t better, more basic, or more important in principle than external form; they just provide so many independent characters for analysis that high levels of similarity could not be separately evolved and must record descent from a common ancestor. If we analyze thousands of DNA bases or amino acids, then we resolve the problem of separating homology from analogy because detailed similarity across so many independent sites of possible difference can only record shared descent. (Evolutionary biologists have always acknowledged, in principle, that sufficient density of information could resolve homology. We could never attain this density with traditional data of external form for three reasons: (1) basic shape provides too few traits for analysis; (2) traits are often correlated so that we measure only an underlying factor of growth when we think we are assessing several features separately; (3) convergence works most prominently on external features directly subject to natural selection.)

Our rejoicing at this molecular resolution of homology might be unalloyed but for one gigantic terminological muddle provoked by our biochemical colleagues. Their data consist primarily of comparisons between genetic sequences of organisms. They might, for example, sequence 1,000 DNA bases in the same gene of two animals and determine the degree of matching. If 800 bases matched point for point, the animals would share closer genealogical relationship than a pair with 400 matches. The problem arises because biochemists insist upon referring to this degree of matching as “sequence homology.” They will, for example, speak of 80 percent sequence homology versus 40 percent homology for my hypothetical case cited above.

This usage drives evolutionary biologists right up the wall. Remember our basic litany, so well supported by the logic of our enterprise: Overall similarity, by itself, means nothing; similarity must be broken into components due to homology and analogy; only homologies indicate genealogical relationships. And now the biochemists come along and use our fundamental and clearly defined term homology for the inappropriate concept of overall similarity (a mixture of our homology and analogy). Homology is similarity due to descent from a common ancestor, period. Homology either is or it isn’t. Homology doesn’t come in degrees. Twenty percent homology makes about as much sense as the old saw about being just a little bit pregnant. One could hardly imagine a more perverse muddle (in the technical, not ethical, sense). Homology to evolutionists is the category of similarity that permits inferences about descent. Homology to biochemists is any old degree of similarity, no matter what its cause. Just imagine the confusion. We might admit that 80 percent sequence homology must imply common descent (true homology) because this degree of concordance cannot evolve twice and therefore lies beyond the power of analogy. But 1 or 2 percent sequence homology may well be produced by analogy (or by random change for that matter). Homology is an absolute quality of relationship; its criterion is descent from common ancestry. Overall similarity is a relative quantity of measurement.

This confusion has been reigning for a long time, at least since the late 1960s when biochemists began to use data on sequence similarities (as they should be called). Evolutionists have not stood passively aside. We have ranted, railed, polemicized, donned hair shirts, and pleaded—all without conspicuous success. I have been keeping a file on this issue ever since I was a baby assistant professor in the late 1960s. My first entry is a yellowed item in the form of a letter to the editor of Science, from Emanuel Margoliash, a pioneer in evolutionary studies of biochemistry (January 19, 1969). He complained about the redefinition of homology as “similarity in amino acid sequence” proposed by chemical colleagues in an earlier article. Defending both the priority and the propriety of the evolutionary definition, he wrote:

Homology, in any biological evolutionary context has a generally understood and well-defined meaning. One cannot argue that such comparisons [of protein or DNA structures] represent an area of knowledge separate from evolutionary biology, and that therefore one may use the same words for other meanings, since such protein studies obtain their interest largely in terms of evolutionary concepts.

He suggested that biochemists could invent “a variety of elegant neologisms” for their concept of overall concordance in protein or DNA, but that “similarity” or a variety of alternatives from Roget’s Thesaurus would do just as well. He pleaded that this new definition of homology as sequence similarity be dropped in order to “prevent an insidious misunderstanding likely to arise in biological literature.”

I have been discouraged ever since. Many scientists have noted and regretted the confusion; flurries of letters with pleas for reform have peppered the major scientific journals from time to time—all to no
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avail. Two traditions of usage (and a good deal of misunderstanding) have become entrenched, and scientists must juggle both meanings, often within the same article. (I have read papers that argue for homology in one structure because a high level of sequence homology exists, but against homology in another as a consequence of low sequence homology. If you can work your way through that, I award you a prize for decoder of the year.)

I was about to throw in the towel and close my file when my waning ardor for reform reawakened with the publication in Cell, our leading journal for cellular biology, of a plea by eleven of the nation's most distinguished evolutionary biochemists, including Margoliash (still fighting the good fight), for rejecting the chemical definition of overall similarity and hewing to the evolutionary meaning of common descent ("Homology" in Proteins and Nucleic Acids: A Terminology Muddle and a Way Out of It," August 28, 1987). Roger Lewin then thought the issue of sufficient importance to write an article about this August plea for the "News and Comment" section of Science, America's leading professional journal (October 1987). At this point, I felt compelled to add my entry in a different forum. The aboriginal evolutionary definition now needs all the artillery it can muster, for this may be our last stand—and we certainly hope to emerge on the side of Sitting Bull (it sure beats submergence with Mr. Custer).

The solution is so easy, as the gang of eleven notes. If, starting tomorrow at noon, all biochemists began to denote overall similarity of proteins and nucleic acids with the perfectly clear and admirable vernacular term sequence similarity, the issue would be resolved in a flash. The plea in Cell ends with this recommendation:

Surely we should intervene. With a collective decision to mend our ways, proper usage would soon become fashionable and therefore easy. We believe that we and our scientific heirs would benefit significantly.

Sequence similarity, sequence similarity. Such a lovely ring! Such fine alliteration! Sequence similarity, sequence similarity. Say it ten more times, and it's yours. But lexical conventions are among the most stubborn and hardest habits to uproot. We shall have little hope for reform if our only goal is abstract clarity or simplification. We must show that the current confusion has important consequences, that it matters in some palpable way. Let me close then with such an example.

On October 26, 1984, Dr. Leonard L. Bailey of the Loma Linda University (Seventh Day Adventist) School of Medicine transplanted the heart of a baboon into the chest of Baby Fae, an infant born with a lethal malformation of her own heart and otherwise doomed to a swift death. The child did well for a few days, but her body soon mounted a massive immunological attack upon the foreign tissue and rejected the graft. She died twenty days later. Baby Fae was front-page news throughout the world; the case even became a central ingredient in the lead song of Paul Simon's Graceland—"these are the days of miracle and wonder . . . don't cry, baby, don't cry, don't cry."

Bailey's procedure also generated a fierce controversy. I will make a strong statement of my own opinion, one that I think almost any evolutionary biologist would share. I have nothing but admiration for Bailey's effort to save a child without hope for survival in the absence of medical intervention on a heroic scale. But I believe that Bailey performed an indefensibly improper experiment from the standpoint of evolutionary homology. Several primates have hearts of the right size and conformation of parts to pump properly in a human chest. Morphological "fit" was never the issue, and the baboon's
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The danger in transplantation from one species to another, technically called xenografting, is immunological rejection of the “foreign” graft by the host’s body. Rejection is a function of genealogical closeness, not morphological appearance. The greater the evolutionary distance between two species, the less the hope that a xenograft can survive rejection.

Readers might think that a baboon’s heart was a good choice on this crucial criterion. After all, baboons are primates and so are we, so the requisite closeness of evolutionary bonding was attained. Moreover, baboon hearts are the right size and easy to obtain.

This argument is tragically wrong. Primates have lived throughout the 65 million years of the Cenozoic era, or “age of mammals.” Many pairs of primates are not closely related by the key term of homology—recency of descent from a common ancestor. Baboons and humans have often been analogized in discussions of behavior (since both evolved social adaptations to group life on African savannas). But we are not particularly close in terms of evolutionary descent within the primates. Our last common ancestor lived 20 to 30 million years ago, or even earlier.

By contrast, we are much nearer by genealogy to the great apes, particularly to chimpanzees. Chimp and human lineages diverged from a common ancestor only 6 to 8 million years ago. Baboons do not approach chimpanzees in evolutionary affinity to us. We note a great gulf in quality, not a continuum in quantity. Extent of homology prevails. The nearest baboon is a vastly more distant cousin to us than the furthest chimp.

Thus, if cardiac transplantation from another species is to be done at all, the donor should be a chimpanzee, not a baboon. Chimps provide the only conceivable, defensible experiment from the evolutionary standpoint of homology. (I am bypassing the important ethical issues of whether animals should be sacrificed to sustain a human life with so little hope, and whether chimps, as endangered species, should be used in medical research. I only say that if the experiment proceeds, chimps offer the best, probably the only, hope of success.) I grieve for Baby Fae because her short life passed in hopeless battle, and because I believe that through conceptual error, she was not given her best chance.

I do not hold this belief only in the abstract. Baby Fae was not the first human to receive a primate xenograft. A few transplants, primarily kidneys but also a few hearts, have been attempted since the...
early 1960s. The prestigious Council of Scientific Affairs of the American Medical Association published an official review on xenografts in the Journal of the American Medical Association (JAMA) on December 20, 1985. They note a rapid rejection of all baboon transplants, but point out that chimpanzee kidneys were often rejected no more quickly or violently than those from human donors. One man lived with a functioning chimpanzee kidney for nine months (during the 1960s before the development of effective drugs for immunosuppression). The Council lists as one of its six major conclusions: “Histopathology of chimpanzee xenograft rejection is very similar to that in human allograft [from one person to another] rejection; baboon graft rejection, on the other hand, tends to be more rapid and severe.”

Bailey hoped that he might overcome previous problems of rejection for two reasons: the supposed “immature” state of a baby’s immune system, and the application of immunosuppressive drugs, particularly cyclosporine. An editorial in JAMA (same issue of December 20, 1985) strongly disagreed. “The reasoning that the baboon shares sufficient homology with the human to anticipate success in control of the rejection response is not so easily accepted.” It continues: “It also seems that the belief that the infant immune system was immature and thus more readily immunosuppressed was wishful thinking.”

How then did Bailey defend a procedure so contrary to basic evolutionary principles? I found his technical report of Baby Fae’s case in the same issue of JAMA, and was surprised and saddened to note that a major focus of his defense rests upon the improper definition of homology as quantified overall similarity, rather than evolutionary descent (“Baboon-to-Human Cardiac Xenotransplantation in a Neonate,” by L.L. Bailey, S.L. Nehlsen-Cannarella, W. Concepcion, and W.B. Jolley, pp. 3321–29). As one of four rationales for their attempt, Bailey and colleagues list on the first page of their article: “Data suggesting variable homology between baboons and humans.” On page 3326, they offer an explicit defense for using a baboon instead of a chimpanzee:

Chimpanzees seem to share greater homology with humans, but are virtually unavailable as organ donors. Baboons are generally less concordant with man than are chimpanzees, but it may be feasible to narrow the “disparity gap” by a careful selection. . . . Some degree of homology between baboon and human lymphocyt antigens must exist.

Note that all these quotations use homology in the improper sense of measured overall concordance, rather than the evolutionary meaning of similarity due to descent from a common ancestor. Bailey apparently envisions a smooth continuum running from human to chimp to baboon. He acknowledges the closer position of chimps and even a gap separating chimps and baboons in their degree of likeness—homology by his false definition—to humans. He argues that the best candidate for transplantation would be an animal with greatest homology to Baby Fae.

Yet, since he defines homology as a number expressing overall likeness, he is led to the false idea that he might find overlap between the closest baboon and the furthest.chimp—so that a particular baboon might be an acceptable candidate, even though chimps are closer to people on average.

But true homology is not a number on a continuum; it is a quality of relationship based on evolutionary descent. And on this proper criterion, chimps are so much closer to humans in recency of common ancestry that any thought of overlap, or even close approach, seems absurd. One might as well say that because both mice and elephants vary substantially in size, the largest mouse could be close enough to the smallest elephant to carry the Maharajah of Ranthambore.

Still, I just couldn’t figure out how Bailey could work in such ignorance of known evolutionary relationships of homology—that is, until I read a chilling comment in the London Times Higher Education Supplement. The Times reported an interview between Bailey and an Australian radio crew. They were forbidden to ask directly about the operation, so they quizzed Bailey on the general issue of why he had used a baboon in the light of its evolutionary distance from Baby Fae. “Er, I find that difficult to answer,” Bailey responded. “You see, I don’t believe in evolution.” Knowledge is power, and the consequences of ignorance can scarcely be overstated.

And so, dear readers and dear colleagues, debates about terminology may be more vital than their reputation as empty and tendentious usually allows. Let homology be likeness due to evolutionary descent, and let similarity be similarity. Let us be clear in our own domicile, for evolution is beset with enough difficulties from outside. “He that troublith his own house shall inherit the wind.”

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.

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The Museum and the printer therefore went back to Audubon's original watercolors, notes, letters and even bird specimens to produce this edition.

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Brother, Can You Spare a Fish?

Florida's panhandling great white herons may be trying to tell us something about the environment

by George V. N. Powell, A. Harriett Powell, and Nancy K. Paul

Just after dawn, Charlie, George, and Herman take up their posts along the waterways of the Florida Keys and wait for handouts. These ghostly sentinels are great white herons—a rare, pure white subspecies of North America's ubiquitous great blue heron. Each is a professional panhandler, adept at soliciting a daily supplement of fish from people living along the edges of Florida Bay.

Florida Bay is the large, shallow estuary that lies between the southern tip of Florida and the Florida Keys. A tropical lagoon, the bay supports a unique community whose membership includes such rarities as the endangered American crocodile, the roseate spoonbill, and most of the great white herons in the world. The Florida Keys, bordering the bay on the east and south, are also a tropical haven for people. Where the two habitats meet, a mutually rewarding relationship has developed between man (or woman) and bird. Many people have opened their hearts and bait buckets to these statuesque beggars. The birds have gained a dependable source of food, and the people find a great deal of satisfaction in being involved with their herons. Completely wild great whites do not beg from humans; they stalk their prey—thread herrings, sardines, and mullet—at night and rest on mangrove islands during the day. The two to three hundred great whites that have become panhandlers also feed at night, but at sunrise, instead of resting, they move to the canals to glean what they can from the hands of humans.

We became acquainted with panhandling herons when we moved to the Florida Keys to work for the research department of the National Audubon Society. There we rented a furnished house-complete with George, the resident heron. Being animal behaviorists, we were immediately intrigued by our house guest and our interest grew as we watched him interact with both herons and people. We soon learned that George had several homes along the canal, each of which he defended as his exclusive territory. Any fish-eating intruder, great white heron or otherwise, was summarily evicted with much squawking and flapping of wings. For their part, every human benefactor considered George (who actually had several names, depending on which house he was visiting) to be his or her own personal heron. The more we observed George, the more interested we became in the whole panhandler-benefactor community and the more we wanted to learn about the local great white herons.

Idle curiosity soon sharpened into scientific interest. We recognized that the very existence of these birds was an opportunity to evaluate the condition of the local estuarine ecosystem. Environmentalists suspected that human activities were adversely affecting plant and animal life in Florida Bay, and at least one study attributed a local decline in ospreys, or fish hawks, to a shrinking supply of fish. Hard data were lacking, but biologists working for the U.S. Fish and Wildlife Service had previously suggested that as fish-eating predators near the top of the food chain, herons might function as biological indicators of the health of the complicated estuarine system they inhabited.

The idea of biological indicators was not a new one. Early British miners took canaries into their mines as a way of monitoring air quality. Healthy, singing birds indicated a safe environment; absence of singing was a sign of danger. In much the same way, the herons were being proposed as indicators of habitat quality in the complex aquatic ecosystems that make up coastal wetlands. Our panhandling great white herons might provide a way to monitor the well-being of the Florida Bay itself.

Just as the canaries were quick to respond to the presence of noxious gases, the heron population might respond quickly to changes in food supply—a highly visible sign of the bay's health. Reproductive success—the raising of a brood of young to independence—should, we thought, reflect the relative availability of food. If Florida Bay is healthy, reproduction by all herons, panhandlers and nonpanhandlers alike, should be comparable to that of average heron populations (in this case great blues) throughout the country. If the bay ecosystem is unhealthy, the herons that depend exclusively on natural food, the nonpanhandlers, should do poorly.
A great white heron waits for a handout in Florida's Bahia Honda State Park.

Ken Brate; Photo Researchers, Inc.
while supplemented panhandlers should be successful.

Turning our observations of panhandling herons into a quantitative study required several steps. First we had to identify individual panhandlers so we could find their nests; then we had to determine how much they were being fed; and finally, we had to determine the number of eggs (clutch size) and fledglings produced by each. We would also have to collect data on both panhandlers and wild herons in order to compare them with one another and to great blue herons countrywide.

Capturing the better than four-foot-tall birds was a challenge. After several false starts, we finally perfected a battery-powered trap that ensnared the bird as it fed. The trick was to strategically place pieces of fish so as to entice the panhandler to step into a small loop of line. At the instant the bird placed its foot in the loop, the operator of the trap pressed a switch that closed the circuit with a battery, which activated a solenoid, which set off a rat trap, which pulled a fishing pole, which quickly but gently tightened the line around the panhandler's leg. The device worked, and in short order we were able to capture twenty-two panhandlers. The captives were measured (most could be sexed, as males are slightly larger than females), banded on the leg with a numbered, aluminum U.S. Government band, tagged on the wing with a numbered plastic marker, and released, all within a matter of minutes. Most birds left the area for several hours, until hunger overcame their loss of pride; others just continued to feed as if nothing had happened.

As we acquired a population of individually identifiable herons, we began to learn about the structure of the panhandler community. Males dominated females and consequently were masters of the prime waterfront. All males and a few females defended their feeding areas, usually several hundred yards of canal front, against intrusion by any other great white herons, even their own mates. Intruders were quickly challenged and "escorted" from the area. If an intruder tried to hold its ground, the resident first responded with ritualized displays of aggression, but ultimately, violent fighting erupted. We learned of a few instances in which severe injury and even death resulted from these encounters, but almost always the intruder quickly broke off the fight and fled.

Most females could not successfully defend territories. Instead they used a method that we called the paper-route strategy. Each female visited a series of houses as much as a mile apart, stopping only if a territorial male was not present, leaving quickly if challenged, and regularly walking parts of the route in order to avoid detection. Some people deliberately fed their dominant heron in an area with an obstructed view so that it could not see the arriving female and even defended their females by chasing away the dominant heron with a stick or broom whenever fights broke out.

Heron benefactors varied from the casual—those people that gave the herons fish scraps after cleaning the day's catch—to the addicted—those that either
fished the canal for, or more frequently purchased, the daily ration of a pound or two of fish. A surprisingly large number of people were thoroughly dedicated to insuring that their heron got a full four-square. With this tender loving care came a name, usually Charlie or George for reasons we do not fully understand, and voluminous anthropomorphic lore on backyard heron behavior.

We enlisted the heron feeders to identify the birds they fed and to record how much and how often they fed them. These data allowed us to measure the amount of food specific panhandlers received and to select only the best fed to compare with wild herons foraging only in the bay. During our three-year study we monitored 97 nests of unsupplemented wild birds. These nests represented all the colonies adjacent to the three islands where panhandlers nested. We determined the absence of panhandlers from the wild bird colonies by observing flight directions of birds to and from the colonies.

Quantifying nesting and reproductive success was relatively easy. We went to the nesting colonies, marked all the appropriate nests, and monitored their success. For three years we visited each nest on a regular basis, first to count the number of eggs laid, and then to see how many young survived to seven weeks of age, when they are grown enough to leave the nest.

The results of our study supported the idea that herons are biological indicators. Reproduction by the herons we studied was in fact very sensitive to food supply. To begin with, only 34 percent of the nonpanhandler nests succeeded, compared with an 83 percent success rate for panhandler nests. For nests that succeeded, panhandlers raised 2.5 young per nest while nonpanhandlers raised only 1.5 young per nest. Combining these results (nest failure rate multiplied by young per successful nest), we find that panhandlers raised 2.1 young for each nest attempt while nonpanhandlers produced only 0.5 young per nest attempt.

The very poor reproductive success of nonpanhandlers was both unexpected and distressing. An analysis of heron survival based on banded great blue herons revealed that pairs must produce a minimum of 1.9 young per nest to maintain a stable population. If the same production of young is necessary to sustain great whites, our wild population is clearly in trouble. We encountered several difficulties when comparing great white herons with great blues, even though they are considered to be the same species. Great white herons inhabit a tropical area where they may breed throughout the year; great blues have only a short nesting season. Thus, one great white pair may make several nesting attempts to produce their necessary 1.9 young per year. Furthermore, great blue herons must migrate, but great whites generally do not. Migration is known to be dangerous to birds and a major cause of mortality. If, by not migrating, great whites live longer, then they may need fewer young to sustain their population. At this point we do not know how long great whites live or how many must be produced each year to maintain the population. The very low production by unsupplemented pairs, however, seems too low to sustain the population without the additional young being produced by supplemented pairs. During our checks of unsupplemented nests, we discovered many young that had apparently died of starvation. They were always very thin and much smaller than their surviving nestmates. If disease had been the cause of death, we would have expected to see widespread mortality in all of the colonies.
We ruled out disease as the major cause of death because the nearby panhandler colonies showed no such mortality.

Our unavoidable conclusion is that most herons are unable to secure enough food to raise their young. Birds that have turned to panhandling—adapting themselves to the suburban environment and defending backyards and docks in addition to their patches of Florida Bay mudflats—are much more successful breeders. They have learned that the best times to solicit food are early morning, when people are likely to be at home, and late afternoon, when boaters return from their fishing trips. They associate returning boats with food and will follow boats until they dock. Some have learned to use mating calls to attract the attention of their feeders. They exhibited great patience and a willingness to wait for their fish, often for hours, with the possible exception of one bird that was reported to have developed the habit of running its bill across an opened jalousie window and making a horrible rattle that spurred its tardy feeder into action.

Successful panhandling by the great white herons partly mitigates the effects of what we perceive to be a very serious food shortage and allows the herons to raise their young successfully. We know that the great white heron did not always experience this much difficulty. In 1923 biologist Ernest G. Holt visited Florida Bay in search of the very rare Wurde- mann’s heron (now recognized as the hybrid between the great white and great blue varieties). As part of his study, Holt recorded the contents of forty great white heron nests. Since very few people lived in the Florida Keys in 1923, and the people that lived there were more likely to eat the herons than to feed them, we can safely assume that the nests Holt studied all belonged to herons that depended exclusively on the natural resources of Florida Bay. Eleven of the nests he found contained an average of 3.8 eggs, significantly more than the 2.9 eggs that we found in our nonpanhandler nests. Twenty-two nests contained an average of 2.6 large young, about ready to leave the nest, while the nonpanhandlers in our study fledged only 1.5 young per nest. Interestingly, panhandlers in our study had almost exactly the same number of eggs (3.6 versus 3.8) and young (2.5 versus 2.6) as did herons in 1923.

In 1923 great white herons were able to raise their young successfully on the food resources available in Florida Bay. Now they have come to depend on our handouts to raise a normal quota of young, and without this help many young simply starve. George, our suburban heron, was coming to our dock in search of food no longer available in sufficient quantities in his natural environment. At night we only had to make the short trip out to the shallows at the end of our canal to find George searching intently for fish. He had not given up his natural foraging instincts as a result of our feeding him, but he was depending on us to supplement his diet.

Our studies have alerted us to a potentially serious disturbance in the complicated food chain of Florida Bay. The consequences may be particularly serious for the great white heron, one of the rarest birds in the continental United States. Only 2,000 great whites live in the United States, and the population that ranges through the Caribbean is even smaller. Clearly the survival of the herons depends on a healthy Florida Bay. We have now begun an intensive ecological study of the area. Thanks to the panhandlers, we know that we must guard the quality of this important estuarine habitat.
A large pack of dwarf mongooses rests on a termite mound in Kenya's Tsavo National Park. Such mounds serve as shelters during the night, dens for young, and vantage points from which to spot predators.

Bruce Davidson
“There’s a dwarf, on that rock, and it looks marked,” my wife called out as we drove past a kopje in Serengeti National Park, in Tanzania. Stopping to get a better look with binoculars, I focused on a small brown animal with a white V on its side and recognized Cindy, one of the marked dwarf mongooses we have been studying. Cindy had disappeared several months ago from the C pack, and we had begun to fear she was dead. But here she was, and foraging nearby were three other mongooses, Cindy’s younger sister Chrysantha and two unmarked males.

As Cindy climbed down the rock, from which she had been watching us watching her, we noticed that her sides were bulging, an indication that she would soon be a mother. We were delighted to know that the two C pack females had not died but had instead moved a little more than a mile to the south and founded a new pack, with Cindy as the female breeder. Dispersal and its relationship to reproductive success has been a focus of our thirteen-year dwarf mongoose study in the Serengeti, and over the years, we have found that individuals use diverse strategies to attain breeding status. Cindy’s method—forming a new pack—is only one of several possible routes.

Against the dramatic backdrop of vast herds of wildebeest, zebra, and gazelle, the little reddish brown mongooses are relatively inconspicuous as they sun themselves on termite mounds or forage across the grasslands for dung beetles and other insects. Yet these small carnivores (adults weigh less than a pound) lead lives as complex as any of the larger, more spectacular species. By following the life histories of hundreds of individually marked dwarf mongooses, my wife, daughter, and I have discovered a social system featuring lifelong pair bonds, an elaborate and effective cooperative antipredator system, and devotion to the young of group leaders, even when these are unrelated.

The great majority of small carnivores lead solitary lives. Only a few species, including the dwarf mongoose, forage, travel, and sleep in cohesive, stable groups. Two group-living mongooses occur in the Serengeti—the dwarf mon-
goose and the banded mongoose; while similar ecologically, the two species differ in their breeding systems. Banded mongooses resemble the African lion and most primates in being polygamous, while dwarfs, like the social canids, are monogamous—and only one pair in each group raise offspring.

Among dwarf mongooses, the breeders, or alpha male and female, dominate all other group members and are usually the oldest animals in the pack. Besides the breeding pair, a pack typically includes subordinate adults, yearlings, and juveniles. Most packs contain from six to twelve mongooses, but packs of more than twenty have been recorded. The tenure of the breeding pair may last for many years, since alpha females—and most alpha males—retain their status and fecundity for life. Our oldest known breeder is now more than twelve years old and continues to give birth to healthy offspring. Breeding pairs regularly produce three litters per year with up to six young in each litter, so their lifetime reproductive success can be very high.

Other factors also make the alpha position a desirable one. As leaders of their pack, the breeders enjoy great popularity, being favored grooming partners of all mongooses of the opposite sex. During mating periods, subordinate adults trail the dominant pair—the males hoping for a chance to mate with the alpha female, who is closely guarded by her mate, and the females attempting to solicit attention from the alpha male. To be a breeder represents the pinnacle of dwarf mongoose society, and every young mongoose must aspire to become one. How can this status be attained?

As a young adult, each mongoose—whether male or female—must make a decision that will profoundly affect its future. Should it remain in its natal pack, with all the benefits of group life, or should it leave and search for breeding opportunities elsewhere? About half the females that ultimately succeed in becoming breeders—and a much lower proportion of males (approximately 5 percent)—stay at home and wait for older, higher-ranking pack members to die. Because of the greater tendency of females to stay, most dwarf mongoose packs are matrilineal, containing adult females born in the group and immigrant adult males. The first two packs that we began to observe in 1974, for example, are still in existence...
Mongooes that join existing packs can become instant breeders if they are lucky enough to locate a group in which a breeder has died without leaving an heir apparent. When its alpha female died, for example, the B pack contained two adult males, a yearling female, and four juveniles. Seven weeks later two adult females transferred from a neighboring pack, and one became the new female breeder; the other, having seen her sister established, returned to her original pack five days later. The yearling B pack female emigrated at the time of the transfer and lived a solitary life for a month, but she was also able to fill a breeding opening by joining a pack in which the only adult female had recently died.

Males sometimes combine forces to attack and drive resident males from a pack. To be successful, the intruders must outnumber the residents. In one case we followed, six males went on the offensive after the death of their alpha female. They invaded a neighboring pack and ousted its two adult males. The following year, all but the alpha male emigrated again. This time, however, they split up into two groups and successfully took over two other packs. Ultimately five of the original six males reached breeding status.

Takeovers are dramatic, but more commonly, mongooses join packs at a subordinate level and must wait for their chance to breed. The wait, however, is likely to be shorter than it would have been had the mongooses stayed at home. In all the cases of interpack transfer that we observed, the mongooses acted in their best reproductive interests, leaving packs with more older individuals of the same sex and joining packs with fewer. An important consequence of intergroup transfer is that inbreeding is avoided. Of more than one hundred breeding pairs of known origin, only four consisted of closely related individuals.

Some transfers go smoothly. One yearling female was accepted immediately and repeatedly groomed by both the alpha male and female when she first contacted their pack. When the alpha female died eighteen months later, the newcomer took her place. But the process is seldom so painless. Females trying to join a group are often chased off by resident females, especially if the pack is large, and males may trail a pack for several weeks, at-
Dwarf mongooses are intensely sociable and curious animals. Mutual grooming, playful chasing, and wrestling are common, especially among young animals. A vigorous bout of playing is sure to catch the attention of any nearby mongooses.

Bruce Davidson

tempting to groom with the females and enduring attacks from the resident males, before finally being admitted to the group.

The cost to aspiring immigrants may be high. We know of one male who died as a consequence of attacks by the resident second-ranking male. Animals usually lose weight while between packs and are generally in poorer condition. And most importantly, they are more vulnerable to predators. As a member of a pack, a mongoose receives protection from the vigilance and antipredator responses of its fellows. Pack members take turns scanning for predators from the tops of termite mounds and other elevated areas; while not on sentry duty, a mongoose can forage or rest in relative safety. If an eagle or jackal is detected, the sentry’s loud alarm calls prompt other group members to run to cover. Mongooses dispersing singly or in small groups lose the benefit of this antipredator system. Thus the dispersal decision involves a tradeoff—increased risk of mortality versus increased breeding opportunities.

To attain maximum reproductive success, a mongoose must do more than survive and become a breeder—it must do so in a large pack. Adult mortality is considerably higher in small packs than in large ones, and we have frequently observed the formation of a new pack only to witness its disintegration upon the death of one of the founders. Small packs with a single adult female are particularly prone to failure. Should a predator take the female, the pack may break up and the survivors leave the area. Even if a breeder in a small pack survives, it will be less likely to raise young than a breeder in a large pack. On average, breeders in packs of eight or more raise 3.5 young to the start of the next birth season, while those in packs of fewer than eight raise only 1.3 young.

Dwarf mongooses typically spend the night in termite mounds, and it is there that the babies are born and spend the first few weeks of their lives. They grow up in a highly protective environment. Every morning, when the pack leaves the den to forage, one or more mongooses remain behind to guard the young. If a predator, such as a slender mongoose, approaches the den, these babysitters will chase it away. The slender mongoose, a solitary species, feeds mainly on rodents and other small vertebrates and would make short
When the main pack leaves to forage, one or more mongooses remain at the den to guard the young. Although sometimes unrelated to their charges, these babysitters are vigilant and fiercely protective. At the first sign of danger, the young are grasped behind the head and carried down a hole.

Josephine Moon
work of an unguarded litter of dwarfs. Yet, although twice the size of its smaller relative, a slender mongoose will not stand its ground to fight but flees an attack by even a single dwarf mongoose.

Changeovers at the den occur frequently so that all pack members have a chance to forage. The mother usually spends the least amount of time with the young, allowing her the most time to search for food. When three to four weeks old the young mongooses emerge from the termite mound's ventilation shafts and tumble about on the surface, wrestling with one another and clambering around the attentive adults. At the first sign of danger, however, babysitters grasp the young firmly behind the head and carry them down a hole. Pack members cooperate in collecting and bringing insects to the young mongooses, and when the youngsters are old enough to travel with the pack, older mongooses dig up insects and let the closely following young take them. Young mongooses may also receive supplemental food by suckling from females other than the mother. Although unable to raise young of their own, subordinate adult females sometimes lactate and thereby help the breeding female by nursing her young.

Many scientists believe that helper behavior has evolved through kin selection. By helping close relatives, which share many of its genes, a nonbreeding mongoose can still perpetuate its own genes. According to this theory, mongooses would be expected to help closely related young but not those that are unrelated. Yet we have found that immigrants who are not related to the young are equally devoted and sometimes superior helpers. Obviously they are getting no genetic benefit from aiding these young, so why do they help? The answer may lie in reciprocity. Immigrants may eventually breed in packs they have joined, and the young mongooses they have helped will, in turn, babysit and feed their young and serve as additional sentries for the group. By helping raise unrelated young, an immigrant works to increase the size of its group and thus acts to maximize its own reproductive success should it become a breeder.

Throughout our study we have been impressed with the complexity of dwarf mongoose society and the variety of decisions individuals make during their lifetimes. Even siblings of the same age and sex may make different choices that result in widely divergent histories.

Cindy, for example, had two sisters—Christy and Cassandra—born, like her, in the 1976–77 birth season. One day I was surprised to find Christy, then a two-year-old, alone on a termite mound two miles north of her natal range. Only a few days before I had seen her as an apparently fully integrated member of the C pack. Why had she suddenly struck out on her own into unknown country? We never saw Christy again, and while we would like to believe that she continued northward, joined a male, and is now a successful breeder, it is more probable that she was captured by a predator.

The other sister, Cassandra, was a stayer. She has remained in the pack of her birth, helping first her mother and then her older sister to raise many litters. Now eleven years old, she is the second-ranking female and—if she survives her older sister—will become a breeder in a large and successful pack. But she will have had a long wait.

Like Cassandra, Cindy seemed content at home, remaining in her natal group until she was five years old. Yet she eventually left and founded a new pack. Cindy has since produced numerous litters and, as the dominant female in a large pack, has been the most successful of the three C pack sisters, a winner in the game of dispersal decision making. Her younger sister Chrysantha, who was born in 1980, didn't fare as well. Two years after helping Cindy found a new pack, Chrysantha moved for the second time, joining a solitary male. But newly formed pairs are seldom successful in raising young, and two years later the pair were still alone. The following year, we were unable to locate Chrysantha and eventually found her mate traveling with a younger male from a neighboring pack—a sure sign that Chrysantha was dead.

Why did the C sisters pursue different paths? Are mongooses genetically predisposed to stay home or to leave? Or is the decision a measure of sexual frustration, avoidance of incest, social pressure—or perhaps just a sense of adventure? We don't know yet, but we hope one day to find out. In the meantime, we look forward to returning to the Serengeti to catch up with Cindy, the successful adventurer, and to discover what lies ahead for her and her many relatives.
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Once a mostly rural population, Gypsies and other traveling people in Britain have gravitated to urban centers since World War II. Here, Irish tinkers have found a niche for their trailers on public land near Saint Pancras railroad station in Camden (London). The portable toilet (far right) was provided by the town council.

George Grutch
Nomads in the Cities

Frequent evictions keep Britain's Gypsies on the move

by George Gmelch and Sharon Gmelch

After being evicted from several camping places around Birmingham, Percy and Margaret Boswell drove east, hoping for better luck in Leicestershire or Northamptonshire. In the evening they made camp on the outskirts of Leicester near the trailers of two other Gypsy families—the Gaskins and Prices (none of these are their real names). Much of the night was spent getting settled and inquiring about friends they hadn't seen since Appleby Fair. Everyone was still asleep when the convoy of police cars and two open-bed trucks carrying city workmen drove up. "All right, lads. Get up!" bellowed one of the policemen. "You have an hour to pull off or we'll tow you off." Striding past the barking greyhounds and lurchers, four officers went from trailer to trailer, banging on doors and repeating the message.

"Give us time to get our breakfast and feed the children," Percy yelled out. A baby began to cry. "We have a court order. You're to be off by eight or we'll tow you off," came the answer. The trailers were parked about thirty yards from the highway, shielded from the view of motorists and a nearby factory by a heavy barrier of bushes and shrubs. It had seemed a perfect spot, but once again the Boswells were being evicted.

Percy dressed quickly. The air in the trailer was sharp and damp, the coal fire dead. While Margaret turned on the gas to make tea and began rousing the children, Percy stepped outside to confer with the other men. Clustered together, smoking cigarettes, they debated whether to cooperate. They were angry enough to force the local council to tow their trailers, but there was the risk that the trailers would be mishandled, and one never knew how far the police would force them to go. Conversation was mostly a way of passing time, since there was little choice.

Inside the trailers, Margaret and the other women set about packing, but there was little sense of urgency in their actions, no reason to treat the council with undue consideration. Besides, it took time to feed and dress the children, wash the dishes, fold and store the bedding. Dishes, pots, pans, ornaments—anything loose—had to be securely put away in their allotted
Gypsies and police face off as authorities try to evict Gypsies from a roadside encampment near industrial land in Leicester. A 1968 law requires local governments to provide campsites for Gypsies in their areas, but such facilities are in short supply.

Both photographs by George Grench

places. Special care had to be taken with the valued pieces of Crown Derby china and cut glass. Outside, the older children loaded the trucks with firewood, bags of coal, work tools and tarps, spare truck batteries, assorted scrap, and milk churns used to store water. The police had gathered some distance away, their patrol cars blocking the exit. Nearby the workmen milled about, restless and cold. They hated this job.

After Percy and the other men had hitched the trailers to their trucks, the youngest children piled into the truck cabs with their parents, while the teen-agers and dogs climbed into the back. Then they pulled out, the trailers lurching from side to side over the rough ground and onto the road. A patrol car pulled in front, two more brought up the rear, and they were escorted away.

Forced out again, just when the men had lined up asphalting jobs in the city. It was expensive to lose a day’s work and to tow a trailer. If the police did not follow them far, they would try to stop soon. The Gaskins and Prices knew of a few places nearby—a vacant field next to an industrial park, a strip of land by some highway construction, a little-used parking lot. Meanwhile, the council workmen were busy digging a deep trench around the perimeter of the land just vacated. No Gypsies would camp there again.

Like their counterparts in other countries, the Gypsies in Britain are descended from people who left India between A.D. 800 and 950. Their ancestors’ South Asian origins and westward migration—into southeastern Europe by the 1300s, western Europe by the 1400s, and the British Isles by 1505 (the earliest record)—can be traced in the dialect they use when speaking among themselves, Anglo-Roman. This dialect uses words of Indian derivation in a matrix of English grammar and contains loan words and grammatical features from Romanian, Slavic, and other tongues of the lands in which their ancestors lived. As the word gypsy suggests, however, in continental Europe and Britain, Gypsies were falsely believed to have come from Egypt. Gypsies probably encouraged this misconception. The earliest written account of their arrival in Britain indicates that they presented themselves as Christian pilgrims from “Little Egypt,” understood to be the Middle East.

They may have done so, suggests sociologist Thomas Acton, to receive sympathetic treatment, for at the time the stereotypical image of Christians fleeing Islamic religious persecution was very favorable. During their migrations, Gypsies have borrowed not only language but also customs and marriage partners from surrounding populations. In Britain, generations of contact and intermarriage with householders and with other nomadic people, such as the Irish tinkers, or travelers, who have lived and traveled in Britain in varying numbers at least since the 1800s, has lightened their skin, Anglicized their speech and surnames, and in most respects made them indistinguishable from other Britons. Nevertheless, they resist assimilation, largely because of their unique economic role, which involves identifying and filling small-scale and irregular demands for goods, services, or labor in the non-Gypsy population.

In contrast to most workers in industrial societies, Gypsies retain control over the organization of their labor, and for them the household remains a productive unit. Their continued existence and identity is linked to their mobility and family-based
operations, which allow them to fill gaps in the market that are uneconomic or too variable for businesses that are large or rooted in one place. When Gypsies exhaust the possibilities in a local area, they simply move on. They can also switch from one activity to another to take advantage of changing opportunities. Unencumbered by property and income taxes and the overhead of a business establishment, they successfully live on the margin of settled society.

Most Gypsies in Britain earn their livelihood (as do Irish travelers) principally from collecting recyclable scrap metals, laying asphalt, or selling carpeting. Jaspar Smith and his relatives, for example, pool their money to buy carpeting wholesale from the factory. The carpeting—typically inexpensive, brightly colored, and heavily patterned—is rolled out on the ground, cut into room-sized pieces (ten feet by ten feet), and divided among the families. The men and older boys then fold the pieces, load them into their station wagons, and drive through working-class neighborhoods, often of Asians and West Indians, to sell the carpets door to door. The Smiths offer on-the-spot service at prices well below those of local retailers. Their smooth patter and persistence can create a demand even where none existed. Once the prime neighborhoods in a city have been canvassed, the Smiths move to a new town or city, not to return until the following year.

Traditionally, Gypsies were rural people who lived in the countryside for at least eight months of the year, harvesting fruit and vegetables, producing tinware and handicrafts, selling small household wares, performing odd jobs, entertaining the populace, and dealing in farm animals. In winter, when rural work was scarce and travel difficult, many moved to the city to find work. Since World War II, however, they have left the countryside and migrated to cities on a more permanent basis. Today Gypsies live in virtually every British city, especially in the populous, industrialized heart of England—an area sometimes referred to as the “diagonal city”—stretching from London north-westward to Birmingham, Liverpool, and Manchester.

The reasons for this cityward shift are largely economic. Most of the rural tasks Gypsies used to perform are now obsolete. The mechanization of Britain’s farms has largely wiped out horse dealing to farmers (although many Gypsies themselves have horses) and has led to a steady decline in the amount of seasonal agricultural work available. Hops, beans, peas, and many other crops once harvested by hand are now harvested by machines. The demand for handmade tinware and wooden clothes pegs has been eliminated by the introduction of cheap, mass-produced plastic
goods. On the other hand, recyclable scrap materials, which Gypsies have collected increasingly since World War II, are plentiful in urban industrial areas.

Modernization has also affected the Gypsy life style. Before the war, the travel of these itinerant people was limited by the distance a horse could comfortably pull a wagon or cart in a day. When families moved they sought jobs along the way, working their way across the land. Today, with trucks and cars, families can range much farther in search of work and can do so from a fixed urban base. Educator David Smith, who has studied Gypsies, notes that the greater cost of operating a truck (gas, maintenance, insurance, license), compared with the grass-burning engine of the horse, is another factor that requires Gypsies to concentrate their economic activities in cities, with their high density of prospective clients. Hence, the mental geography of the modern Gypsy is no longer continuous but rather a series of points (urban centers) separated by voids of uneconomical countryside and small towns. The countryside, the home and life-blood of earlier generations of Gypsies, is of little significance today, merely land to be crossed in getting to the next city.
Government legislation has also worked to drive Gypsies from the countryside toward the cities. The 1959 Highways Act, for example, made it an offense for Gypsies to camp along the roadside or on a lay-by. Burdensome conditions imposed on landowners from 1960 onward, requiring that they install costly flush toilets and water for any “caravan dwellers” living on their property, resulted in farmers closing their land to Gypsies. Families who harvested for farmers and who had previously remained camped on their land once the crops were picked were now turned away. Most recently, the 1986 Public Order Act has given British police broad new power that allows them to evict Gypsies from private land without first receiving a complaint from the landowner. They may also arrest Gypsies on the spot if they do not leave. According to Gypsies, there are now so many statutes that curb their activities that the only time they are really safe, that is, within the law, is when they are actually moving.

The postwar expansion of Britain’s suburbs, along with modern highway construction and road improvements, has eliminated many traditional campsites. Others have been deliberately closed. “The trouble,” says Percy Boswell, is that there is no open land where you can pull in without being bothered. All the land is claimed. When you stop in a place, you might be there no time at all when the policemen come around and tell you to move on. And if you don’t move yourself, they’ll come around with a tractor and pull you into the road and show you to the next county. And when you get to the next county, it’s the same worry all over again.

Gypsies now camp in the worst possible locations—on rubble-strewn waste ground in industrial estates or decaying urban neighborhoods or next to railway lines, highway overpasses, sewage treatment plants, and landfills. And even here families are not safe from eviction.

There are only about 50,000 Gypsies and Irish travelers living in the British Isles, less than one percent of the total population. But because so many are no-
Light, durable, and difficult to overturn, the barrel-top (or bow-top) wagon, right, is the most popular of some half-dozen types of Gypsy covered wagons. It is also commonly used by travelers in Ireland, who originally adopted it from the Gypsies who fled England during World War I to avoid conscription. Below: An Irish traveler girl.

Both photographs by George Gmelch

madic — camping along the roadside, in vacant lots, and on parkland — they have a high profile. No sooner do they arrive, than efforts begin to move them off. According to one Manchester city official, “If the average householder can even glimpse a Gypsy by standing on top of his wardrobe and looking out the corner of his bedroom window, he’ll complain.”

Rootless and different, Gypsies have been treated as pariahs ever since their arrival in Europe. They were said to steal children, to be subversive. Gypsy women were thought to be licentious and accessible to outsiders. The Nazis sent hundreds of thousands of Gypsies to the gas chambers (despite this loss and suffering, not a single Gypsy was called to testify at the Nuremberg trials). As examples of the way entire subgroups can succeed outside the formal economy and conventions of settled society, they have been the repeated targets of government policy. The state, first through Draconian laws and more recently through social service programs, has attempted to regulate them and turn them into standard citizens.

For some (although generally not for members of the working class), Gypsies have also been a focus of romantic fascination. In the early nineteenth century, at a time when England was reeling from the excesses of urbanization and industrialization, the Gypsy’s picturesque rural and seemingly carefree nomadic lifestyle inspired the admiration of such authors as George Borrow and Sir Walter Scott. And painters during the Romantic Movement, such as Richard Westall, often placed Gypsies, with their tents and donkey-drawn carts, in their bucolic landscapes.

Part of the modern Gypsies’ problem in Britain is that they no longer conform to this romantic image. Living in trailers in the midst of urban decay, rather than in tents at woods’ edge, present-day Gypsies are often regarded as impostors. They are frequently dismissed as “dropouts” or “vagrants,” anything but “real” Gypsies. As one Camden (London) councilor said when justifying his district’s eviction of several Gypsy families, “If we had a
happy group of rural Gypsies sitting around making clothes pegs then the committee might have been minded to leave them there."

Prejudice also stems from the belief that Gypsies no longer pull their weight in society. Not perceived by house dwellers as performing useful services, they are seen to live off the welfare state, tapping the full range of benefits available to the poor while shunning regular employment. "There was no Gypsy problem until the Gypsies entered the twentieth century," says Dennis Holmes, who is responsible for carrying out the Dudley (Birmingham) Gypsy eviction policy.

Years ago, they were camped on land where they wouldn’t be seen. And they were poor, visibly poor. Now they have moved into cities to make a living and there isn’t enough open land for them. And now that some are driving Volvos and own flashy trailers there is little sympathy for them. People resent Gypsies driving better cars than they have.

The Gypsies' predicament is not due solely to prejudice: their presence in urban areas often creates real problems for house dwellers, especially when large numbers camp together. Homeowners ob-
ject to the "unsightliness" of Gypsy camps—the visual clutter of parked trailers and trucks with milk churns, wash basins, domestic paraphernalia, and litter scattered about. The worst offenders, in the eyes of the homeowners, are the families who deal in scrap metal, whose camps contain heaps of discarded metal pipe, appliances, and car bodies. Property is sometimes damaged as well. Landscaping and fencing may be destroyed as families try to gain entrance to land on which to camp; sometimes buildings and public facilities are vandalized. Theft also occurs, although according to the police, at no higher rate than within the non-Gypsy community. More often, house dwellers are disturbed by relatively minor things, such as the nuisance of noise (from the small electric generators some Gypsy families own or from barking dogs), requests for water, and straying animals.

The local response to the Gypsy problem has been to send the families packing and to trench the land they leave or barricade it with concrete posts and fences. Many councils employ private security firms to enforce eviction policies; others have set up their own Gypsy eviction task forces. The procedure is costly: the aver-
At the annual Gypsy horse fair in Appleby, left, the wares are trottled out before onlookers and prospective buyers. Until Britain's farms became mechanized, horse trading to farmers was a means of livelihood for Gypsies. The family of the Irish traveler girl below owns horses both as a hobby and as a mobile form of investment.

Both photographs by George Gmelch

age eviction now costs more than $1,600. In Wolverhampton, a single eviction of a large group of Irish travelers cost $10,000. Two months later, local authorities in nearby Dudley evicted the same group from a public park at a similar cost.

Ninety of the 118 families we interviewed had been forced by the local authorities to leave their previous campsite. In twelve months, the families in our sample had moved an average of seventeen times, or about once every three weeks, usually in response to eviction. Many of Britain’s Gypsies have thus become more nomadic than at any time in their history.

And this has occurred despite government legislation (the Caravan Sites Act of 1968) requiring local authorities to build official campsites for all Gypsies “residing in or resorting to” their area. Since 1968, 240 official campsites have been built across Britain. Nevertheless, more than half the Gypsy population still has no legal place to camp. And under Margaret Thatcher’s Conservative government, the building of Gypsy sites has become the lowest priority. They have never been popular with the public anyway. Virtually every proposal to build a Gypsy site has been met with heated protest by local residents. “The Gorgios don’t want sites being built,” remarks Margaret Boswell, “but they complain even more when we spend the night on the roadside near their homes. They must want us to just disappear.”

John and Mary Price, interviewed in the summer of 1987, told of their family’s movements during the previous year. In June 1986, they left a vacant lot in Winson Green, a poor neighborhood of Birmingham, and traveled 180 miles north to Appleby for the annual Gypsy horse fair. There they camped for two weeks with hundreds of other Gypsy families on the hill above the village. From Appleby they traveled 100 miles south to Manchester to lay asphalt, and were evicted twice within a month. After the police threatened them with a third eviction (John was dissatisfied with the prospects for further asphalting jobs anyway), they traveled 40 miles east to Sheffield to camp near John’s parents, who live in a council house.

Three weeks later, again threatened with eviction, they moved to Leeds, 34 miles to the north, first stopping on a layby outside of town and then camping on a derelict city lot in the midst of abandoned buildings, a location where they were likely to be able to stay. But conflict between their children and those of another Gypsy family camped on the same lot caused them to leave. With the onset of autumn, they turned south, stopping near Derby (two weeks), Birmingham (three weeks), Warwick (three days), and Oxford (two weeks). In November, with the weather turning cold, they tried unsuccessfully to find a space on an official caravan site in north London. They settled for a field in Stevenage. A social worker helped them enroll their eight- and ten-year-old sons in school, and the family settled in for the winter.
The Prices remained in Stevenage until late April when, eager for new clients and a change of scene, they headed west and made camp on a disused lay-by just outside Bristol. Within the month they were evicted and decided to travel 45 miles farther west to the city of Cardiff in south Wales, where they camped in a large field alongside both Welsh and Irish travelers. In August, they left Cardiff after some trouble with other families and traveled 115 miles back to London. There they camped on a small patch of waste ground in the shadow of a large gasworks and Saint Pancras rail station, hoping that if they kept a tidy camp and didn’t disturb anyone, the local council would let them remain through the fall and winter.

Many legislators believe that the only way to bring about harmony is for the Gypsies to take up residence in permanent housing. “Make them settle down for good and live like the rest of us,” declared a Tory councilor. “Why should they be any different?”

Some Gypsies would like to settle, but most would not. Mobility is both intrinsic to their livelihood and a valued part of their identity. Recreation is found in traveling to distant fairs, weddings, and funerals, and in socializing with the relatives and friends who gather there. Travel is associated with health and good luck, while a sedentary existence, especially in a house, is equated with illness and misfortune. Gypsies are accustomed to frequent changes of scene, and if induced to adjust to permanent settlement on sites and in housing, they complain of “the boredom of looking at the four walls every day.”

Mobility is also a way to deal with trouble of all kinds. When conflict occurs between families, it is resolved by one or both leaving camp for a new location. A family’s concern over a teen-age daughter’s involvement with a boy from the camp or the neighborhood, a court summons, a complaint from a dissatisfied client, the accumulation of garbage around the camp—all are dealt with by moving away. The response to death has traditionally been to move away after destroying the belongings of the deceased person, which are considered polluted and dangerous. This may include burning the trailer (and, among settled Gypsies, sometimes the house). Leaving the area also helps survivors escape painful memories and, they believe, the ghost of the dead.

“A Gypsy who doesn’t travel isn’t a real Gypsy,” many of them say. To live outdoors and to be on the move is to be free and, in the words of one elderly man, “to be as healthy as a trout.”
A caterpillar mines an oak leaf, below, leaving a trail of frass in its wake. Leaf miners usually keep their food source clean, either by depositing frass behind them and never recrossing the mine, or by using discrete "midden heaps" to the side of the main mine. Opposite page: The serpentine path of this miner (on a leaf in the Costa Rican rain forest) never backtracks on itself and does not cross the thick midrib except at the leaf tip.

Thomas Eisner
Eating a Thin Line

When leaf miners gang up on a leaf, their mines may become their tombs

by Peter D. Stiling

Like many shallow, sandy-bottomed lakes in northern Florida, Lost Lake in the Apalachicola National Forest is thickly bordered by sand live oaks. These evergreen oaks hold on to their leaves throughout the winter and quickly replace their foliage each spring. The time for most leaf drop, or abscission, is in April, just before the new buds burst. At Lost Lake, however, certain trees also lose a large proportion of their leaves in summer and autumn. In some cases, almost three-quarters of the leaves are partly or completely discolored, as if in the grip of a deadly blight. Telltale frass, or insect excrement, on the underside of a leaf reveals the culprits—minute caterpillars feeding on a leaf’s spongy mesophyll and extruding their frass through leaf pores. As these larvae tunnel along, they create little trails known as mines. Most of the sick-looking leaves on the sand live oaks at Lost Lake are marked by one or more such mines.

In 1985, Daniel Simberloff and I began studying these caterpillars—larvae of the moth Stilbosis quadricustatella—at Lost Lake. Among other things, we wanted to find out if they were causing the sand live oaks to drop their leaves prematurely. Other researchers were beginning to document a connection between leaf mining and early loss of leaves in water oaks, Emory oaks, holm oaks, apple trees, and alfalfa plants.

The collective term leaf miners refers to the larvae of small moths, flies, beetles, and wasps that have independently adopted the same way of life: residing within leaves and feeding on the internal tissue. Despite the constraints of this life style, which requires a flattened body, leaf mining has its advantages, including protection from the elements and predators, and possibly, avoidance of chemicals that plants produce on leaf surfaces to repel externally feeding herbivores.

Leaf miners usually spend their entire larval lives within a single leaf, widening their feeding tunnels as they grow. Since each species creates a distinctive mine, the design of the mine is as good a characteristic as any to tell similar-looking species apart. Some miners create long, tortuous mines, others gnaw out blotchlike blisters, and still others excavate trumpetlike mines that start small, then widen.

When feeding is complete, most miners cut their way out of the leaf, drop to the ground, and begin the next stage of their lives as pupae. Others simply pupate in the mine. The new moth, fly, or beetle either hatches shortly thereafter to lay eggs on the foliage of its choice or remains dormant inside the pupa until spring.
Mines are a graphic record of the fate of their creators. Successful miners usually cut a crescent-shaped exit hole at the end of their mines on emergence, although in some cases the pupation takes place at the end of the mine and the pupa protrudes through the leaf. If a larva has been killed by parasites, a smaller hole or a series of holes appears where the parasites emerged after killing the miner. Some miners fall prey to marauding ants, spiders, or birds and are ripped out of the mines in a dramatic fashion. Larvae may also be killed by invading fungi or by competition with other miners. Their carcasses can be found entombed within the leaf. One leaf miner may attack another, slashing and killing with its mandibles, or it may simply appropriate the leaf tissue by hatching earlier, leaving the later-hatching species to starve in a labyrinth of empty mines.

Compared with larvae, adult leaf miners are often small and innocuous. Adult *Stilbosis* moths, for instance, are delicate, their wings fringed with the long hairs characteristic of many tiny, lightweight insects that seem to swim through the air. *Stilbosis* produces one generation a year, emerging from pupae in the soil in late May or early June and laying eggs a few days later on upper leaf surfaces, at the junction of the midrib and subsidiary veins. Larvae enter the leaf where the egg is deposited and feed within, creating blotchlike mines that may occupy about one-quarter of a square inch.

At Lost Lake, mined sand live oak leaves commonly contain one larva, often two or three, and more rarely, four or five. The size of a completed mine makes it impossible for the leaf to support more than six fully developed larvae. (While we once found thirteen mines on one leaf in July when larvae were small, we never encountered such dense populations in September.) *Stilbosis* larvae usually finish feeding at the beginning of October, when they are about one-eighth of an inch long. After cutting their way out of the leaf, they drop to the ground and spin up cocoons.

The first question that we tried to answer was why, when there were two of these tiny caterpillars on a leaf, did they usually occupy opposite sides of the midrib? (Midribs are considerably bigger than other veins and are surrounded by a tougher sheath.) Pairs of mines appeared together on one side of a leaf less than 20 percent of the time. To examine mines, we used a hand lens and simply recorded our observations in a notebook. (Even in these days of computerized sophistication, in some cases there is no substitute for simply going out into the field and painstakingly examining great numbers of animals.) We looked at mines on more than 11,000 leaves and censused the trees periodically between July and October. Larvae did not need to be on opposite sides of the leaf in order to avoid one another. For
Sand live oaks normally hold on to their leaves throughout the year, but at Lost Lake, left, trees infested with leaf-mining caterpillars may drop up to 10 percent of their leaves in the summer. Below: A cluster of sand live oak leaves is marred by brown, blotchlike mines. Most leaves have a single mine on one side of the midrib.

Both photographs by Peter D. Sillinger

even when two larvae were on the same side of the midrib, the mines were always separated by a thin, unmined section of the leaf and a hardened wall of frass. Stilbosis larvae never interacted. And staying apart apparently did not protect them from being eaten by carnivores. Parasites and predators attacked them at the same rate, whether pairs were on the same or opposite sides of the midrib.

Our periodic censuses sometimes turned up other herbivores, such as larger caterpillars, browsing on the sand live oak foliage. We hypothesized that such caterpillars might ignore a leaf with damage spread out over its entire surface and prefer to concentrate on a leaf with at least one unblemished side. Perhaps by spreading out on the leaf the Stilbosis larvae were protecting themselves from being accidentally devoured by larger leaf eaters. To find out, we marked more than five hundred mined oak leaves on each of eleven trees, giving each leaf a number and mapping its position on the tree for easy reference. Results showed that large, externally feeding caterpillars usually chewed whole leaves to the nub, consuming the Stilbosis miners in the process, but they made no distinction between leaves with miners concentrated on the same side and those on which the larvae were more spread out. In other words, we still didn’t know why it was to the miners’ advantage to keep to one side of a leaf.

As often happens with ecological studies, however, we came up with some interesting and completely unexpected conclusions. To our surprise, a significant number of our marked leaves fell well before October. Leaves with two miners on one side of the midrib were especially likely to fall early, providing a good explanation as to why they are seen less often. The miners inside leaves that fell before the normal pupation date of Stilbosis were committed to an early grave, usually expiring inside the mine as the leaf dried out on the forest floor. (Sometimes a larva would cut its way out, but laboratory experiments showed that only when leaves fell within a few days of the normal pupation date could Stilbosis proceed to the next stage.) Mined leaves began to fall from June onward, and we estimated that about 30 percent of all the larvae in our marked leaves were killed by premature leaf abscission. In fact, early leaf fall was by far the greatest killer of leaf miners, striking down more than twice as many miners as all other known causes of mortality—such as predation, parasitism, and starvation—combined.

Our mapping of the leaves also revealed that Stilbosis moths preferred to lay eggs on large leaves on the periphery of the tree—so much so that these peripheral leaves were also much more likely than interior leaves to contain more than one mine. Interestingly, the outermost leaves most often dropped early. We immediately suspected a connection with the leaf miners, but had to make sure that outside leaves weren’t falling prematurely simply because they were more vulnerable to wind and weather. Our data gave us a straightforward answer. The most important factor affecting how long a leaf stayed on a tree was miner density. A leaf with one mine had a 20 percent chance of dropping before the normal date. A leaf with two mines had a 30 percent chance of dropping early; three, 40 percent; four, 65 percent. More than four mines nearly always caused a leaf to drop.

Since early leaf fall means death for the miners inside, the distribution of Stilbosis mines appeared suicidal. Why were the
The growth of the caterpillar that mined the leaf below can be seen in the gradual counterclockwise widening of the mine. Right: Leaf miners leave distinctive signatures, and whoever can read the runes can readily identify the species that has been feeding on the affected leaf. Here, a Phyllocnistis moth larva mine works its way through an aspen leaf.

Peter Ward, Bruce Coleman, Inc.

moths clustering on the outside leaves? Does the attraction of laying eggs on larger, more sunlit (and therefore more nourishing) leaves sometimes outweigh a female moth’s disinclination to oviposit on a leaf where another of her species had already done so? We don’t yet know.

Another possibility lies with the other player in the evolutionary game—the oak tree itself. Extensive damage from leaf miners impairs the tree. Leaf-mining butterflies and moths are known to reduce the photosynthetic capacity of Japanese pear trees up to 30 percent, even when leaves are retained. Furthermore, our calculations show that, on average, leaf mining causes about 10 percent of all leaves to be shed early. Were the trees inducing moths to lay most of their eggs on a few large, peripheral leaves that it would then drop, killing the miners? In such a defense scheme, the number of leaves to be sacrificed would be minimized.

Plants have developed a wide array of chemical defenses against their insect adversaries, from indigestible tannins to poisonous phenolic compounds, cardiac glycosides, mustard oils, and alkaloids. Tobacco, for example, contains the deterrent nicotine, and deadly nightshade produces atropine. Insects, in their turn, have retaliated with midgut oxidases that neutralize the poison that is produced by the plants.

Is selective leaf abscission part of a plant’s defensive arsenal? Such a possibility has recently been invoked by researchers Alan Williams and Tom Whitham of Northern Arizona University. In terms of sand live oaks, at least, a number of questions remain to be answered. First, we must show—perhaps by comparing growth rates of infected and uninfected trees or by gauging acorn production—that the sand live oaks benefit more by dropping than by retaining mined leaves. Second, we must find out whether the trait can be passed on to future generations. Third, it must be proved that insects are faithful to individual trees. Getting rid of insects by abscission is effective only if the chance of being reinfested next year by a neighbor’s enemies is slim.

It is also conceivable that the trees are not the major agents in inducing the moths to lay most of their eggs on the outside leaves. Perhaps, being frail flyers, the moths are blown to the outside of trees by the wind and tend to stay there. Perhaps they select the leaves on the slender, outermost branches of the tree because in this position they are less vulnerable to being hunted by birds. Our hunch, though, is that the answer will ultimately be found in studies of Stilbosis’s mining habits.
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The Mysteries of Miranda

Theories abound on the origin of craters and strange geologic formations on one of Uranus's moons

by Stephen P. Maran

Miranda, the smallest of the five large moons of Uranus, was discovered in 1948 by the late Dutch-born American astronomer Gerard P. Kuiper. Not a subject of great interest among astronomers during succeeding decades, and little more than a dim spot of light on photographs made with large Earth-based telescopes, Miranda’s sole distinction was that it was both the smallest and innermost of Uranus’s then-known moons. Now, however, it has become an object of great attention and some controversy among planetary scientists, astronomers, and geologists.

The new interest in Miranda came after January 24, 1986, when NASA's deep-space probe, Voyager 2, swept past Uranus and its retinue of rings and moons at a speed of more than 32,000 miles per hour, making measurements and taking photographs at a furious rate. During that sweep, Voyager discovered ten more moons, or satellites, within Miranda’s orbit, each smaller and closer than Miranda to the mother planet.

Miranda and the four other large moons of Uranus are dim and gray, so that short time exposures were needed to photograph them from Voyager. A new control technique was therefore developed for the January 1986 flyby to allow the spacecraft’s onboard cameras to take photographs without blurring the images. Because Voyager 2 approached Miranda more closely (within 19,000 miles) than any other object it has hurtled past in its more than ten years of travel through interplanetary space, it mapped Miranda in finer detail than anything else it has so far encountered. In the words of Robert G. Strom, a planetary geologist at the University of Arizona in Tucson, the detailed photographs revealed that “Miranda is geologically one of the most unusual bodies so far explored in the Solar System.”

What aroused the curiosity of Strom and other planetary experts, including Edward C. Stone, of CalTech in Pasadena, and Bradford A. Smith, of the University of Arizona, was the presence of two wholly different kinds of terrain on the surface of Miranda, which is only 300 miles in diameter, or about one-seventh the size of the earth’s moon. On the one hand there is what is called the old terrain, which is heavily pocked with craters made by the impacts of objects falling at high speed from space. The old terrain resembles the extremely cratered lunar highlands—the bright regions of our moon—but it has about three times as many craters per equal area. On the other hand, there is the so-called resurfaced terrain, which has fewer and smaller craters than the old terrain. The resurfaced terrain consists of three large areas: two roughly oval ones, known as the ovoids; and one with four relatively straight sides, which is called the trapezoid. The proportion of large craters to small ones is greater on Miranda’s old terrain than on its resurfaced terrain. This distinction suggests that many or most of the craters on the old terrain as well as those on the resurfaced terrain may have been created by different classes of objects.

The unexpected difference between the craters on the old and resurfaced terrains is one of two major Miranda mysteries. The other is the origin of the intense geologic activity that seems to have produced the resurfaced terrain and also such Miranda-wide features as long fault scarps—a type of cliff—that span the two kinds of terrain and were apparently caused by the motion of blocks of material relative to one another along a fracture in the planetary material. Miranda does not appear to have a present source of energy. Even when it was young, Miranda should have cooled rapidly if inner heat was produced by radioactivity or by the accretion of smaller objects. In addition, Miranda is very small, and small objects do not retain heat for long periods of time. That is why the cause of its tectonic activity, the shifting and building of landforms in ages past, and of its trapezoid and two ovoids, which are marked by odd bands of dark and light material, is a mystery.

To investigate the origin of the strange terrains of Miranda, the Voyager imaging science team, led by Smith, checked to see whether Uranus’s other large moons offered any clues. The research team found that Umbriel and Oberon are both heavily marked with craters as large as thirty to sixty miles in diameter. The number of craters per unit area is about the same as on the lunar highlands. Titania and Ariel seem to be marked by proportionately fewer and smaller craters, resembling in that way the resurfaced terrain on Miranda. Also, Titania and Ariel are marked by faults that appear to be caused by or associated with material extruded from the interior. Thus, they have undergone tectonic activity and may well have once had many more craters that have since been submerged, partly covered, or obliterated.

All of this information, taken together, inspired the idea that the disparate surfaces of Uranus’s five large moons can probably be viewed as the common product of ancient collisions with planetesi-
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mals, asteroid-sized objects orbiting the sun. Created early in the history of the solar system, planetesimals banded into one another and some merged to form the planets as we know them today. According to this so-called collision theory, Oberon and Umbriel, each more than twice the size of Miranda, were least disturbed by these collisions. Titania and Ariel are believed to have been somewhat more disturbed. But Miranda suffered the most because it was a smaller body and because the strong gravity of Uranus should have concentrated any incoming planetesimals, producing the most collisions on the innermost of the five moons. According to the collision theory, large craters formed on Miranda at about fourteen times the rate at which they formed on an equal area on Oberon. If the theory is correct, it suggests that Miranda may have been wholly broken apart by the impact of planetesimals but was then re-assembled as the ejected fragments fell back and merged.

The Voyager imaging science team proposed that Miranda may have suffered this fate several times, that Ariel was probably disrupted and re-formed at least once, and that Titania may or may not have ever been disrupted. This theory is intellectually stimulating, since it may explain how disparate landforms like Miranda’s ovoids and trapezoid columns could come to lie check and block with the old cratered terrain. If you break up a moon, hurl its pieces into space, and let them come back together again, they may well re-merge in jumbled form. In addition, the collisions might have provided the energy needed to melt the icy matter of Miranda and produce its tectonic activity. But the theory does not explain why so much of Miranda’s surface survives in the relatively pristine form of the old terrain. I would expect Miranda’s entire surface to be jumbled up, melted, or seriously deformed by so catastrophic a series of events as repeated disruption and reformation.

At the same time that geologists were attempting to account for Miranda’s strange surface features, other experts were trying to explain the process that once energized its tectonic activity. Miranda, which now probably consists in large part of ice, is very cold (about −330° F). Ice does not flow there and therefore cannot re-form the landscape. Theories of what made the frozen matter on Miranda shift, extrude, or flow can be divided into bristle-force ideas like the collision theory, according to which great energy came from an external source; and subtle ideas like one proposed by two investigators of planetary interiors who suggested that if the ice on Miranda has an earthly composition, relatively little energy would be required to make it flow. These investigators suspect that Miranda’s ice might be “very fine-grained” and that in the spaces between the grains there may be a cryogenic fluid (one that remains liquid at very low temperatures), such as methane or even liquid nitrogen.

Alternatively, the frozen material on Miranda might not be ice as it is commonly understood but rather clathrate hydrates, that is, chemical structures with interstices containing molecules of cryogenic fluids. In either case, the ice (or the clathrate hydrates) might flow as a consequence of the fluid within it and the pressure of overlying layers without the necessity of a great energy source. I know of no evidence that rules out this clever suggestion; on the other hand, it invokes the existence of fluids that cannot be detected by present methods, and therefore it can neither be verified nor disproved.

Still another brute-force theory for the energy source of landscape changes on Miranda was propounded by two other Arizona astronomers last July. Robert Marcialis and Richard Greenberg suggested that the necessary energy might come from tides. They pointed out that although Miranda is now a stably rotating object and always keeps the same face toward Uranus, just as our moon always keeps the same face toward us, it may have been a chaotic rotator in the distant past.

Simply put, a chaotic rotator is one that turns alternately faster and slower with no apparent rhyme or reason, so that, in effect, its rotation rate at any given future time cannot be predicted from present knowledge. The mathematical techniques needed to understand such objects have only recently been developed. According to the Arizonans’ theory, if Miranda were previously slightly elongated in shape, and if its orbit were noticeably more elliptical than circular, it would have rotated chaotically and that behavior would have led to the accumulation of large amounts of heat in its interior as a consequence of the tidal force exerted by Uranus.

The beauty of this theory is that the chaotic rotation and tidal heating themselves would have taken energy away from Miranda’s orbital motion, making its orbit more circular, and they would also have caused Miranda’s shape to smooth out gradually and become less elongated. As a consequence, heating would stop, and Miranda’s orbit and rotation might have assumed their currently observed forms. There is no doubt that tidal heating can provide great energy to a moon—that is what energizes the actively erupting volcanoes of Jupiter’s moon Io. However, the tidal heating of Io is under way now, whereas the hypothesized tidal heating of Miranda is a process that existed only in the distant, unobservable past, if at all.

Strom has proposed a straightforward approach to the twin problems of Miranda that provides a common solution for both. He carefully noted the numbers of craters of different sizes on the old and resurfaced terrains of Miranda and for Uranus’s four other large moons. He found that craters larger than about twenty miles in diameter are densest on Oberon and Umbriel, less dense on Titania, still less dense on Ariel, and least dense on the resurfaced areas of Miranda. He also pointed out that craters smaller than twenty miles in diameter are densest on the resurfaced terrain of Miranda, less dense on Ariel and Titania, and least dense on Oberon and Umbriel.

In terms of geologic age, Strom found that Miranda’s resurfaced terrain is the youngest and Oberon’s and Umbriel’s surfaces are the oldest of Uranus’s five moons. What this means, he suggested, is that as time went by in the Uranus system, an initial population of large objects, which often collided with the Uranus moons and with one another, was gradually depleted as the large objects were removed from orbit by hitting moons or by being broken into smaller pieces. At the same time—since one big rock will fragment into many smaller ones—the number of small objects on a collision course with Uranus’s moons increased. For this theory to work, the objects had to be in orbit around Uranus. If they were orbiting the sun, then, like the impacting objects envisioned by the collision theory, they would rarely encounter one another. Thus, the Strom theory proposes that the surfaces of Uranus’s moons have been marked by large craters made by the impacts of objects, known as accretion fragments, that were left over from the formation of Uranus and its moons, and that the small craters on the Uranian moons were caused by chips knocked off these accretion fragments as they gradually ground themselves up over a long period of time during the early history of the solar system. Which, if any, of these theories of Miranda is correct remains to be seen.

Stephen P. Maran is a senior staff scientist at the Laboratory for Astronomy and Solar Physics at NASA’s Goddard Space Flight Center in Greenbelt, Maryland. The opinions expressed here are his own.
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Tracking Uranus

by Thomas D. Nicholson

A rare gathering of planets in Sagittarius this month provides sky watchers with a rare chance to see Uranus, the seventh planet out from the sun.

We usually think of only five planets as being bright enough to be seen without optical assistance: Mercury, Venus, Mars, Jupiter, and Saturn. All are very bright in our sky, virtually as bright as or far brighter than the brightest stars. All have been known since the beginning of recorded human history. Then in 1781 the British amateur astronomer William Herschel, using a telescope he made himself, found Uranus during a routine search for unusual objects in the constellation Gemini. It is much fainter than the other planets, but surprisingly bright nonetheless.

Uranus can be seen by the unaided eye under favorable conditions and had probably been seen many times before Herschel recognized it as a planet. At magnitude plus 5.5, it is reasonably bright and can be seen on a clear, dark night, but you have to know exactly where to look. This month you can use easy-to-find Mars and Saturn to locate Uranus. And the crescent moon will help you find the two brighter planets in the morning sky.

Mars, Saturn, and Uranus will be in conjunction with one another this month in Sagittarius, which is in the morning sky above the southeastern horizon before daybreak. The three planets are stretched out a bit at the beginning of the month. Mars rises first, then Saturn and Uranus, but the distance between them closes continuously. Saturn’s slow, easterly motion is barely noticeable, but it passes Uranus on the 12th. Mars’s motion will be the easiest to discern as it closes with Saturn each day, passes it on the 23rd after passing Uranus the day before, and then separates again from both planets. The three objects will be closest to one another on the 22d and the 23d, when a disk only the size of the moon could almost cover them all.

The bright planets Mars and Saturn are guides to Uranus. Mars is best when it is closest to Uranus on the 22d and 23d. With Mars centered in binoculars on those mornings, Uranus will be just below it on the 22d and above it on the 23d. Saturn doesn’t get that close to Uranus at any time, but stays relatively close throughout the month, never more than about one degree (two lunar diameters) away. Mars, Saturn, and Uranus form a

Uranus, Mars, and Saturn will be in their closest conjunction of the year on February 23. Uranus has been moving left since January 1 and will swing through the left and right extremes of its course before returning to its more central year-end position on December 31. Saturn’s motion takes it past Uranus three times this year: on February 12, going from right to left; on June 27, during its retrograde movement; and on October 18, after it turns again. Mars moves through Sagittarius this month and is nearest to Uranus on the 22d and to Saturn on the 23d. The morning crescent moon enters this area of the sky in mid-February; its position on the 14th and 15th is shown. (The dashed line is the ecliptic, a projection of the earth’s orbit on the sky.)
Celestial Events

shortly after moonrise on the East Coast. Saturn is in conjunction with Uranus at about 8:00 p.m., EST.

February 13–14: The moon passes Mars, Saturn, and Uranus on the 13th and Neptune at 4:00 A.M., EST, on the 14th. Mars and Saturn can be easily seen near the morning crescent moon on the 13th and again the next morning. Saturn is the brighter of the two planets.

February 17: The lunar–solar new-moon syzygy (when the moon and the sun are in line with the earth) occurs at 10:54 A.M., EST, bringing spring tides with it. Perigee (when the moon is nearest the earth), about six hours earlier, adds its effect to the tides. These conditions can produce flooding coastal tides if reinforced by strong onshore winds.

February 19–21: The slender crescent moon, passing Venus on the 20th, moves closer to Jupiter nightly, shifting from below it to above it from the 20th to the 21st, when the moon moves east of the planet.

February 22: Mars passes Uranus within one-half minute of arc (that's about the size of a dime at a distance of about 250 feet) at their conjunction at about 4:00 p.m., EST. With Mars centered in binoculars on the morning of the 21st or the 22d, you can also see bright Saturn nearby. Uranus will be visible as a fifth-magnitude object close to Mars.

February 23: Mercury, now far enough around its orbit to the sun's right, resumes direct (easterly) motion in the earth's sky.

February 24: First-quarter moon, at 5:15 A.M., EST, is in Taurus. The moon is high in the south after dusk, the hazy stars of the Pleiades group (the Seven Sisters) are to its right, bright red Aldebaran is below it, and Orion's bright stars are still lower.

February 26–27: The evening moon, in Gemini again, is near Pollux and Castor on the 27th.

February 29: Leo chases the gibbous moon up the sky for the second time this month.

Editors Note: The Sky Map in the January issue shows the evening constellations and stars for this month and gives the dates and times for use.
Witness to China's Wonders

by Andrew T. Smith

The People's Republic of China is a land of stark contrasts. The third-largest country in the world, China's boundaries include five climatic zones from alpine/boreal to tropical. Elevations range from the second lowest lake in the world (505 feet below sea level) to the highest mountain, 29,028-foot-high Qomolangma Feng (Mount Everest). China has the world's highest plateau and some of the driest deserts, lushest tropical forests, most expansive grasslands, and largest river drainages. This diversity has produced a varied and complex flora and fauna, with approximately 10 percent of all plant and vertebrate species represented.

Until recently the natural history of China has been poorly understood, because natural history, as practiced in the West, was not avidly pursued by the Chinese. And culture, politics, and physical isolation have limited exploration by Western biologists.

But for the past thirty years, and especially in the decade since the end of the Cultural Revolution, there has been an awakening of a natural history consciousness, and with it a commitment and resolve to tackle conservation issues that had previously not been identified. This, I believe, is the result of two trends. The first is the development of a biological national pride; its most obvious manifestation is the current public relations campaign to elevate the endangered giant panda to a national symbol. The roots of this movement originated with a series of large-scale biotic surveys of unknown areas (analogous to the biological survey conducted in the United States in the early 1900s). At this time Chinese biologists are beginning to grasp more than ever before the distribution, status, and uniqueness of their plants and animals.

The second trend is the increased cooperation between Chinese and foreign scientists. Initially, it was difficult for Chinese scientists, often unable to practice their trade and literally cut off from the world during the Cultural Revolution, to regain a foothold amid the progress that had occurred. Now they are attending and hosting international conferences and working on projects with foreign scientists. Chinese institutes have initiated new scientific journals, and the government has become partner to international cooperative agreements concerning conservation.

The fruits of these new developments have been chronicled in several books. Until now, however, there has not been a single volume that takes a long look at China's natural history and conservation agenda. This niche is now filled by Tang Xiyang's Living Treasures. Tang, a journalist recently turned nature writer, sets out to portray the ever-increasing number of China's nature reserves, but along the way he accomplishes much more. He has written a book that can be digested at many levels. Woven through the book's twelve chapters, each of which focuses on an endangered species or parcel of land, is the history of the conservation problem in China and current attempts to mitigate the effects of past abuses. Tang also presents, often for the first time, general natural history accounts of some of China's endemic endangered species; often these are enhanced by earlier poetic descriptions of these same species.

On another level, the book is written in a very personal manner. For Tang, his search through China's nature reserves was indeed an odyssey. He pays particular attention to the efforts and motivation of
those persons involved in the conservation endeavors he addresses. The result is a new philosophy that represents, in the context of the Chinese experience, an even more dramatic shift than did the writings of John Muir and Aldo Leopold to the development of thought in American conservation. Efforts to preserve habitats and species and develop a nationwide conservation ethic in China must compete with the reality of a population of more than one billion persons and a history of wide-scale environmental abuse.

Tang concentrates on China’s nature reserve system because it is central to the government’s efforts to protect the country’s natural diversity. At the time the book was written, 316 reserves had been established, encompassing 42 million acres, or 1.8 percent of China’s total area. The goal is to create a total of 500 such reserves by the year 2000. The short final

LIVING TREASURES: AN ODYSSEY THROUGH CHINA’S EXTRAORDINARY NATURE RESERVES

by Tang Xiyang. Bantam Books/New World Press, Beijing, $29.95; 208 pp. illus.

chapter outlines the general types of nature reserves: those that protect natural ecosystems; those that protect precious animals (such as the panda reserves); those that protect forest vegetation; and those that protect special areas (such as geological sites or areas near cities). I view the book’s failure to present comprehensive data on the establishment of this reserve system and a tabular list of the reserves as major oversights.

The difficulty of a program as ambitious as setting up this large reserve sys-
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All-star Casts

When Michele Oka Doner took her two sons to the Hayden Planetarium for the first time in 1983, she noticed the cracked asphalt plaza in front of the Planetarium steps and imagined “the beauty and splendor of stars” portrayed across its broken surface. Doner, a sculptor who lives and works in Manhattan’s SoHo district, stopped by a hardware store on her way home that afternoon and purchased cement, clay, and bronze glaze. That night she began creating a model of the plaza with an added element: hundreds of inlaid bronze shapes symbolizing various celestial objects.

Last November, nearly three years after her idea was proposed to the Museum and accepted, Doner went down on her knees and embedded the bronze casts in the newly cemented plaza. The sculptures depict a variety of elements in the universe, and no two are the same. Spiral shapes represent rotation and the release of energy. Spiral shapes with cilia-like fringes represent the sun. Some forms, ancient symbols of the sun and earth, were inspired by Doner’s collection of pre-Columbian artifacts; others are purely imaginary. A flat bronze human torso symbolizes the relationship between humanity and the universe.

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Michele Oka Doner arranges the celestial objects (in
their wax stage) on the floor of her SoHo loft
At the American Museum

Black History Month
February is Black History Month. Weekend programs in the Leonardt People Center at the American Museum of Natural History will include lectures, music and dance performances, and readings. On Sunday, February 21, at 2:00 and 4:00 p.m. in the Kaufmann Theater, the Charles Moore Dance Theater presents a history of black dance in America. On Sunday, February 28, at 2:00 and 4:00 p.m. in the Kaufmann Theater, the Lowdown 'n Blues Jazz Band will play the music of Thelonious Monk, Duke Ellington, and others. For information about these free programs call (212) 769-5146.

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This four-part, slide-illustrated series explores current research in animal nutrition and explains how proboscis monkeys, pandas, and wombats stay healthy on a diet of leaves.

For further information about these other lectures (including ticket prices, dates, and times) call (212) 769-5310.

An Evening with Richard Leakey
On Thursday, February 25, at 6:00 and 8:30 p.m. in the Main Auditorium, paleoanthropologist Richard Leakey will illustrate and discuss his views on human origins with slides of his extensive fieldwork in Africa. Tickets are $10 for members and $15 for nonmembers. For information call (212) 769-5600.

Lullabies from the Heart
Lullabies from around the world will be discussed and performed on Sunday, February 14, at 11:00 a.m. and 1:30 p.m. in the Kaufmann Theater. The program was organized by poet and folklorist Julie Lebentritt, who has conducted research among parents and children of New York City's various ethnic communities. Tickets are $2.50 for members and $5 for nonmembers. For further information call (212) 769-5600.

Avoidable but essential to their beauty and purpose. Doner has left the polishing up to the feet of visitors waiting on line to enter the Planetarium. And now perhaps even the longest line will seem a little shorter—a glance at the ground is all that will be needed for a preliminary glimpse of the heavens. —Renee Bacher

Doner cleans excess cement from the bronze casts

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A Simmering Sabbath Day

The worldwide diaspora of a culinary concept

by Raymond Sokolov

The philosopher Richard Popkin became famous for his speculative account of the Kennedy assassination. But his academic work on the history of philosophical skepticism led him to the great national libraries of Europe. When I met him in Paris in 1966, he was taking a break from reading in the Bibliothèque Nationale, and while applying body English to a pinball machine in a small café in the nearby Square Louvois, he propounded a pet theory even more outrageous and much less seriously held than his famous notion that Lee Harvey Oswald had had an accomplice. Popkin, a tongue-in-cheek Jewish chauvinist, liked to break up his philosophical investigations in European archives by reading the journals of the early explorers, where, he insisted, he always came upon the same remarkable occurrence. After every exotic landfall, each of the explorers invariably found that he was not the first European to set foot on the new land that he thought he had discovered. In fact, Popkin claimed, there was always a Jewish trader already ensconced there, who offered the sea-tossed explorer chopped liver and a corned beef sandwich.

The joke makes fun of our automatic assumption that all Jews eat what we in modern America think of as Jewish food. But Popkin's trader, doubtless a product of Iberian (Sephardic) Jewry, would never have known about cold-climate Ashkenazic deli foods. Even today, the two major Jewish communities, the Ashkenazic (Eastern European) and Sephardic (Mediterranean and Near Eastern), set very different tables, and members of one group can hardly believe that the other is eating Jewish food at all. Paul Levy, an American of Ashkenazic heritage who is food editor of the British Sunday paper The Observer, once said in mock astonishment at his London neighbor, the exiled Egyptian cookbook author Claudia Roden, "Claudia thinks that stuffed grape leaves are Jewish food."

All Jews do, nevertheless, share a few special foods that are fundamentally Jewish. These are what might be called liturgical foods, and they are almost all associated with Passover, the only traditional holiday that revolves around food. Matzo, the unleavened bread of the flight from Egypt, is the principal example of a universal Jewish food, always and everywhere basically the same. There is, however, another, more elusive category of Jewish food found throughout the world wherever there are practicing Jews, but it goes by different names and contains different ingredients from place to place. Jews from one area would probably not recognize the version of this food eaten by Jews in other locations. I am speaking of the hot dish served at midday on Saturday after the Sabbath morning service.

In this country, with its overwhelming Ashkenazic coloration, the Sabbath dish is almost always a slow-cooked stew of beans and beef called cholent. I once heard the poet John Hollander refer to cholent as the cassoulet of the Jews, which was an apt description, given the narrow definition that contemporary American Jewish usage gives to cholent. The mistake most of us make—I certainly did until very recently—is to think of cholent as a dish. It is in fact the Eastern Yiddish term for a category of Sabbath dishes eaten originally in Ashkenazic Europe. We think of the meat-and-bean cholent as standard, but in Russia potatoes were substituted for beans. And there are richer variations that combine meat (including calves feet in a Galician variant) with beans, potato, and barley. A cholent could just as well be a pudding of baked grated potato or noodles known generally in Yiddish as kugl. In Bavaria kugels even included apples and matzo.

So a cholent was not always a cholent. Throughout the Western range of Yiddish speech, from Germany to France, it wasn't even called a cholent; the word...
A Matter of Taste

Stew

schalet was in use instead. Schale
t even found its way into the standard encyclo-
dia of French gastronomy, Larousse Gas-
tronomique, as schalet à la juive, which
turns out to be a double-crusted apple-
sauce pie.

The German-Jewish poet Heinrich
Heine rhapsodized about schalet in one of
his Hebrew Melodies, a ballad called
“Princess Sabbath” (Prinzessin Sabbat)
that overtly parodies Schiller’s “Ode to
Joy,” the text Beethoven used for his
Ninth Symphony:

Schalet, schöner Götterfunken,
Tochter aus Elysium!
Also klänge Schillers Hochlied
Hätt’ er Schalet je gekostet.

Schalet ist die Himmelspeise
Die der liebe Herrgott selber
Einst den Moses kochen lehrte
Auf dem Berge Sinaï . . . .

Schalet ist des wahren Gottes
Koscheres Ambrosia . . .

(Cholent, spark struck from God, daugh-
ter of Elysium! That’s how Schiller would
have sung his ode if he had ever tasted
cholent. Cholent is the food of heaven,
which the Lord God himself once taught
Moses to cook on Mt. Sinaï . . . . Cholent
is the kosher ambrosia of the true God.)

The comparison is bombastic but apt in
one way or at least: neither ambrosia nor
cholent is a definable food in the ordinary
sense. Ambrosia is celestial food in the
abstract; cholent is any hot food that satis-
fies the religious definition of a dish ko-
sher for Shabbat (Sabbath).

Work is prohibited on the Sabbath.
This means that the lighting of fires is
forbidden, as is cooking in most senses of
the word. It would, of course, be possible
to satisfy these conditions by eating cold
leftovers, as long as they were normally
kosher. But the Sabbath is not meant as a
day of suffering, so special efforts are

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made to serve hot food that does not involve cooking or lighting fires.

The Sabbath begins at sundown on Friday, which means that the Friday evening meal is not particularly difficult to bring off in accordance with the Sabbath rules. The Jewish wife gets her meal under way in the afternoon and plans so that her work ends before dark. The problem meal is Saturday lunch. The solution is a filling one-pot dish whose preparation can be completed before sundown on Friday. From there on, for the ensuing sixteen to twenty hours, the covered dish cooks slowly, in an oven or on top of the stove over an asbestos pad or other heat-diminishing device (the Yiddish name for this is blech, for tin or sheet metal).

Strict observers do not remove the pot cover to see how their cholent is doing nor do they stir it or add water or in any active way cook the dish. And when they get around to serving it, they can only return it to the oven or the blech if (a) it was their intention to do so when they removed it and (b) they did not set it down anywhere else while they were serving it. These restrictions may not be observed except by the most zealous householders but they derive coherently from a liturgical phrase in the Talmud that is repeated in the synagogue service on Friday night. This Mishnah, or rabbinical commentary, first introduced into the liturgy in Babylonia in the tenth century, deals with preparations for the Sabbath and, in particular, the question of kindling fires. It contains a phrase (taman et hakkhamin) that translates literally as "hide or bury the hot things," meaning cover the hot food.

As the linguist Paul Wexler and others have shown, the two basic words of this phrase have impressed themselves on all the Jewish languages of the Diaspora, from the Judeo-Arabic of Yemen to the Yiddish of Vilna to the transplanted Baghdadi Arabic of Calcutta. The actual dishes vary radically from place to place, but their mode of cooking remains roughly the same, and their names translate to Hebrew-Aramaic words: one meaning hidden; the other hot.

Many false etymologies for cholent have been put forward. The most ingenious is shul ende, the end of the synagogue (service). Another derives cholent from the French word for shallot, échalote. A third makes a connection with a Hebrew expression implying "kept in the oven." But the word clearly emerges out of the Vulgar Latin calente or some early Romance form of the word for hot (later yielding Spanish caliente, Catalan calent, and French chaud from Old French chaud). The Hebrew-Aramaic word for hot, khamin is itself used as the name for Sabbath food in some Arabized settings, and in Calcutta, it crops up as hameen. But the other key Mishnaic notion, hidden, shows itself all over the Middle East in various forms of the same basic Arabic root (dfina, tfina, adaftina, adeftina), all meaning covered or buried. In Iraq, some speakers substituted yet other synonyms for covered: ibit (whose original meaning was to take shelter) and kubanah (a Sabbath food made of milk, apparently related to a verb meaning hem or conceal). And in Yemen, Judeo-Arabic has gillah (a word whose original meaning was earthen jug) for a Sabbath bean dish.

In Spain, what I am going to call the cholent concept produced that most typical of Madrid dishes, the boiled dinner with chickpeas known to the wide world as cocido madrileño, but still referred to by Spanish Jews as adaftina. In its pure form, this dish contained no pork, but supposedly after the expulsion of the Jews from Spain in 1492, the nominally converted

2. Add the onions and paprika and stir for a few minutes.
3. Add all remaining ingredients.
4. Pour in enough cold water to come three-quarters of the way up the ingredients. Bring to a boil, reduce heat, skim off the foam for several minutes, partly cover the pot, and simmer for about two hours.
5. Just before sundown, add more water if the beans and barley have absorbed so much that the level is reduced to less than halfway up the ingredients. Cover the pot tightly and place on the blech (asbestos pad or metal flame tamers) over the lowest possible heat and cook until lunchtime Saturday (16 to 20 hours).

Yield: Eight servings
Marranos who managed to stay behind added pork to show their fealty to their new faith. Some of the refugees or their descendants must have come to the Americas, perhaps fulfilling the Popkin theory, although without benefit of chopped liver. No doubt some of them did bring traditional Sabbath food ideas with them. Somewhere, then, perhaps even before 1500, some European Jew must have cooked dfina in the New World, spreading the planet's cosmopolitan food idea to yet another continent. Perhaps there should be a monument to this unknown dfina erected in Cuba or some other site of early Spanish penetration.

The dfina that Claudia Roden grew up with in Egypt (and published a recipe for in A Book of Middle Eastern Food) is a very close relative of the cocido of Madrid, but it also contains the unshelled eggs known as hamine. Long, slow cooking turns their insides creamy and their shells brown. This is the basic dfina. Le- one Jaffin prints several Algerian variants in 150 Recettes et Mille et Un Souvenirs d'une Juive d'Algerie. One version adds Swiss chard to the traditional meat-and-chickpea stew; another substitutes dried favas for the chickpeas; a third substitutes bulgur, a fourth adds a pasta in the shape of coffee beans.

After Algerian independence, adafina came to metropolitan France with the pieds noirs Jewish refugees. And, according to Norman Stillman, a specialist in the history of Jews in Arab countries, French-speaking Jews today shorten adafina to daf, as in J'ai mangé un bon daf.

In Morocco, the same basic dish is also known as sefrina (or skhina), meaning hot. But the most exotic “hot” cholent is the hameen of Calcutta, which accommodates to local taste by adding typical Indian spices and substituting chicken for the beef repugnant to the Hindu majority. Rice replaces chickpeas.

The cynic might wonder if this transplanted Iraqi stew hasn’t been converted in every way but name into a chicken curry. Similarly, all of the cholents from hither and yon could be subsumed under the heading pot-au-feu ouolla podrida. A daf by any other name . . .

But that misses the point. The name for once really does define the dish. A cholent is a tfina is a hameen, all of them hot and buried, cooked while you sleep and pray. The concept transmogrifies the ingredients, whatever they may start out as, into kosher ambrosia.

Raymond Sokolov is a writer whose special interests are the history and preparation of food.
Head
Hunting

Unperturbed by the ups and downs of perching on a piraffe's neck, a pair of red-billed oxpeckers search high and low for tick-hunting oxpeckers—a subfamily of starlings widespread in sub-Saharan Africa and the only birds that feed on ticks—spend most of their time in transit, inspecting the hides of wild and domestic mammals for blood-sucking parasites. Hosts, like this piraffe at a water hole in South Africa's Kruger National Park, benefit by being relieved of disease-bearing ticks and have been seen carrying as many as thirty oxpeckers at a time.

Since ticks clump where a mammal's skin is thinnest and blood vessels most accessible, oxpeckers are most likely to dine near the eyes, ears, neck, nostrils, and rump. Hide dealers who complain that oxpeckers ruin skins claim that the birds prefer animal flesh to ticks and actually enlarge sores to feed on blood. European stock kept free of ticks, however, does not attract oxpeckers. One scientist who examined the contents of fifty-eight oxpecker stomachs found 2,921 ticks. At about 32.5 ticks per bird (give or take a peck) it may be worth going out on a limb—or neck.

—Renée Bacher

Photograph by
Rita Summers
(Crests-Nature/Photographs Stock)
Although regarded by some as a devil's advocate, C. Vance Haynes, Jr. (page 4) is respected for insisting that archeologists adhere to the highest standards of evidence in their search for New World origins. Trained in geology, Haynes holds a joint appointment as professor of anthropology and geosciences at the University of Arizona, in Tucson. His recent collaborations with archeologists include working out the stratigraphy of Deep Ravine at the Custer Battlefield National Monument in Montana, where twenty-eight fallen soldiers were said to have been buried in place. "I eagerly accepted the invitation to investigate the Custer site," he says, "because one of my hobbies is the development of the breech-loading Springfield rifle that figured in the Indian wars." For further reading, see "Elephant-hunting in North America," by C. Vance Haynes, Jr. (Scientific American, June 1966, pp. 104–12), and The Great Journey: The Peopling of Ancient America, by Brian M. Fagan (New York: Thames and Hudson, 1987). For those interested in following the latest developments in the field, a lively newsletter, the Mammoth Trumpet, and other publications on the peopling of the New World are available from the University of Maine's Center for the Study of Early Man, 495 College Avenue, Orono, Maine 04473.
Jon P. Rood (page 40), his wife, Hazel, and three-year-old daughter, Josephine, were traveling as tourists in East Africa nearly twenty years ago when a pack of banded mongooses ran across their path. Until then, Rood had not realized the animals even lived in groups. His curiosity aroused, he arranged to study banded mongooses in Uganda the very next year. With the rise to power of Idi Amin, Rood shifted his activities to Tanzania’s Serengeti National Park, where he has been studying dwarf, banded, and solitary mongooses ever since. A research associate at the Smithsonian Institution and adjunct associate professor at Purdue University, Rood is helped in his work by his wife and daughter. Josephine, now a biology major herself, hopes in time to conduct her own in-depth study of the banded mongoose. For the Rood family, following the mongooses is a bit like watching life in a village; during parts of the year when they must be away from Africa, they eagerly await news on how the mongooses are faring. To gain further knowledge about mongooses, readers can turn to O. Anne Rasa’s story in the September 1985 issue of Natural History, “A Taru Life Story,” and to Mongooses: Their Natural History and Behavior, by H. E. Hinton and A. M. S. Dunn (London: Oliver and Boyd Ltd., 1967).
Having done fieldwork on itinerant Irish tinkers, or travelers, since the early 1970s, George Gmelch and Sharon Gmelch (page 50) were invited by the Department of the Environment in England and Wales to study the nomadic portion of the British Gypsy population. The authors are associate professors of anthropology at Union College, Schenectady, New York. In October 1985, George Gmelch wrote about return migration to Barbados for Natural History. With Sharon Gmelch, he had previously contributed an article about Irish bogs (November 1980). They are now doing research among the Tlingit Indians in southeast Alaska. For further reading, see “A Portrait of Tinkers,” by Bryan MacMahon (Natural History, December 1971); The Gypsies, by Jan Yoors (Prospect Heights: Waveland Press, 1987); Outsiders in Urban Societies, by David Sibley (Oxford: Basil Blackwell, 1981); The Traveller-Gypsies, by Judith Okely (Cambridge: Cambridge University Press, 1983); and Nan: The Life of an Irish Travelling Woman, by Sharon Gmelch (New York: W.W. Norton, 1986).

Peter D. Stiling (page 62) learned about the insect larvae known as leaf miners the old-fashioned way: he and a colleague examined more than 11,000 leaves with a hand lens. Then, armed with black “sharpie” pens, they marked 500 leaves and followed their fates. The results raised some provocative questions on how trees defend themselves. Stiling intends to continue to study leaf miners and their role in leaf fall. Born in Great Britain, Stiling received his doctorate from University College, Cardiff, and spent five years as a research assistant and lecturer at the University of the West Indies, in Trinidad. He is currently a research associate in the Department of Biological Sciences at Florida State University, in Tallahassee. A published insect photographer (Butterflies and Other Insects of the Eastern Caribbean, Basingstoke: Macmillan, 1986; Florida’s Butterflies and Other Insects of the Sunshine State, Sarasota: Pineapple Press, in press), Stiling also plays center forward for the triumphant Tallahassee Budweiser Blues soccer team. Not much has been written about leaf fall as a tree defense, but for further information on interactions between plants and insects, Stiling recommends the following: Insects on Plants: Community Patterns and Mechanisms, by D. R. Strong, J. H. Lauton, and Sir Richard Southwood (Oxford: Blackwell Scientific Publications, 1984).

To snap this month’s “Natural Moment,” (page 92) Rita Summers and her husband, Charles, parked their Land-Rover beside a water hole in Kruger Park, South Africa, and waited for animals to arrive. More than two dozen species, including zebras, bushbucks, and wart hogs, came and went silently. Summers says the atmosphere at a water hole is very still. Although the animals are on their guard for predators lurking about, most of them ignore cars and clicking camera shutters. To get this shot, Summers used a Nikon F3 with a 200–400mm lens and a windowpod (a version of a tripod that can be put in a car window). Summers became interested in photography after her husband gave up his career as an engineer to pursue professional photography. When they are not on the road shooting or giving lectures, the Summerses are busy designing a computer software package to suit the needs of photographers who face the task of managing a large inventory of photographs.
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A Bride for Raman
Manuel Moreno
In India, the road to an arranged marriage can be rocky.

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Robert H. Mohlenbrock
Newaygo Prairies, Michigan

This View of Life
Stephen Jay Gould
Honorable Men and Women

A Naturalist at Large
Richard W. Byrne and Jennifer M. Byrne
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The Living Museum
Houdini's Watch and Other Baubles

Celestial Events
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Photographs by Anthony Bannister
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Cover: To introduce the world to American gems at the turn of the century, Tiffany & Co.'s designers created special pieces of jewelry, including this chrysanthemum brooch of freshwater pearls from a tributary of the Mississippi River. It is included in an exhibition, "Tiffany: 150 Years of Gems and Jewelry," that opens in March at the American Museum of Natural History (see page 74). Photograph by Josh Haskin.
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Are marriages in India made in heaven?

by Manuel Moreno

During the early 1970s, when I first lived in India, I often heard young people proclaim the advantages of arranged marriages. Most of them seemed to believe that arranged marriages were foolproof, particularly compared with the precarious love marriages of the West. When I returned to India a few years later, I noticed that Hindu preachers often provided a rationale for this belief by saying that marriages were made in Heaven. And they used the English expression, “made-in-Heaven,” pronouncing it as one word. Curious to know what they meant, I asked a very popular preacher from the city of Madurai, after he had used the same formula when addressing a rural audience on the topic of marriage. According to him, it simply means that marriages are preordained by a person’s karma, that is, by the destiny that results from actions in past lives and even in the present life. “It is written in the head,” he had preached, using a popular southern Indian translation for the word karma. “No matter how much you and your parents and elders get involved in the arrangement of a particular marriage, the outcome is the same, for it has already been decided by higher forces. Then why do you worry so much about your future marriage?” The message appeared to be simple and soothing, particularly to the younger members of the audience.

“Do young people in India worry about much of their future marriages?” I wondered. During a two-year sojourn in southern India’s Tamil region, I was able to follow various marriage negotiations closely. I discovered that the arrangements are very complex and often a source of intense anxiety for prospective brides and grooms. Their emotions build up during the often lengthy period of negotiations. Uncertainties, conflicts between their desires and those of their elders, the fear of potential refusals, and most important, the possibility of discovering unknown flaws in themselves dominate this period. To make things more tense, young people are carefully watched and scrutinized, so that an inappropriate action can have devastating effects on the development of these proceedings.

In the predominantly rural region where I was staying, marriage arranging involves various steps. The process may begin with the celebration of a girl’s reaching puberty, when her parents invite the parents of eligible young men to the feast. Soon after, the young woman’s horoscope is sent to the families of these prospective grooms. In turn, each of these families may express a willingness to consider a match by sending the young man’s horoscope to the family of the prospective bride. Astrologers then advise whether and to what degree the couple’s horoscopes are compatible. Of some twenty possible matchings in horoscopes, a minimum of eight are considered necessary to assure compatibility between bride and groom. Certain matchings are considered indispensable. If the horoscopes are incompatible, apologies are exchanged and the process ends there.

When the horoscopes are compatible, and both families would like to go on with the proceedings, the family of the bride sends word to the family of the groom for preliminary consultations. The first meeting may take place on neutral ground, for instance, in the house of a common acquaintance. I found that people are always ready and glad to offer themselves as hosts and their dwellings as negotiating grounds. Considerable social prestige and religious merit derive from this activity.

Negotiations involve a series of visits by the prospective groom’s family to the young woman’s house, to assess and discuss various important matters, such as the prospective bride’s education and personal abilities, her family’s wealth, and the like. Often—particularly in the case of educated young men who, although they live with their parents, have a substantial income from professional jobs—these visits are conducted by the prospective groom and a group of his equally educated...
friends. When both sides reach an understanding, a betrothal ensues, and the date and auspicious time of marriage are determined by the astrologers of both families. The process may be swift, taking a matter of months, but often it is protracted over a number of years, involving a large number of people and issues.

One young man's search for a bride has been an object lesson for me in the difficulties of arranging a marriage and some of the attendant sources of anxiety. Raman (as I will call him) is the eldest son in a family belonging to the dominant farming caste of the Tamil region. His family is not well off by local standards, owning only ten acres of rice land. His father was influential in village politics, however, owing to marriage connections with the families of regional caste leaders. Raman remembers well the times he used to accompany some of these leaders on their rural political campaigns. This association soon paid its rewards, and Raman was sent to high school and later to college, where he obtained a master's degree. Then a position as a college teacher was found for him. When Raman was twenty-five, his father and caste leaders began to consider horoscopes of various young women, to line him up with a suitable bride. His position and income and the backing of the leaders make Raman a very attractive groom. Nevertheless, all the proposals he considers seem to fall through.

Personally, Raman values the education and beauty of a bride over the wealth of her family. His elders, on the other hand, are not especially concerned with these features, but would like to marry Raman to a young woman from a well-to-do family, one owning at least fifty acres of rice land, to ensure a substantial dowry. They know that Raman's education and monthly salary would make such an alliance not only possible but easy. There is thus a conflict between Raman's objectives and those of his elders, although they have never discussed it openly. I often heard such concerns expressed by well-

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educated young men, who would say to me: "We don't want to get married to one of these rich, uneducated women. They have no manners. They don't know how to behave in public. We want a companion with whom to discuss things and feel comfortable." I understood what they meant. After all, we were seeing the same romantic Indian movies and reading the same avant-garde novels serialized by the Indian weeklies.

These attitudes seemed to suggest some opposition among educated Indian young people to the prevalent arranged marriage system. I soon realized that this was not the case. Raman and his peers have very mixed feelings when it comes to making personal decisions, particularly on the issue of marriage. The most common reason for hesitation I heard was ignorance about women. "I'm very shy," Raman often said to me; "I know nothing about women. I wouldn't know how to treat them." Others, reacting to the image of the modern Indian woman, often portrayed in films and weeklies as being filled with illusions of romantic love, would say: "Nowadays, women have too many expectations, and these are not fulfilled in marriage because we men don't know about women's psychology. How can we when they live in a world of dreams?" These young people are in a dilemma—unwilling to marry a "traditional" woman, but terrified to marry a "modern" one, even if she is only a fragment of the mass media.

One of Raman's early marriage negotiations was with a family from a nearby town. He liked the daughter very much, although he had never spoken to her. She was fair in color (a usual index of beauty in India), of the same caste, college educated, and had thirty acres of rice land as family holdings. Horoscopes had been exchanged and the astrologers evaluated them positively. Raman's elders had informally spoken to the head of the family and looked favorably on the possible union, although they would have preferred a bride from a richer family.

One day Raman went with some friends to visit the family, in order to get negotiations going in a more formal and definite fashion. To his befuddlement, the father of the prospective bride proved discourteous and rather uninterested. Raman and his friends were not offered the customary coffee and snacks, as good manners demanded. And after a very brief introduction, the father told them: "Whenever we are ready to marry our girl to a fellow like you, we'll let you know." Naturally, Raman took this breach of etiquette as a personal insult. His friends, however, always ready to smooth the corners of difficult situations, thought that the father's apparent rude manner was only a strategy to lower the dowry, especially since he may have detected Raman's attraction for his daughter. Raman's friends were probably on the right track, for bluffing sometimes is part of marriage negotiations.

Other horoscopes were sent to Raman's family for consideration, many of them by richer families, but the prospective brides were either too homely and dark (and thus unattractive to Raman) or totally illiterate. At times Raman was able to stop these negotiations by bribing his family astrologer or finding other astrologers under whose philosophies the horoscopes were incompatible. Raman's elders were well aware of his desires and backhanded means to fulfill them, but an open confrontation was always avoided.

By the third year of this search, a palmist found a sign in Raman's left hand that indicated a dangerous influence from the planet Mars. Weeks later, another palmist denied the importance of that finding, alleging that the negative sign was visible only in the left hand, and thus dangerous only to women. Raman's preoccupation escalated to serious anxiety as a result of these confusing interpretations. During the next two years he spent a considerable amount of money and time consulting astrologers, palmists, and "headwriting" (karma) readers, always eager to hear a fresh opinion on the influence of Mars in his life. Eventually, when he was thirty years old, soon after I met him, Raman came to accept the guidance of a renowned astrologer. This astrologer told Raman that he should not marry within his thirty-second year, for the planet Mars would be predominant in his horoscope during all that year, making him a poor candidate for any good marriage.

Meanwhile, Raman increased his religious practices, going almost daily to worship in the temple of the god Murugan and the goddess Mariyamman, to involve them in his troubles with the planet Mars and with the search for a suitable bride. One common divinatory procedure he followed was to place two envelopes, one with a white flower and the other with a red one, on the platter held by the temple priest as he bestowed the gods' blessings on the faithful. A child would then be asked to pick one envelope at random. The color of the flower would indicate to Raman whether or not it was written in his head that he was going to be married before his thirty-second year and with the kind of girl he wanted. The results were often contradictory from day to day, and Raman had to find more elaborate and costly divinatory procedures.

During Raman's thirty-first year, he and his family again received many horoscopes for consideration. During that time I was often among the friends who went with Raman to negotiate with some of the proposed families. Our role was to speak for him and his family and do most of the required wheeling and dealing regarding the amount of the dowry, wedding expenses, and other such matters. The young woman's father or elder brother also was usually accompanied by a friend, who similarly acted as a mediator. Assuming a marriage is concluded, this system helps prevent future harsh feelings between the families. Since the interested parties are seldom involved openly in the discussions, they cannot be blamed later if the negotiations take a rough course.

I remember one midsummer evening when Raman and his best friend called on me and asked me to accompany them to a meeting with a potential bride's family. The meeting was to take place in the house of one of my neighbors. The man of the house was a teacher in the same college as Raman; his wife taught in the same elementary school as the sister of the potential bride. As we entered the gate, we took off our sandals and were greeted by the host, who accommodated us on one side of the front porch. The prospective bride's father was sitting at the other end of the porch, on a cot, together with a friend he had brought as mediator. The host did not make any attempt to introduce us. After what seemed to me a very long time, and in a rather casual manner, the mediator came to our side. Without saying a word, he handed two horoscopes to Raman, that of the young woman and Raman's own horoscope, which had been sent to her family a few weeks earlier.

Raman, without even glancing at the horoscopes, passed them along to his best friend. The friend looked at the prospective bride's horoscope with profound concentration, now and then making noises of surprise and gestures of approval. He then rather solemnly cleared his throat and got ready to speak. "These horoscopes match well," he said, "especially the parts concerning offspring and desire." The mediator seconded this opinion with profuse gestures, adding that all the astrologers consulted had unanimously agreed that the horoscopes showed a match of eighteen out of twenty possible compatibilities.

The horoscopes were then passed on to me. Raman's second-best friend. While I was looking at them with similar concentration, Raman's best friend inquired about the prospective bride's educational qualifications. The mediator immediately enumerated them with great detail, listing
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the young woman’s progress and achievements from first grade to her almost completed B.A. in education. At this point the father intervened—the only occasion he ever spoke during the meeting—to relate the qualifications of his other three daughters. Raman’s best friend met that long list of apparent successes with various negative-sounding nasal grunts. Later, when I asked him, he told me what those seemingly impolite grunts meant: “Well,” he said, “I didn’t want them to think that our groom’s family is less than them. We have our successes too.”

Once the horoscopes had been examined and the qualifications established, the host family served us coffee and snacks. “The first hurdle is over,” I thought. While we were sipping the extremely hot coffee and munching peanuts, however, a point of serious conflict between the two families came to the fore. It turned out to be of peculiar complexity. According to the young woman’s astrologer, in that Tamil calendar year she could only marry in the months of Avani (last half of August and first half of September) or in Maci (last half of February and first half of March). Outside of these periods, her marriage would not be advisable. Since we were already in the first week of August, the first alternative was considered too early by the young woman’s side. They were pressing for the second alternative, the coming February or March.

This was in complete disagreement with Raman’s situation. He was going to enter his thirty-second year that September, so he had less than a month before the dangerous influence of the planet Mars became active in his life. Only the first part of the month of Avani (second half of August) was suitable to Raman, but this was too early for the prospective bride’s family. All of these concerns were thoroughly discussed by Raman’s best friend and the mediator for the other side. After two hours of repeating the calendric complexities of the situation, a conclusion emerged. We should check with new astrologers and see whether they could find a more flexible interpretation of this astrological impasse.

Once in the street, Raman’s best friend said that he did not believe any of the arguments he had heard. “More likely than not,” he said, “this family has some money troubles—a debit of some sort—and they want to postpone the marriage for six more months.” And then he added, “It could just be that knowing Raman’s pressure for time they are using the astrological excuse to lower the dowry, in case they change their minds and accept an early marriage in late August.” I asked Raman whether he was willing to wait until February or March and expose himself to the dangers of the planet Mars. He was too upset to speak. His best friend replied for him. “Listen, Raman. If the girl has nice qualities, we shouldn’t pay any attention to Mars. Good qualities are the most important consideration in a marriage; forget about planets. So our next step should be to go to her village and discreetly inquire from neighbors about her character and her family’s standing.” Raman expressed neither agreement nor disagreement with that strategy. He said that his only wish was to marry a good girl as soon as possible.

A week later, when I asked Raman whether any change had taken place, he said that a chief astrologer of some remote village had told him that he could get married in his thirty-second year without any fear of danger from the planet Mars. Raman thought that his worship of the god Murugan and the goddess Mariyamman had been very effective. Consequently, he was willing to wait until February or March, but would consider other possibilities meanwhile, just in case a suitable match came along for an earlier marriage. In August and September he considered about a dozen more proposals, all submitted through his elders. None was found suitable. Exhausted, Raman began to visit a doctor for shots of vitamins. “I seldom eat at home,” he complained. “This is the problem, all the rotten food I eat with so much traveling around.” I knew what he meant, for I had accompanied Raman on some of his travels.

Two weeks after Raman entered his thirty-second year, his father died suddenly of an ill-diagnosed infectious disease. During the following months Raman underwent a period of strong depression in which his life was dominated by grief, fear of being himself infected, and a conviction that he was indeed under that dangerous influence of the planet Mars. Moreover, being the eldest son, he had to take charge of the family lands and some pending court cases with which he was entirely unfamiliar. February and March came, but Raman could not marry because the elders had imposed a long mourning period and, also, because he was by then totally sure that Mars was ruling his thirty-second year. When I last saw him, he was in the middle of his thirty-third year, free from the dangers of the planet Mars, but still anxiously searching for a suitable bride.

Manuel Moreno is an associate professor of anthropology at Northeastern Illinois University.
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Newaygo Prairies, Michigan

by Robert H. Mohlenbrock

A nearly continuous sea of tall grasses once covered the central region of North America, from the edge of the boreal forests in Manitoba south to Texas, and from the woodland borders in Indiana halfway across the Dakotas, Nebraska, and Kansas. Pioneers named this landscape "prairie," while the terrain from central Kansas westward to the Rocky Mountains, which was dominated by shorter grasses, became known as the Great Plains. Although much of the original prairie has been plowed under during the past one hundred years for such crops as corn, wheat, and soybeans, parts of it survive. Some isolated patches even turn up in (of all places) Michigan's Manistee National Forest, amid wooded and cultivated land east of the town of Newaygo.

The Newaygo prairie patches, the largest about 110 acres in size, are remnants of what once was a tongue of grassland that extended north into the forests of central Michigan. Similar extensions (collectively termed the Prairie Peninsula in 1935 by botanist Edward Transeau) penetrated the forests of northwestern Pennsylvania, western Kentucky, and northeastern Arkansas. These, as well as the more extensive sections of the North American prairie, apparently owed their origin to the uplifting of the Rocky Mountains thirty-five million years ago, which altered precipitation patterns. Winds from the Pacific Ocean were induced to shed most of their water west of the Rockies before reaching the flatter regions to the east. Ecologist Henry Allen Gleason has speculated that the drop in summer rainfall and the even drier winters were responsible for the disappearance of existing forests and their replacement by grassland.

Grasses and other plants that grow on the prairie succeed in part by exposing little surface area in the heat of summer. John Weaver of the University of Nebraska, who devoted a lifetime of study to the prairie, noted that half or more of the typical prairie plant is below ground. In addition, the aboveground parts are usually active only from April to October, dying back for the winter. The rest of the year the prairie is underground, the root systems of most prairie plants storing...
Big bluestem is one of the tall grasses that typify prairieland.
Photographs by Susan Crispin
Newaygo Prairies

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enough food to start off the spring with a burst of rapid growth. The roots also form a dense network that prevents alien plants from invading the prairie.

Despite a reputation for visual uniformity, prairieland contains grasses and wildflowers varied enough to make the most of the available resources. Some plants have most of their root system in the upper two feet of soil, some in soil between two and ten feet deep, and others have roots extending well below ten feet, so that the soil moisture is tapped at different levels. The energy of the sunlight is captured by plants ranging from small, broad-leaved species that form a ground cover to such grasses as big bluestem, which may grow more than twelve feet high. In addition, some plants have their period of maximum growth in the spring, some in the summer, and a few in the autumn, so that demands for light, water, and nutrients are spread throughout the growing season.

The long, slender grasses that dominate the prairies allow some light to reach the broad-leaved plants below. Still, the growth is so dense that few seedlings are ever able to attain maturity. Prairie plants, therefore, rely heavily on vegetative propagation—reproducing by sprouts from roots or new shoots from the buds on rhizomes (underground stems).

The Newaygo prairies, like most other isolated remnants of the Prairie Peninsula, contain fewer species and support less robust growth than the prairieland to the west, mainly because the moister Michigan climate tends to favor forest species rather than prairie species. However, Kim Chapman and Susan Crispin of the Michigan Natural Features Inventory have recorded as many as 125 plant species in the largest Newaygo prairie patch. Although the dark, rich topsoil typical of Kansas prairieland is replaced at Newaygo by a sandy substratum, the species are much the same. Big and little bluestem dominate among the grasses, with Indian grass and June grass also common. Among the showy wildflowers are the heath aster, prairie cinquefoil, two kinds of blazing stars, and the rare prairie smoke, a member of the rose family.

"This Land" highlights the biological phenomena of the 154 U.S. national forests. Robert H. Mohlenbrock is Distinguished Professor of Botany at Southern Illinois University at Carbondale.

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THE LADY AND THE UNICORN FROM THE FRANKLIN MINT
Honorable Men and Women

Flexibility and intelligence have been a hallmark of our species for eons

by Stephen Jay Gould

Mark Antony claimed, for rhetorical effect, that he had “come to bury Caesar, not to praise him.” But he then promptly reminded his audience that a man’s decency often accompanies him to the grave, while evil tends to retain a life of its own—“the good is oft interred with their bones.”

Mark Antony’s words beautifully capture both the excitement and dilemma of human paleontology. We have bones aplenty, but they speak to us in limited and muted ways. We wish, in our justified parochialism, to learn more. We yearn to know how and when those distinctively human traits of cognitive ability and moral decency entered our history. We wish, in short, to disinter the “good” that lies with the bones. But goodness doesn’t fossilize. (Some caveats before proceeding: I do not equate cognition and goodness. I do not believe that kindness first arose with humanity, while murder, mayhem, and general nastiness have longer pedigrees. But I would maintain that our vernacular idea of “humanity” resides in a unique combination of our inherited capacity for decency with complex social organization only possible in creatures at our cognitive level. This is the distinctly human sense of “goodness” that we seek to understand.)

Since decency and cognition make no fossils directly, the challenge for explorers of these most important and elusive aspects of human history lies in developing criteria of inference from the material record. Bones tell us something—particularly the size and conformation of the brain as inferred from bones of the skull, but also capacities for tool making indicated by the mobility and precision of hand movements deduced from bones of the wrist and fingers. More tenuous inferences from social behavior can be enlightening: Can we tell what ancient humans ate and how they obtained their food? What can we infer of social organization from campsites, hearths, and living floors? Artifacts may add yet another level of inferred complexity: some students of human tools argue that they can determine cognitive abilities of abstraction, and even aesthetic sense, from the character of flakes, axes, and choppers.

When we delve into the history of lineages older than our own circumscribed group of modern Homo sapiens, our inferences become more and more tenuous, for complexity of artifact and culture decreases, and we begin to grasp at straws. Thus, even for Neanderthals, survivors of the last glacial age and probably our closest cousins, much has been made of very little. Novels have been written, and more than one movie based, on the claim—supported by little and dubious evidence—that the Neanderthals’ vocal tract differed from ours, and that they could probably utter but one consistent vowel sound. And the discovery of flower fragments and pollen associated with a Neanderthal burial at Shanidar in Iraq occasioned a flood of commentary on the aesthetic (and even moral) sensibilities of Alley Oop’s people. The discoverer of Shanidar wrote a book on the subject, which was profitably published in 1971 as the counter-cultural reached its apogee. He named it Shanidar: The First Flower People.

We do not really obtain enough information for reasonably firm and complex inferences until we reach our own lineage—modern Homo sapiens, particularly from the best-studied sites of Europe and the Near East, and beginning with the Cro-Magnon peoples some 30,000 years ago. The Cro-Magnons, and their relatives and descendants from the last glacial period, have therefore provided the classical focus for studies on the earliest expressions of higher cognitive and moral thinking—the inception of “humanity,” if you will. For these people are old enough—from before the origin of agriculture and writing—to evoke mystery, yet young enough (and sufficiently like us) to provide good evidence and inspire empathic understanding. Moreover, they are our ancestors or at least part of our species, not (as the Neanderthals) our cousins on a close, but collateral, branch of the human family tree.

The advent of these people heralded a cultural explosion marking a distinct break with ancestors who left little more than their bones and simple tools of clear and immediate function. (I speak here of people usually called Upper Paleolithic, or late Old Stone Age, in popular texts and spanning the period from roughly 30,000 to 10,000 years ago, before the origin of agriculture and metalworking.) Consider just three categories, the last newly discovered and the trigger of this essay.

These are the people, first of all, who created the “Ice Age” art that has so captured the imagination of their modern descendents—the famous wall paintings in caves of France, Spain, and elsewhere; the stunning Venus figures of Willendorf and Lespugue; the ivory horse of Vogelherd; the remarkable carvings and bas-reliefs of horses, mammoths, reindeer, and bison carved on bone and ivory, on flat surfaces, and on the heads of throwing sticks. These are not “primitive” scratches or rudimentary attempts at literal likeness, but remarkably wrought and subtle designs, often invoking abstract or symbolic properties still deemed more aesthetically pleasing than the natural model itself. I find some of the Ice Age horse heads every bit as compelling as those later carved on the metopes of the Parthenon. These sophisticated figures only gain in wonder when we realize that they are linked to no known simpler predecessors. They represent our first evidence for any form of
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representational art. (For preceding Neanderthals, we have only tenuous inferences from flowers at burial sites and ochre that could have been used to adorn bodies. Could any astonishment in all human history have been greater than that of the first Neanderthal who met a Cro-Magnon and saw that a rock or bone could be wrought in the form of an animal?)

As we search beyond representation for other cognitive abilities embodied in artifacts, we find further, striking evidence in the use of symbol. (Proper classifications remain a problem. We do not know how Paleolithic people viewed or used their own art. Representations of animals are often abstract and may have functioned as symbols. And just because the markings discussed below don't generally strike us as art, we should not assume that our ancestors allocated their cave paintings and symbol plaques to different categories.)

Alexander Marshack, our leading student of Paleolithic cognition, has interpreted patterns of incision on flat surfaces of bone as a form of notation for keeping track of days and astronomical cycles. The Blanchard plaque, for example, dates from the time of the Cro-Magnon skeletons, about 28,000 years ago. It contains sixty-nine small incisions of circular or crescentic form, arranged in a serpentine pattern. Marshack argues, convincingly I think, that the sequence of marks "represented a non-arithmetic observational linear notation covering a period of two and one-quarter months." The serpentine turns all occur at major changes of the moon's phase, with full moons at the left, new and crescent phases at the right, and half-moons in the midlines. Marshack reminds us that this notation was developed "some 20,000 years before the invention of formal record-keeping or writing in the later agricultural civilizations of the Middle East."

Much later, toward the end of the Ice Age some 10,000 years ago, a plaque of similar concept, but much greater complexity, was carved in another part of France at the Grotte du Tài. Marshack found a similar system of incisions in horizontal rows connected by serpentine bends. But this time the bends occur at equinoxes and solstices, and the system spans three and a half years. The year had been discovered, and cognitive powers of abstraction were in full flower. If Marshack is correct, these people must have grasped the more general idea of cyclicity if they could use a common notation, but place either lunar phases at the bends to mark months or key solar positions to designate years.

Marshack writes that for Ice Age people, "art and symbol form the only body of materials in which the full range of higher cortical function is evident." (All quotes from Marshack may be found in his 1984 James Arthur Lecture on the Evolution of the Human Brain, "Hierarchical Evolution of the Human Capacity: The Paleolithic Evidence," given at the American Museum of Natural History.) To art and symbol, however, we should add a third category, for our usual definition of human worthiness includes kindness as well as cognition. What, then, can we learn of compassion from a study of bones and artifacts?

A remarkable discovery has just been reported from this domain of more circumstantial evidence. The November 5, 1987, issue of Nature (the leading scientific journal of Britain) announced the finding of an unusual skeleton from Romito, an Italian cave deposit some 11,000 years old ("Dwarfism in an adolescent from the Italian late Upper Paleolithic," by D. W. Frayer, W. A. Horton, R. Macchiarelli, and M. Mussi, pp. 60-62). From skeletal evidence, this male, who died at about age seventeen, was a dwarf with a syndrome technically called acromesomelic dysplasia. This form of dwarfism produces a head of approximately normal size, but several shortened limb bones and, particularly, an extreme reduction and bowing of the lower arm bones. The elbow joints cannot be fully extended and, consequently, the motion of the arm is greatly restricted. Such an individual, the authors judge, would have been greatly limited in his ability to participate in the major activities of his group—hunting and gathering. Moreover, given the inferred nomadic life style of his people, this man's handicap might have placed a severe strain on the mobility of his group, since acromesomelic dwarfs generally tire after walking even short distances.

Other Paleolithic skeletons show evidence of disability after injury or of decrepitude in old age. But the Romito dwarf offers our oldest evidence for the nurturing and protection—presumably at some expense to the group—of a handicapped individual who was profoundly different from his peers and physically disadvantaged from birth. All other examples of lifelong physical handicaps at this scale date from the origin of agriculture and complex societies. If we consider care of the handicapped (particularly at some cost to caretakers) as a key attribute of humanity, then the Romito people surely practiced compassion at this level. Interestingly, the Romito dwarf was buried in a cave apparently reserved for a few people of high status. Perhaps his social standing engendered his acceptance; but then we might also conjecture, in direct contrast, that he achieved his high status because his differences were valued or because his deeds or intelligence won respect despite his physical handicaps.

I have, so far, discussed a popular subject in a conventional manner. But I have not presented this account merely to review knowledge in a well-plowed field; rather, I want to ask a different kind of question that has long perplexed me: Why are we so surprised and gratified whenever we find a new example of prehistoric cognition or compassion in early members of our own species, Homo sapiens? Why should we marvel? What else should we expect? The Cro-Magnon people are us, not some primitive palimpsest waiting for the engraving of humanity. Even Paul Broca, the great French anthropologist who described the Cro-Magnon skeletons, and who spent a large part of his career making invidious distinctions among modern human races, noted that the five Cro-Magnon skeletons, discovered in 1868, were better endowed than modern Europeans in some crucial ways. He wrote in 1872:

They were superior in stature to ourselves. ... The skulls are large in diameter, curve, and capacity, and surpass the mean of those of existing races. ... The forehead is wide, not receding, and describes a beautiful curve. The amplitude of the frontal compartment denotes a great development of the anterior cerebral lobes, which are the seat of the most noble faculties of the mind.

Of course we expect that earlier species in our lineage would lack modern skills of cognition. I anticipate no soliloquies from an australopithecine, no statuary from Homo erectus, and no sonnets (with vowels either few or numerous) from Neanderthals. But at some point, modern Homo sapiens split off from an ancestral group and founded our own species. They were us at the beginning, are us now, and shall be us until we blow ourselves up or genetically engineer ourselves out of current existence. Homo sapiens, as I argued in my column for June 1987, is an entity, not a tendency. Once we arose as a species—and 100,000 to 250,000 years ago in Africa is our best current assessment of time and place—we were probably pretty much ourselves in terms of mental organization (although not, of course, in technological accomplishment). Since the Cro-Magnon carvers and reckoners represent a much later migration of Homo sapiens into Europe, we should be even less surprised that they looked and reasoned like us. So why are we astonished by art, symbol, or care of the disabled so long ago?
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Our surprise, I think, teaches us more about our hopes, biases, and expectations than about the actual state of our ancestry. We like to think of ourselves as a pinnacle of predictable evolutionary achievement. We have also been taught to view evolution as a process of continuous change. Put these two notions together—continuity of change and growth of human superiority—and you arrive, inerexorably if unconsciously, at the meliorist notion of progressive betterment. Such an idea imposes a definite view about the nature of time. Time is no longer only a matrix for the passage of events. It becomes almost a force in itself or at least a reliable marker and measuring stick of human advance. Thus we equate passage of time with growth of skill, intelligence, or achievement. And the further back we go, the less we had of all these good things. Ancientness means primitiveness, and older implies less endowed.

We gaze upon the pyramids and judge them close enough in time to be the products of people like us. But why should a cave painting only three times as old (13,500 as opposed to 4,500 years) be deemed the astonishing accomplishment of a supposedly primitive creature? Do 9,000 short years make such a difference in principle? Similarly, we are deluged year after year by the same expressions of surprise whenever someone claims that an ancient shrine or monument—be it Stonehenge or Chaco Canyon or Casa Grande—was really an astronomical observatory with key features lined up to sunrises of the equinox and solstice. Why not? These later people were us; they shared our cognitive abilities. They were agriculturists; they needed to know. You can't raise corn effectively unless you can track the seasons. Prehistoric doesn't mean primitive.

Moreover, the equation of ancient with less able is not a necessary inference or a clear empirical truth. This assumption is itself, a culturally embedded idea of relatively recent origin. All the classic works on this subject—from J.B. Bury's *The Idea of Progress* (1920) to A.O. Lovejoy's *Great Chain of Being* (1936) to R. Nisbet's *History of the Idea of Progress* (1980)—argue that the notion of inherent progress is a relative newcomer in Western thought, an idea that arose with the scientific revolutions and political upheavals of the late seventeenth century and gained strength with subsequent waves of industrialization and imperial expansion. Previous convictions often placed just as much confidence in the opposite interpretation of decline from a former golden age. Early historians and scientists often viewed the history of both human life and the earth's surface as a continuous degeneration from original perfection represented by Adam and Eve in the Garden of Eden. Some 500 years ago, scholars and artists called their movement the Renaissance (or rebirth) because they strove to recapture the ancient glories of Greece and Rome, a time of achievement that, in their judgment, might be rediscovered, but never exceeded.

We might be tempted to argue that these views only indicate past ignorance and that Darwin's demonstration of evolution established continuous change for the better as a fact of life. Not so. Darwin proved that evolution had occurred—that all organisms are the products of historical change, and that all are linked in a genealogical nexus. His theory did not establish a characteristic rate or directionality for evolutionary change. The comfortable idea that time alone can make us better is a psychological hope or cultural bias imposed, by our own weakness, upon unyielding nature.

In the large scale of geological time, substantial change will occur. In the full span of human history—some six to eight million years since the split of our lineage from common ancestry with the forebears of chimpanzees—we can trace a trend to larger brains and greater cognitive ability. But life is not a fractal. The patterns of one scale do not apply to all other amounts and times. We may note a trend across the half dozen or more species that link modern humans to the first australopithecines. But each species is an entity, a package if you will. Species may develop their distinctive features as they arise in a geological moment and then remain stable for all or most of their long subsequent history. The norm for a widespread, successful, and populous species is stability, not constant change. Evolution occurs largely by rapid origin and replacement of species, not by gradual progress within the long history of a species.

This last paragraph epitomizes the theory of punctuated equilibria that Niles Eldredge and I first proposed in 1972. Our theory clearly implies that Upper Paleolithic and modern humans are part of the same entity, and that we should not be surprised when we discover the products of modern intelligence among our Ice Age ancestors. But even an evolutionist who rejects punctuated equilibrium, and who believes that most change accumulates gradually within species, may be equally unsurprised that the passage of 30,000 years has yielded no perceptible change in human cognition. This geological moment is but a very small segment, by anyone's standard, in the life of most species.

Perhaps this message is finally getting across. At the awesome exhibit of Ice Age art mounted at the American Museum of Natural History in 1986, I was pleased to note the beginnings of a new age in captions. (I may not be surprised that Paleolithic people could produce such art, but awe is a different matter—and the beauty of these objects is awesome, in the literal meaning of that word, before its recent debasement by kiddie culture.) I can guarantee that twenty-five years ago, the thrust of the signs would have proclaimed: "See what primitive man could do." But this time, the exhibit stated with devastating accuracy: "See what we did in our infancy." Time is a matrix for all forms of change or for stability. Time is not a motor of progress. Old does not mean less advanced.

I speak, of course, about the human mind, not about our technological accomplishments. Technology advances and progresses—whether toward a better life for its inventors or toward destruction, I do not know—because each new step builds upon the last. But the substratum of technology—the human mind—has not altered since the origin of art, of agriculture, or of cities. We may discover better media to manufacture and distribute our paintings and sculptures, but a Cro-Magnon cave painter may shake hands with Picasso across the centuries. We have developed a technology to aid the handicapped, but our compassion may span the ages.

I would reverse our usual perspective on surprise. We are stunned by what our Ice Age ancestors could do. I think that we should look the other way, onward from the origin of our species. Is it not remarkable that all of what we call civilization, all of agriculture, of the arts and sciences, of technology, of life in complex cities, could be built by the unchanged power resident in the mind of a creature who evolved a large brain for reasons obviously unrelated to this future potential? The watchword of our evolution is flexibility, and the many uses of a complexity not designed for its current accomplishments. Mark Antony was right in his final eulogy over Brutus, although he might have been describing the unrealized potential of the first Cro-Magnon artist: "and the elements so mixed in him that Nature might stand up and say to all the world, 'This was a man!'" And so, as a result, are we all today, all honorable men and women.

*Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.*
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_Tangling with big cats is risky business, but at least occasionally, chimps get away with it_

by Richard W. Byrne and Jennifer M. Byrne

"Leopard! There’s a leopard in there! The chimps must have found it." Hiroyuki Takasaki emerged, breathless and excited, from a particularly dense area of forest. He quickly told us he’d heard leopard roars and the calls of excited chimpanzees coming from nearly the same direction. At first, the reception he got from us was less than enthusiastic: drama is all very well, but it conflicts with work. We had come to the Tanzanian forest of Mahale to discover the meaning of chimpanzees’ long-range calls, and Mariko Hiraisha-Hasegawa, the other researcher with us, was studying mother–offspring relationships. But even as we were contemplating the disruption of our morning’s work, we, too, began to hear cries in the distance—the agitated calls that are usually made by chimps when they are hunting monkeys or other small mammals. Immediately, all was forgotten except how to reach the site in time to find out, firsthand, what was going on.

The Mahale National Park lies on the eastern shore of Lake Tanganyika—"the sea," as the locals call it—and a few miles inland are the 8,000-foot peaks of the Mahale Mountains. In between is the chimpanzees’ stronghold. Most of the forest there is a jumble of secondary vegetation, a legacy of the slash-and-burn methods of the Tongwe people who lived in the park until recently and who long ago cut down the primary forest.

Cutting our way through the tangled thickets of vines, we homed in on bursts of screams and aggressive barks. As we got closer, we heard the leopard: not its usual "sawing" call, but deep roars like a lion’s. To avoid surprising the leopard, we had to move at a frustratingly slow pace. When we reached the scene, all we could see at first were about fifteen chimps gathered around a group of huge boulders hung with vegetation. Tension was high. Many of the chimps were in trees, and some were whimpering or urinating, a sure sign of fear. Their attention centered on a narrow, dark cleft at one end of the boulders. Several chimps clustered around this entrance, and at the mouth of what we later found to be a small, narrow cave.

Both males peered intently in, and one, known to us as Lubulungu, almost disappeared into the cave but jumped back when a deep growl came from inside. We were surprised to find Lubulungu in a leading role as he seldom asserted himself so forcefully and then only when his friend, top-ranking Ntologi, was nearby to protect him. At the leopard’s growl, the chimps retreated in an explosion of screams and barks. During the next forty-five minutes, this scene was repeated at least fifteen times.

Juveniles and females with infants also approached the cave mouth at times, often swinging at it from the vines above, but it was a small core of males—chiefly Lubulungu and the much older Kagimimi, whose hairless, flattened face always reminds us of museum reconstructions of Australopithecus—that pressed home the harassment. Both males entered the cave at times, and once, Kagimimi, in a display of aggression, charged over the boulders.

There are two puzzles here: What were the chimps so interested in? And what were the humans so interested in? The latter is easier to answer. Chimpanzees are such close relatives of humans, separated by only five to eight million years of independent evolution, that scientists seeking to understand the origins of our unique human intellect and cultural institutions hope to learn much from chimp behavior. Toshisada Nishida (who invited us to come to Mahale) and other Japanese anthropologists set up this study site in the 1960s and have worked there ever since, just as Jane Goodall has studied the chimpanzees of Gombe, about eighty miles farther north up the lake shore. The discovery at these two sites of toolmaking, game hunting, patterns of friendship and mating, and intercommunity violence has fully justified hopes of learning something about the roots of human culture.

But much about the behavior of our distant ancestors remains a mystery. For instance, we know from the fossil record that early hominids coexisted with several kinds of large carnivores. How did they react to one another? All these creatures are extinct, so the best model we have is the interaction of their nearest modern equivalents—chimpanzees (or gorillas) and leopards (or lions). Researchers studying chimps have seen them encounter leopards a number of times. Sometimes, chimps hardly react to the sight of a leopard, but usually they call aggressively and have managed to chase leopards away. In the daytime, leopards seem to be somewhat wary of the apes, even though, at up to 200 pounds, the cats are much larger than the primates, which weigh 70 to 85 pounds. Once, a single adult chimpanzee even drove a leopard up a tree.

At night, when leopards do most of their hunting, the tables may be turned. Chimps sleep on platforms of interwoven branches that they fashion in tree forks. Leopards, however, are expert tree climbers, and from hairs found in their scats, we know that leopards at least occasionally eat chimpanzees. And yet in no previously reported encounter between chimps and leopards was there such a sustained aggressive interest as we were seeing. The closest was in a series of experiments in which Adriaan Kortlandt, of the Univer-
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An adult chimp examines the leopard cub's body.
later, Kalindimya was able to snatch back the cub and drag it off, and this time he groomed its belly.

For chimpanzees, as for many primates, grooming is more than a practical way to keep the skin and hair in good condition and remove any parasites picked up from vegetation. It is also how the animals express affection and build up relationships: mothers groom their children, and adults who groom each other also support each other in situations of competition or aggression. For instance, low-status Lubulu regularly engages in mutual grooming with top-ranking Ntologo, and as his "friend," he is often able to share meat that Ntologo would not allow other males to touch.

But chimps do not normally groom dead animals. The only observations of similar behavior are found in reports of chimpanzee infanticide. Both at Gombe and Mahale, groups of male chimps have attacked and killed infants. Occasionally these dead babies were eaten, but when they weren't, adult chimps, even the former aggressors, sometimes displayed unexpected behavior, such as grooming, toward the bodies. Perhaps, like humans, chimps find that their compassion can be triggered by inappropriate objects as long as they have baby-like characteristics.

Forty minutes after the cub had been seized, the general excitement and interest in its body ended. At this point, Mimi, a young adult, picked up the body. She carried it, first by hand and then with its tail in her mouth, as she traveled through the branches of small trees. Then she laid the cub on a tangle of vines, groomed it, and began to build a small day-bed. When she had finished, she sat cuddling and grooming the cub. She rolled on her back and dandled the cub, holding it with all four limbs, "tickling" and playing with it. After ten minutes of this, she left her day-bed and, still carrying the cub's body, headed off into dense forest where we lost contact with her. We never found the cub's body.

As for the mother leopard, we never heard from her again, but at one point—after the ringleaders had departed but while we were still watching the cub—we heard chimpanzee screams coming from the area of the cave. We guessed that the leopard mother was taking her chance to slip away and that in doing so, she had attracted the attention of other chimps.

It is extraordinary to think that an adult leopard could have been so intimidated by chimpanzees that she did not even come out to protect her cub from them. Could she have been injured? We will never know for certain: the chimps may have

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been bold enough to come between the leopard and her cub, but we humans had no wish to face the distraught mother and so did not choose to sit by the mouth of the cave until she emerged. As most hunters know, a big cat can be especially dangerous when wounded. Later that morning, however, we returned to inspect the cave and found no blood or anything else to suggest she was injured.

Wounded or not, leopards are nothing to trifle with. Anyone who has read Jim Corbett’s true story The Man-eating Leopard of Rudraprayag (Oxford University Press, 1948) would not wonder for long about the potential threat these cats pose to humans. The 7½-foot-long leopard described in that book terrorized a number of villages in the Himalayan foothills for eight years, killing between 125 and 400 people before Corbett finally shot it. It was strong enough to hold the bodies of adolescents and old people above the ground, thus avoiding leaving a trail, and it dragged one grown man for four miles. Even gorillas are not safe from these cats: one Ugandan leopard killed several adult gorillas, including one male five times the weight of a chimp. And yet our chimpanzees got away with their attack. It is possible, then, that early hominids, too, could have successfully tangled with big cats.

But even so, what could ever drive them to undertake such a dangerous encounter?

One answer is suggested by cut marks on bones from Olduvai, a hominid site in Tanzania. When examined under an electron microscope those bones show signs of having been butchered with stone tools. Pat Shipman has found that some of these marks overlapped carnivore tooth marks, implying that the hominids were not the first holders of the bones. She suggests that early hominids may have scavenged regularly for their meat (see “Scavenger Hunt,” Natural History, April 1984).

Studies of modern animal scavengers, such as hyenas, have shown that scavenging to yield any useful quantity of meat, the carcass has to be stolen from the killer quickly, that is, while the rightful owner is still dining or guarding its prize.

Stealing food from big carnivores might seem foolhardy behavior to postulate for chimp-sized hominids, until one begins to consider how much power chimps evidently have over a leopard. Our observations demonstrate that chimps can, at least occasionally, take big risks with a leopard and get away with it. And giving further credibility to Shipman’s ideas, Japanese researchers at Mahale have found circumstantial evidence that chimps there do sometimes scavenge meat from leopards.

But in the incident we witnessed, there was no sign of scavenging. The cub itself was clearly the focus of the chimps’ attention, and their aim was to kill it, not eat it. The chimps certainly had no shortage of red meat in their diet; at the time of the episode, Mahale chimps were catching and eating monkeys daily. So we still had to ask ourselves why the chimps took such a risk. We and our Japanese colleagues can only suppose that the function was predator control: because of the incident, one baby leopard will not grow up into a potential chimp killer, and one mother leopard will probably move to a different place to care for her next offspring.

We are left with an uneasy feeling. Humans make connections such as these because they can understand the relationship between today’s cub and tomorrow’s possible man-eater, and can then use their superior intelligence to think out a way of anticipating and so controlling the behavior of powerful carnivores. Can chimpanzees do the same?

Richard W. Byrne is a lecturer in psychology at the University of Saint Andrews in Fife, Scotland. When not acting as her husband’s research assistant, Jennifer M. Byrne teaches home economics at Saint Leonards School in Saint Andrews.
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Halley Has Some Crust

Space probes gleaned important data from the comet, but for viewers on the earth, it made its poorest showing in centuries

by Stephen P. Maran

On a warm tropic night in April 1986, the deck of the Queen Elizabeth 2 rocked gendy over the placid Caribbean Sea. I steadied a pair of binoculars for the first of many people who were waiting patiently in line for their turn to look at the most famous comet of all time. When I boarded the QE2 in Los Angeles the previous week, with the assignment of "comet lecturer," I thought that the four pairs of binoculars in my luggage were probably unnecessary. Only an astronomer who had experienced the visual flop in 1973 of the highly touted Comet Kohoutek, as I had, would have taken that much optical insurance along for the sea ride. The binoculars, in fact, turned out to be necessary to convince the would-be viewers on the QE2 that they were indeed scanning the comet, although most could discern Halley with the naked eye once they knew where to look. Although the comet was a much better sight far to the south, on Easter Island and in Australia and Chile, astronomers had basically been right in predicting that the viewing conditions for Halley's 1986 return would be the worst in centuries (see "Getting Ready for Halley," Natural History, November 1981). In addition, the comet seemed to fade unexpectedly after a fleet of space probes swept by it in mid-March, so my belief that the best viewing would occur as Halley neared the earth in early April proved sadly mistaken.

Although I have read glowing reports from other astronomers, fortunate enough to see the comet in March and April 1986 over Ayers Rock, Australia, or in the dark clear sky over the Atacama Desert in Chile, the best views of Halley were not witnessed by humans but by robot cameras on the automated Soviet space probes Vega 1 and Vega 2 and the European Space Agency's Giotto, which flew through Halley's coma, or atmosphere, on the sunward side of the nucleus—the side opposite the comet's tail—to send back the first images of the so-called dirty snowball at the heart of the comet.

The pictures from these probes confirmed the snowball theory first advanced in 1950 by Fred L. Whipple, at Harvard University, that the nucleus, the solid core, of a comet is a mass of ice and rock dust, not the loose swarm of sand or gravel hypothesized by earlier investigators. The pictures also showed, however, that much of the current thinking about the cometary nucleus was still off the mark: the
nucleus is larger and darker than previously thought and, most remarkable, it is
topped by a hot, black crust with large holes through which vapors and dust parti-
cles blast into space from layers below. These cometary geysers are the source of
jets that not only inject fresh gas and dust into the coma but also turn on and off like
clockwork. As Halley's nucleus rotates on its axis once every seven days and nine and
a half hours, also apparently wobbling like a top (one wobble every two days and five
hours), the jets pour out of the geysers when they face the sun and turn off when the
sun sets and night falls.

If the jets are the most spectacular feature found at the nucleus of the comet, Halley's surface crust seems to me an even more remarkable finding. An infrared
sensor aboard Vega I recorded the tem-
perature of the surface at about 170°F, although a snowball at the comet's dis-
tance from the sun at the time (about 74
million miles) would be about 120° below
zero. Thus, the surface of the nucleus was
much hotter than the temperature that ice
can withstand. Yet there seems to be no
doubt that the nucleus as a whole is mostly
frozen water, for water vapor makes up the
largest amount of the material blowing
out from Halley through the jets and
must constitute the bulk of the material
that enters the coma.

Not only was Halley's surface hot, it was also very dark, as dark as the blackest
known features in the solar system. One
such is the dark side of Saturn's mysteri-
ous moon, Iapetus, which is comparable to
soot or black velvet. Halley's black sur-
face layer is presumably a good absorber
of sunlight, so the surface becomes hot.
All of this means that the snowball's sur-
face isn't snow or ice, since any such fro-
zen water would swiftly melt and evapo-
rate. But in space, water ice does not melt
when heated, but instead, like dry ice,
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ice also escapes, blown into space by the gas jets photographed by the space probes. But the particles that are left behind somehow become cemented together (at least, that's what I think), and form the black crust. The crust must be thick enough so that, although it gets hot at the surface, it provides thermal insulation to the ice below. Otherwise, the ice just beneath the surface would vaporize and perhaps form a huge vapor pocket that would blow the crust to smithereens. Instead, there must be local punctures, blowoffs, or fractures that make the holes from which the jets photographed by the Vega and Giotto probes emerge whenever the sun shines through them, heating and vaporizing the ice below.

Two Japanese probes also visited Halley, and NASA's International Cometary Explorer (ICE), veteran of an earlier visit to the small comet Giacobini-Zinner, swept by Halley on March 25, but at a distance of 17.5 million miles. Surprisingly, even at that range, ICE detected ways in which Halley affected its environment. Readings taken by instruments aboard ICE at both comets and by the five foreign space probes that visited Halley show that comets are surrounded by an invisible medium of electrified gas and magnetic and electric fields, created as a result of the interaction of gas from the comets with the solar wind that blows constantly outward from the sun.

When ICE visited Giacobini-Zinner in September 1985, it passed through the little comet's coma and tail and discovered that the comet was surrounded by a region of electrical turbulence and that it generated plasma waves—oscillating disturbances in the electric field in space—that can be detected with suitable antennas at great distances. ICE detected similar waves from Halley. Halley also proved to have the same type of electrically turbulent surroundings as Giacobini-Zinner and to have, deep within its coma, an electrically calm and unmagnetized region surrounded by a so-called contact surface. Outside the contact surface, electrified gas and magnetic fields from the sun clash with ions (electrified molecules) of gases that vaporize from the nucleus, but within the contact surface there are only the undisturbed, pure cometary gases.

One of the remaining major questions about comets is, What are their masses and densities? In other words, how much matter makes up a comet and how fluffy or compact is it? Whipple, now in his eighties, and currently director emeritus of the Smithsonian Astrophysical Observatory, in Cambridge, Massachusetts, feels that enough has been learned on the mass of Halley to say that it is very light. The size of the nucleus was measured from the telemetered photographs made by Vega 1, Vega 2, and Giotto. The nucleus is about ten miles long and nearly five miles wide; it resembles a long Idaho potato that has been charred to a blackened state in the coals of a campfire. Those measurements yield the volume of the nucleus. If Whipple's conclusion about the comet's mass proves to be correct, then the nucleus is much less dense than ice, or "about as dense as a loaf of bread." It is, he says, not compacted like a dirty snowball but more like a dirty snowdrift, with perhaps regions within it of frozen gases that are lighter than water. Future space missions, such as NASA's planned Comet rendezvous and asteroid flyby, may be needed to test this theory. In the meantime, I'm not sure Whipple is right, but I get his drift.

Stephen P. Maran is a senior staff scientist in the Laboratory for Astronomy and Solar Physics at NASA's Goddard Space Flight Center in Greenbelt, Maryland. The opinions expressed here are his own.

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The Bird Illustrated

With the Renaissance came science and printing—and an explosion of ornithological art

by Joseph Kastner

Four centuries ago, Ulysses Aldrovandus, one of the first men of modern times to produce a comprehensive natural history of birds, tried to explain what it was that caused him to undertake his long and almost endless task. Doing it, he decided after some thought, “leads to honor and renown” and, he went on to say, “it is accompanied with the most exquisite gratification and astonishment.” In the years that followed, many others took on Aldrovandus’s task and examples of their work are represented here. Some of them have indeed achieved honor and renown but only scholars know the others. The birds they drew or painted could be stiff and plain or graceful and extravagant. Sometimes their art was awkward, sometimes deft.

Humans have watched and portrayed birds for millennia. Drawings of birds, vivid in their bare outlines, are found scratched on the walls of prehistoric caves in France and Spain, and there are recognizable swans, eagles, owls, and ravens carved on Paleolithic stones and bones. Paintings in ancient Egyptian tombs are alive with waddling geese and stately cranes. In early manuscripts, birds appeared as religious symbols or as accompaniments to stories—to illustrate Aesop’s fables, for example—or simply to provide familiar detail for scenes of daily life. Not until the Renaissance were birds portrayed as themselves, as creatures to be

Woodcut of the peregrine falcon, above, was executed by Cristoforo and G.B. Coriolanus for the three-volume Ornithologiae, by Ulysses Aldrovandus (1599–1603). Hand-colored lithograph of gyrfalcons, opposite page, by Josef Wolf and William Hart is from The Birds of Great Britain, by John Gould (1862–73). “We see distinctly only what we know thoroughly,” wrote Wolf, the nineteenth-century master of zoological illustration, and his own thorough knowledge is evident in his portrait of the gyrfalcons.
From Saturday, February 6, through Saturday, May 7, 1988, the New York Public Library, Fifth Avenue and 42d Street, will present an exhibition entitled “Splendid Plumage: Bird Illustrations, 1550-1900, from the New York Public Library.” One hundred and sixty illustrations from the works of the world’s foremost artists and naturalists, all drawn from the library’s ornithological collections, will be on view.
recognized and classified. They had been studied and classified long before, of course, by Aristotle, but his work had become so encrusted with error and the interpolations of fusty pedants that it had to be done all over again. When Renaissance men looked around with opened eyes at their world, they began to see it—and to show it—as it really was, not as outmoded teaching told them it should be.

The Renaissance impulse to learn all there was to know was joined by an ambition to set this knowledge down. Within a century after the first use of movable type, books on birds appeared. The first ornithologies were printed in the middle of the sixteenth century. In 1551, in Zurich, Conrad Gesner, a Swiss physician and naturalist, began publishing his encyclopedic *Historiae animalium*, an account of all that was known about the animal world. One 800-page volume was given over to descriptions of birds—their anatomy and habits and the myths about them. The text was enlivened with more than 200 illustrations, and largely because of them, Gesner's book achieved an enduring popularity. At the same time, Pierre Bélon, a widely traveled French botanist and ornithologist, published his *Histoire de la nature des oiseaux*, with portraits of some 200 birds, including species from the Americas.

Meanwhile at the University of Bologna, Ulysses Aldrovandus was laboring away, but it was not until a few years before his death, about 1605, that he published his three-volume, 2,600-page *Ornithologiae*. Aldrovandus called himself the "illustrator of nature" and employed the best artists he could find.

Engraving with etching of the great auk, below, by the Danish scientist Ole Worm (1655). This particular great auk was a pet of Worm's; the ring around its neck was a collar. Later artists, copying this print, mistook the collar for the bird's plumage. Great blue heron, opposite page, is a hand-colored etching, by George Edwards, from A Natural History of Birds, by George Edwards (1802–6).
Aldrovandus anticipated modern procedures by going out on bird walks “accompanied,” he wrote, “by my draughtsmen and amanuenses,” who made sketches and took notes on the master’s field observations. He was infinitely painstaking, giving every bird’s name in Greek, Latin, Hebrew, Arabic, and Italian, recording their uses as “images in sacred and profane mythology, on coins, in proverbs and hieroglyphics,” so that he could claim that “whatever can be usefully said about birds may be found here.”

If what Aldrovandus said about birds has not turned out to be altogether useful today, what he said about studying birds rings as true now as it did when he said it more than 400 years ago. Expressing the awe and reverence that in one way or another every true student of nature must feel, he remarked that he had reached the richest of rewards for, through his work, he had “become acquainted with those matters with which the Almighty alone seems to be familiar.”

Put most simply, the ornithological purpose of depicting a bird is to provide a recognizable likeness by which that bird can be identified. In the earliest books, illustrations were reproduced by the simplest process, the woodcut. In this method, a drawing was made on a plank of hardwood and the wood cut away around it, leaving a raised image on the block. The woodcut was simple and inexpensive but it had its limitation: it could rarely reproduce subtle shadings or differences in emphasis.

Woodcuts were gradually displaced by metal engravings. Here the image was cut into a steel or copper plate. Ink settled into the grooves and the

Hybrid pheasant, above, a hand-colored lithograph by Joseph Smit (from a drawing by Josef Wolf), is included in A Monograph of the Phasianidae or Family of the Pheasants, by Daniel Giraud Elliot (1870–72). Wolf was able to observe this pheasant, a cross between the golden pheasant and the Lady Amherst pheasant, in the convenient setting of the Zoological Garden at Regents Park, London. Maguari stork, opposite page, a hand-colored lithograph by Edward Lear, is part of The Birds of Europe, by John Gould (1832–37). Lear’s stork, however, is a South American bird.
image formed by the grooves would be transferred to paper. It was far easier to cut fine lines into metal than to carve them out of wood and the engraving provided a truer and more elegant picture. A somewhat similar process, the etching, came into more limited use.

In the nineteenth century the engraving gave way to the lithograph. The image was drawn on a flat stone with a grease pencil. Greasy ink applied to the dampened stone would adhere only to the drawn image and could then be transferred to paper. The lithograph enabled the artist himself to draw directly and freely on the stone, instead of giving his work to an engraver who would painstakingly cut it into metal. It was the relative ease and inexpensiveness of the lithographic process that led to the great expansion of illustrated book publishing in the nineteenth century.

Each of these methods produced a basic black-and-white image. Colors were almost always applied by hand afterward and hand coloring became a cottage industry, done for the most part by overworked wives, anonymous spinsters, or young ladies with an artistic bent. The colorers got little pay—three to nine pence per page—and less credit, although one author was gracious enough to acknowledge that “the coloring of the plates has been executed by Miss Bertha Sharpe and Miss Dora Sharpe with the occasional help of their sisters Emily and Eva,” all of whom happened to be the author’s daughters.

Joseph Kastner is the author of A World of Watchers and A Species of Eternity.

Dodo, below, a hand-colored etching by George Edwards (from his own drawing) for A Natural History of Birds, by George Edwards (1802–6). Edwards concentrated on foreign birds, working whenever possible from captive live models and otherwise from mounted specimens. This drawing was based on an oil painting made in the late seventeenth century from a live dodo brought to England from the island of Mauritius.

Hand-colored lithograph of a collarled scops owl, right, by H. Arnoul, is from Les Oiseaux de la Chine, by Armand David and Emile Oustalet (1877). Father Armand David, a French priest, was the first Westerner to study and describe the botany and zoology of China under the auspices of the Chinese government.

Hand-colored lithograph of a collared scops owl, right, by H. Arnoul, is from Les Oiseaux de la Chine, by Armand David and Emile Oustalet (1877). Father Armand David, a French priest, was the first Westerner to study and describe the botany and zoology of China under the auspices of the Chinese government.
A brown antechinus mother transports her seven- to eight-week-old young, which hold fast to the teats within her pouch. With a body roll and a shake, the mother can unload her passengers.
Marsupial Femmes Fatales

*Males of a small Australian mammal species pay a high price for fatherhood*

by Andrew Cockburn and Anthony K. Lee

Twenty-five years ago, a student live-trapping small mammals in a rain forest near Brisbane, Australia, made a puzzling discovery. For several months he had been catching several kinds of rodents, as well as the small, shrewlike marsupial species known as the brown antechinus. Quite suddenly, in late September, all the male antechinuses seemed to disappear from the area. Perplexed, the student set more traps in a nearby section of forest, but there, too, he failed to ensnare any males. Then, one month after the last male had been trapped, the females began appearing with about eight minute young attached to their teats. At the end of a three-month suckling period, the new generation, including males, began to enter the traps, thus ending a four-month period when the population apparently consisted solely of adult females carrying offspring. The student deduced that all of the adult males of the previous generation had died shortly after mating; this was later confirmed when corpses of males were found on the forest floor. This phenomenon, extremely rare in mammals, first attracted us to this species some fifteen years ago, and the brown antechinus has provided us with new insights into natural history and ecology ever since.

Although sometimes called “marsupial mice,” antechinuses, with their pointed snouts, several pairs of sharp incisors, and rows of cheek teeth with sharp cusps, closely resemble large shrews. The tiny brown antechinus adults rarely exceed one and three-quarter ounces in weight, and within local populations, females are always smaller than males. Antechinuses have classic marsupial reproductive traits: the male’s scrotum is in front of, rather than behind, the penis, and the female’s teats lie in a pouch. In contrast to the pouches of other female marsupials, however, the antechinus pouch is not enclosed but forms an open cup. When a female carries young—newborns weigh about one-sixteenth of a gram and are the smallest mammals at birth—the entire brood is visible on her belly.

We studied the brown antechinus in the wet forests and heaths along the east coast of Australia, where they are the second
A tree nester, the brown antechinus inhabits forests along the eastern coast of Australia. In wet areas supporting lush vegetation, below, antechinuses forage for insects, worms, and spiders in the damp litter at the base of tree ferns. Mating takes place in tree hollows, right, and once under way, may last for hours. Sexually receptive for three weeks, females store sperm from many matings and ovulate only at the end of the mating season.

most common species of mammal, outnumbered only by the bush rat, a native rodent. Belying the popular image of Australia as a land of sunbaked deserts, these wetter areas are dominated by eucalypt forests. In one of our study areas, the most common eucalypt is the mountain ash, the world’s tallest hardwood tree, with some specimens towering 300 feet above the forest floor. Despite their height, the trees provide an open canopy through which sunlight filters, encouraging a lush growth of ferns and shrubs. This damp environment supports large terrestrial leeches, which seemed to enjoy fighting their way through our socks, as well as an array of insects and spiders that are the primary prey of antechinuses. The mammals are also partial to peanut butter and rolled oats, which we used to lure them into our live traps. By tracking animals fitted with radio collars, we now know that antechinuses nest in trees and can be caught there. Almost any kind of forest tree and even tree ferns are used for nesting, provided they furnish hollows of suitable size. The usual nest consists of a leaf-lined sleeping chamber with a separate latrine area. (One family we know of nested in a house, finding a warm bed in a drawer used for underwear. An adjacent sock drawer provided the perfect latrine.) We managed to study nesting behavior—difficult when dealing with most nocturnal animals—by placing traps on small platforms strapped to trees. A plastic collar fastened to the tree beneath the platform prevented animals from reaching the trap from the ground. In this way we were able to catch and identify all the occupants sharing a nest.

We found that all females in our population give birth within a couple of days of one another, usually at the same time each year. While photoperiod, or day length, triggers the reproductive urge, we know that synchrony is fine tuned by social interactions, since females kept in isolation ovulate at different times and ovulation and births are scattered over wider periods in sparse populations. Mothers carry their young attached to the teats for about a month, but then leave them in a nest while foraging. Toward the end of the lactation period, a female may be suckling as many as ten young with a total body mass five times her own. By this time, she will be nursing her young only intermittently and sometimes even nesting away from them, often with other mothers.

Tolerated by their mothers, daughters usually stay in the nest after being weaned and may spend their entire lives in their native range. Mothers force sons to disperse soon after they are weaned, and these young males move at least a quarter of a mile before resettling in nests containing unrelated females.

Dispersal of males from their birthplace is not uncommon in mammals. In many species of primates, for instance, males transfer from troop to troop while females remain in their natal troop. (In some birds, the pattern is reversed. Cocks usually stay near the nest where they are born, while the hens move away.) Male mammals usually mate with several females and put much less time and energy into the care and rearing of offspring than do females. While the female remains near stable local food resources necessary to rear young, the male may, without the responsibility of feeding offspring, benefit by moving to areas where there are groups of unchallenged females and his chances of mating are greater. But why should just
one sex do all the moving? The most widely accepted theory is that male mammals are intolerant of competition from their sons, but this idea does not explain dispersal of young male antechinuses, whose fathers die before the young are born. We think that young antechinus males are probably exchanged throughout the population by mothers to prevent their sons and daughters mating incestuously. This theory is not new, although it has languished for lack of any rigorous way to test it. The simplicity of the antechinus life history rules out several other alternatives and suggests that avoidance of inbreeding is a primary cause of male dispersal, at least in antechinuses, and that it may be important in some other mammal species as well.

Soon after the dispersal of the juvenile males, individual antechinuses establish permanent feeding ranges, each slightly more than two and a half acres. Since the ranges overlap extensively, they are not true territories. The animals also nest in groups, and in the autumn—March through May in Australia—we often found mothers nesting with one or two of their daughters, along with a female from a nearby nest and a few unrelated males. During the austral winter, antechinuses venture farther and farther—often up to 1,200 feet—from their foraging range to join nesting communes where they may huddle with more than twenty others. Neither sex confines itself to a single nest, but males are more likely to roam and may have contact with sixty to seventy other animals during the winter.

Using telemetry to follow the nighttime activities of these secretive mammals, we discovered that before the mating period they regularly foraged in the early evening before returning to the communal nests. We were eager to see what the pattern would be in the mating season; circumstantial evidence from livetrapping suggested that during this period males ran around in a frenzy, trying to locate and mate with females. But in the seventy-two hours they carried our transmitters, the males failed to visit their feeding areas, and all of them assembled in only two of the seventy nests we knew were in our study area. Trapping confirmed that as many as a dozen males may use the same nest tree at the same time, and the telemetry showed that they pack themselves into the same area in the tree.

One female, whose movements we knew very well, illustrates female behavior during this period. She spent most nights foraging in her small feeding range and huddled with other animals during the day. One evening during the first week of the mating period, she suddenly left her feeding area, trotted over to one of the sites where males had congregated, spent one hour with the males, and then left to resume her feeding. (The gathering of males in "arenas" that are visited by females solely for the purpose of mating is called lekking. Not uncommon in some bird species, lekking is extremely rare in mammals. If the antechinus mating system proves to be one that involves lekking, we will also be able to test any criteria females may be using to judge the quality of potential mates.) Our female made at least one other visit to the male group during this week. In the final days of the mating period the picture had changed dramatically. The males were still confining their activity to a few communal nests, but were running desperately from one nest to the other, perhaps in search of a nest with a receptive female. Our female ignored the frenzy and stayed within her feeding range, using a nest that was visited by neither males nor other females during this time. Seven days later, every male in the entire population was dead. (Females become receptive for three weeks and ovulate only at the end of this period. But since females can store sperm for two weeks, sperm from matings early in the rut are still viable when they ovulate.)

What killed the males, which appeared to be healthy one day and died the next? Can spending so little time at feeding grounds during the mating season—particularly for this small mammal whose high metabolic rate calls for a high food intake—cause death? The best clues come
from the pathology of males at the time of their death. 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 may pay the ultimate price. Analogous hormonal changes take place during the spawning period of the Pacific salmon, which also dies at the conclusion of a massive mating effort.

In all populations of antechinus species that we have studied, males live no longer than eleven and a half months and die at the conclusion of their first rut. Females may live for three years. Most breed only once, but some survive to breed again with the males of their sons’ generation. Females do not leave the population abruptly but are subject to the gradual attrition that affects most mammals, with death caused by starvation, cold snaps in winter, or predation by owls and nonnative cats and foxes. The proportion of females surviving to breed a second time varies among populations.

Our study of the postmating mass death of male antechinuses has broadened out and led us to test ecological and evolutionary theories, using the antechinus’s life history. Theoreticians, for example, have attributed great importance to the distinction between repeated reproduction (iteroparity) and single reproduction (semelparity). The latter term derives from Greek myth. Semele, one of the foolish human lovers of Zeus, was incinerated in a dramatic encounter with her lover when he appeared to her in all his glory. Antechinuses and their close relatives the marsupial phasogales are the only semelparous mammals.

At first blush, death after mating seems inconsistent with the idea that animals always attempt to maximize the number of descendants they leave, and it raises the question of how many more young a semelparous animal must produce to be relatively as successful at leaving healthy descendants as an iteroparous animal. Some researchers have also argued that iteroparous animals must “invest” less in reproduction if they are to survive to breed again. This idea that reproduction itself is risky has been invoked to explain a trend among birds and mammals: in general, the farther a species is from the equator, the greater the number of young it produces. Early explanations of this trend were directed only toward the behavior of birds. Some forty years ago, the British ornithologist David Lack suggested that as the summer day length increases with distance from the equator, birds that breed in the summer will have more time to feed and can therefore raise more young. In the Canary Islands, the European robin’s average clutch is 3.5 eggs; in Finland it is 6.3. This hypothesis quickly ran into difficulties, notably that the same latitudinal correlations are found for nocturnal birds, such as owls, and in nocturnal mammals, which would be expected to show the reverse trend. Further, the clutch size of some arctic birds continues to increase beyond the Arctic Circle, even though day length does not continue to increase. One of the subsequent hypotheses argues that while birds have a better prospect of surviving in the equable conditions of tropical latitudes, the young face limited opportunities in the competitive environment that prevails there; therefore parents need to conserve reproductive effort so that they may breed many times.

The population biology of antechinuses provides an unusual opportunity to test these explanations. In most of the populations of brown antechinuses we have studied, all males and most females reproduce only once. In contrast, many females of a related, more robust, co-occurring species,
When the young are about a month old, the mother deposits them in a tree nest. She may then nest elsewhere with other mothers but return periodically to nurse her offspring. Two-month-old brown antechinus littermates, left, are cupped by the eucalypt leaves lining their sleeping chamber. Eleven-week-old dusky antechinuses, below, their mother scarcely able to span them, are on the verge of weaning and independence. One, already roaming, enters the chamber from a tunnel on the left.

the dusky antechinus, breed twice. Both the brown and dusky antechinus populations closest to the equator have the smallest litters. Farther south and notably in the “alps” of southeastern Australia, litters consist of ten young. But there is a clear exception: on the capes and promontories of southern Australia, the litter size drops to six, the average for the tropics.

Since brown antechinus females will only breed more than once in exceptional circumstances, variation in litter size is not a trade-off between current and future reproduction. Similarities in the variation in litter size in the two species suggest that the effect applies equally to semelparous and iteroparous females. For example, on Cape Otway in southern Australia, the litter size of the two species changes at exactly the same place, suggesting strong and consistent patterns of selection associated with the environment.

In the 1960s, one of David Lack’s colleagues suggested that differences between the clutch size of tropical and temperate seabirds reflected the degree of seasonal temperature change. If a bird could survive the season when food was least abundant, it could avail itself of a surplus of food at more plentiful times. Surplus food energy could then be channeled into reproduction. This hypothesis fits our antechinus data very well. At cold, wet Cape Otway, and in warm, moist northeastern Australia, where seasonality is slight, antechinuses have litters of only six young. In the Australian alps, temperature fluctuates dramatically, and spring and summer bring a flush of edible insects. Here, at the top of their altitudinal range, females of both antechinus species have litters of ten. On the eastern Australian coasts, where seasonal fluctuations are more moderate but not altogether absent, the animals have eight young.

Establishing the connection between number of teats and litter size led us to another puzzling find. We discovered that in some brown antechinus populations, females had more daughters than sons in their pouches, while dusky antechinuses sometimes bore as many as four sons for every daughter, at least in the first year of the female’s life. The ability of mammals to vary the ratio of male to female offspring is restricted by the way sex chromosomes are inherited. For this reason, sex ratio biases—the production of significantly more males than females or vice versa—are rare. However, in areas in which both antechinus species live, we found that dusky antechinuses show the most extreme male bias ever recorded among mammals, and some brown antechinus populations have a female bias equaled only by some lemming mothers that produce only daughters.

The dramatic difference in sex ratios between these closely related antechinus species probably results from the combination of postmating male mortality and male-biased dispersal. When males disperse into a pool competing for access to other females, overproduction of males may be favored where competition among
females is strongest. Dusky antechinus females are usually iteroparous and so compete with their daughters, whereas the predominantly semelparous brown antechinus females die before their daughters give birth. This may explain why duskies produce so many sons. But second-year dusty mothers, like first-year brown antechinus mothers, will not survive to compete with their daughters. Remarkably, in this second season, they often produce a preponderance of daughters. Competition between mother and daughter appears to influence the sex ratio more strongly than competition among the daughters themselves.

How mothers juggle the sex ratios is not clear. We suspect that behavior during the rut may be important. Females can store sperm for long periods, and the most fertile matings are those that take place more than a week before ovulation. Long periods between copulation and conception have been found to cause female-biased sex ratios in white-tailed deer, and female antechinuses mating early in the rut may well be more likely to have daughters. (For a special report on findings of "juggled" sex ratios throughout the animal kingdom, see next month's issue of Natural History.)

Marsupials have attracted the curiosity of naturalists since their discovery in 1500 by Vincente Yáñez Pinzón, during the first European voyage to South America. Pinzón and his crew captured a female opossum with young and, on his return to Spain, presented the female to Ferdinand and Isabella, who marveled at the animal's pouch. The discovery of the much more diverse Australian marsupials came about a century later, but even in the scientific community, they have until relatively recently been considered curiosities, labeled "primitive," and seen only as stepping stones toward the evolution of placental mammals. We now know that much of the biology of marsupials is highly sophisticated and lacks parallels elsewhere among the mammals. The discovery of their remarkable habits has opened new vistas to naturalists, and we will continue tramping through the misty forests in search of these creatures for some time.□
His days numbered, a male dusky antechinus exhibits the ravages of the mating season. Driven to frenzied searches for receptive females and failing to feed, males can lose hair, teeth, and one-third of their weight within days. All male brown and dusky antechinuses die in their first year, having bred just once.
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THE HEARTBEAT OF AMERICA

TODAY'S CHEVROLET
Sharks of the Shallows

"The inside of the shark was soft and smooth.... I took the tail of one of the pups and gently pulled it back to the opening of the birth canal"

by Samuel H. Gruber

Fifty miles east of Miami, just beyond the deep waters of the Florida Straits, Bimini sits on the western edge of a vast, shallow, sandy submarine plain known as the Great Bahama Bank. Between the islands of North and South Bimini is a lagoon five miles long and one-half to three miles wide. Except for the deep waters near the small harbor of Alicetown, the lagoon averages about three feet deep, with a depth of only inches in some places and areas that become completely dry at very low tide. Its sand floor is a dazzling white, speckled with green blades of turtle grass and clumps of algae. In the shallows the sun may heat the water to more than 100° F.

The borders of the lagoon are a deep green tangle of mangrove trees. With their buttresslike roots forming knobby "legs," with "knees" in the air and "feet" in the water, the mangroves look like an army of green spiders with misshapen reddish legs. The roots provide shelter for fish and invertebrates that would otherwise be easy prey in the open, transparent waters. The mangrove leaves, together with the algae and turtle grass on the lagoon floor, take care of the main business of converting sunlight into the organic matter that fuels the marine food web, which in Bimini lagoon culminates in the lemon shark.

One afternoon in 1985 I was patrolling the lagoon in an airboat, a flat-bottomed craft capable of operating in only a few inches of water. Even with plugs of wax jammed deep into my ears, the roar of the engine behind my head was deafening. I had already had run-ins with the local fishermen over the commotion caused by the boat, but there was no other way to penetrate the extremely shallow waters. My assistant, Robert Jureit, stood on the prow of the boat; with a rope in one hand and a long-handled dip net in the other, he scanned the waters ahead of us. Suddenly he pointed excitedly with the net handle at the dark silhouette of a large shark contrasted against the light-colored bottom. I throttled back, and in the reddening glow of the late afternoon sun, the chase began. The shark was a pregnant female more than nine feet long, her belly so swollen with pups that it touched the bottom in
A newborn lemon shark wriggles free of its mother.

Doug Perrine
nearly three feet of water while her dorsal fin broke the surface.

As the female tried to escape, the first pup emerged, breaking for the mangroves as soon as the umbilical cord was severed. Robert used the net handle to direct me as the shark turned this way and that, trying to escape us. Finally, exhausted by her efforts and burdened by her yet-unloaded cargo, she began to slow. I maneuvered the craft alongside her, and with a swoop of the net, Bob snared her head. She erupted into fury, biting the net while thrashing the water with her tail.

The idea of trying to capture a 300-pound animal with a net meant for dipping mullet may seem ridiculous, but once the shark got a good bite on it, she believed she had a hold on her tormentor and stopped struggling briefly—just long enough for me to reach over the side, loop a slip knot over her tail and one over her pectoral fin, and secure them both to the side of the boat.

She lay limply alongside. Reaching under her swollen belly, I felt the pups moving restlessly inside. I began to fear that she would not survive our handling or that she'd be unable to birth the remaining pups successfully. Cautiously I rolled her belly-up. In this position the shark enters a trancelike state called tonic immobility. I inserted my hand into the animal's birth canal and to my surprise, she remained relaxed. Reaching in up to my elbow, I could feel the two-foot-long pups squirming around within their protective sacs. The inside of the shark was soft and smooth, unlike the rough exterior that was abrading my skin at the elbow. I took the tail of one of the pups and gently pulled it back to the opening of the birth canal.

Once in position, it wriggled out and swam vigorously away. I birthed the remaining pups one after another. As each fully formed miniature lemon shark emerged from the womb, the remoras that accompanied the mother would swim back and forth in a highly agitated fashion, finally dashing forward to consume bits of the afterbirth. These curiously specialized fish have flattened heads capped with suckers that evolved from the dorsal fin. Attached to a larger fish, sharks, or whales, the remoras subsist on parasites culled from their hosts' skin and scraps from their hosts' meals. Nearly all sharks attract one or two remoras, but pregnant sharks seem to collect a few extra.

I removed nine pups from the female before beginning our work. We took several measurements of the mother's length, injected her with oxytetracycline (an anti-
Some 200 lemon sharks, most of them young, inhabit the shallow water flats of the Bimini lagoon, left. The lagoon itself is the area containing the three small islands between South Bimini, the island at the top of the photo, left, and North Bimini, the narrow strip of land on the right. The lagoon is ringed by mangrove trees. Newborn sharks head for the safety of the mangroves, below, where they find shelter and prey among tangled roots.

Samuel H. Gruber

Biotic that leaves a stain in the skeletal parts, which can be used in determining an animal’s age and growth rate), inserted two labeled tags just beneath the dorsal fin, and slipped off our ropes. With two beats of its tail, the shark began to glide forward, picking up speed with each stroke, then vanishing quickly into the rapidly darkening waters of the lagoon. Including the baby that was delivered during the chase, she had birthed a litter of ten. An observation of the live birth of lemon sharks in the wild had never been reported before, but dissections of pregnant sharks showed that a litter of eight to twelve was normal. The small litter size of the lemon shark (one member of the large family of requiem sharks, which includes bull, tiger, blacktip and whitetip reef sharks) is the key to its differences from the bony fishes. (Sharks, skates, and rays have skeletons of hardened cartilage, not bone.)

In 1958 the ecologist Robert MacArthur coined the terms r selection and K selection to describe two types of natural populations with different strategies for survival. R and K derive from coefficients in a mathematical equation for population growth. R-selected organisms are small, short-lived, grow rapidly, have high mortality rates, produce a large number of poorly developed offspring, and tend to give little or no parental care to their offspring. Examples of r-selected species are insects, crustaceans, and bacteria, organisms well adapted to changeable environments. When conditions are good they can multiply rapidly. When conditions are poor they can hedge their bets by broadcasting a large number of eggs or young, of which a few may survive to reproduce. They are also the “pioneers,” colonizing new or unfavorable territories. When the environment becomes more stable, K-selected species move in.

K-selected organisms are mostly large, slow-growing, and long-lived. They produce a small number of well-formed offspring, to which they devote a great deal of care. Human beings are an ideal example of a K-selected species. Whales and crocodiles are also good examples of K-type animals. Such species do best in stable environments where the fewer numbers of offspring are compensated for by high survivorship.

The vast majority of marine organisms, and in particular most bony fishes, lie at the extreme r-selected end of the scale. During the breeding season, a single individual may produce millions of eggs, which are fertilized externally and must fend for themselves as tiny larval forms totally unlike the parent. Only a few individuals will survive to reproduce, but the number of young produced by each mature adult is so great that the population can rebound even in the face of catastrophic losses due to environmental stress or fishing. Since the young of such species are greatly affected by fluctuating environmental conditions, catches of bony fish are often highly variable from year to year.

Catches in shark fisheries are variable too, but in a different way, since the number of young depends more upon the number of adults than on environmental conditions. The catch is good for a few years, then begins to decline. Then all of a sudden there aren’t any more, and they don’t come back for years and years.

Lemon sharks grow very slowly in the wild, at only one-third the rate of bony
When I first came to Bimini to begin my shark research in 1979 I knew there were lemon sharks there, but I didn’t know where. After several hot and frustrating days out on the brilliant shallow waters of the lagoon I decided to seek out the Reverend William James Duncombe, better known in the islands as Bonefish Willie.

Willie was long a legendary figure on and off his native island, having made his reputation as a fishing guide and friend of sportsmen such as Ernest Hemingway and Sam Snead. People came from all over the world to fish with him for the very highly prized and very elusive bonefish, a denizen of the shallow waters known as the flats. Duncombe was out on the flats every day and knew how the tides changed the contours of the sandy bottom and where the fish went to find shelter, cool water, and food. He simply knew more about the creatures of the Bimini flats than anyone else alive.

I offered him fifty dollars if he could show me a lemon shark. He laughed and said it would be the easiest fifty dollars he ever made. We hopped into his boat and zipped out to the flats. He stopped, quickly caught a couple of fish, cut them, and tossed them back into the water. Within five minutes there were three lemon sharks swimming around the boat. We tossed one a "transmitter sandwich," an ultrasonic transmitter stuck inside a small fish. The shark swallowed it and we were able to track it for a couple of days.

Over the years, Willie not only provided us with valuable information on the natural history of sharks in Bimini but also interceded on our behalf with the local populace. For Willie was in touch with many of them as minister of an evangelical church he founded and presided over for thirty-six years. When this shy man, whose stutter sometimes made him difficult to understand, stepped behind the pulpit, he would astonish us with his sermons and hymns. Accompanying himself on the church organ, he often leaped from the pulpit in his fervor (no mean feat for a man in his seventies). His sermons never failed to bring one or more members of his congregation to their feet in excited dancing, ecstasy, or speaking in tongues. From his pulpit, the Reverend Mr. Duncombe waged a tireless crusade against the drug trade that had taken over the lives of many of the island’s youth.

A fine person, a loyal friend, and a great naturalist and fisherman, Duncombe died November 21, 1986.

S.H.G.
fishes, taking twelve to fifteen years to reach maturity. In the first year of life lemon sharks barely double their weight. Their slow growth may be the result of a very slow digestive process. A lemon shark that eats the same size meal as an equivalent-sized bony fish, takes three times as long to digest it through its corkscrew-shaped intestinal tract. As a result, these sharks tend to feed in four-day cycles, a far cry from the “eating machines” of popular conception.

This information was not gained from following sharks around and watching them eat, which would be next to impossible, but from laboratory experiments and from an examination of the stomach contents of wild-caught sharks. Sharks have a remarkable ability to empty their stomachs of indigestible contents by spitting the stomach out the mouth and turning it inside out. My crew and I used gill nets rather than baited hooks to capture the sharks because animals caught on hooks usually have nothing in their stomachs except for the bait. The sharks were mildly anesthetized and the stomachs everted using a pair of forceps. After removing the contents, the stomach was replaced and the animal revived by pushing it back and forth through the water. Nearly all of our subjects swam away unharmed, with a bright yellow numbered tag fastened to the base of their dorsal fin.

With Enric Cortes, a graduate student of mine at the University of Miami, I found that the lemon shark consumes a ration equivalent to only 2 percent of its body weight per day, only half of what a tuna might eat. The diet consists mostly of fish and an occasional shrimp, crab, octopus, or ray. They turn prey into tissue with a 15 percent efficiency. That is, 100 ounces of prey yields only 15 ounces of new shark growth. A bony fish, such as a catfish, might, under ideal conditions, turn 100 ounces of food into 50 ounces of growth—a rate of efficiency that makes catfish farming a profitable venture.

The tetracycline previously mentioned helped determine the growth rate and longevity of the lemon shark. As the animal grows, it deposits rings of calcium phosphate in its vertebrae, much as growth rings are formed in a tree. The rings are caused by differences in the density of the cartilage, which in turn is related to the animal’s growth rate. When the shark is injected with tetracycline, the drug leaves a fluorescent band in the spine, visible under an ultraviolet lamp as a golden ring. By dividing the number of days elapsed since the injection by the number of rings outside the gold band, graduate student Craig Brown and I found that the rings are laid down at the rate of thirteen per year—one each lunar month. We believe that the lemon shark goes through regular cycles of growth each lunar month. Why this is so we don’t know, but we guess that the animals feed better at the time of the full moon or on certain tides related to lunar phase.

By tagging the captured sharks (in some cases with ultrasonic transmitters either surgically implanted or fed to the shark in a piece of fish) I was able to get a picture of their movements. My students and I followed some animals on a twenty-four-hour basis for up to five days. We found that the lemon shark has a home range that expands as the shark grows. During the first year or two of life, pups are confined to the shallow nursery grounds in the mangroves. Here they feed—often in schools—on small fish, including mojarras, minnows, needlefish, grunts, snappers, and barracuda. Only 60 percent of the sharks will survive the first year; most of the others will fall victim to larger sharks. I once captured a four and a half foot lemon shark that disgorged a two and a half foot lemon shark. Those sharks that survive to the end of the first year will be about twenty-nine inches long, only slightly longer than their twenty-four-inch length at birth.

The lemon sharks of Bimini (I have estimated that some 200 live in the lagoon) stay almost exclusively within the confines of the lagoon for at least the first five years of their lives. Their gills are extremely efficient at extracting oxygen from the water, enabling the animals to function in the low-oxygen conditions that sometimes prevail in the mangroves. They gradually expand their range out onto the banks. When mature enough, they leave the lagoon entirely to feed on the deep reefs, and can wander as far north as New Jersey and as far south as Brazil.

Although adult sharks are more solitary than juveniles, they still often move in small groups. Within the lagoon, lemon sharks are more likely to be seen in groups than alone, following or circling each other—males perhaps following the scent of pheromones released by the females. I
A young lemon shark, below, prowls among the grasses of the Bimini flats. Juveniles are more likely to move through the lagoon in groups. Since the noise of the boat frightened the sharks and broke up their groups, an ultralight aircraft, right, proved ideal for observing and censusing the sharks in the lagoon. The silhouettes of two lemon sharks can be seen in the waters just in front and to the left of the plane.

Doug Perrine

followed the group movements at low altitude from an ultralight aircraft, which gave me the opportunity to count and observe the sharks without disturbing them as I would have if I tried to follow them in the airboat.

The adult sharks move eastward (onto the banks) at sunrise and westward (toward the lagoon and harbor area) at sunset. An ultrasonic transmitter with a paddlewheel speed sensor attached to a few of the sharks measured their swimming speed. The sharks averaged 1.1 mph during the day, rising to 1.6 mph during evening twilight, when we believe the sharks do most of their hunting, then dropping to 1.2 mph for the rest of the night.

Once, using a hand-held receiver, I tried to track a shark underwater, but each time I swam toward the signal, the shark swam away. Finally, exhausted from swimming, I stopped and hung motionless in the water. Within moments I was surrounded by a school of jacks, mackerel, and barracuda that swarmed excitedly about for a few seconds, then dispersed. Suddenly the shark appeared, swimming straight for me, then veering away as if having determined that I was of no interest. I tried this test several times, always with the same result. Whenever I held still in the water, I would be investigated first by the fishes, then by the shark.

Observations from the ultralight confirmed the association of lemon sharks with various species of jacks, as well as with barracuda, nurse sharks, and stingrays. I believe that the sharks may benefit from the expanded sensory capability of the school of fish. The fish can spread out over a larger area. If they find something, their excited vibrations will be transmitted through the water to the shark. The fish, in turn, may gain some measure of protection from the shark.

I recently collaborated with Adrianus Kalmijn (see Natural History, November 1987, page 94) to demonstrate that lemon sharks, skates, and rays can utilize their electric sense to detect fields of less than one-billionth of a volt per centimeter to navigate. Kalmijn installed equipment on the Bimini flats (at the east end of the lagoon) that enabled him to rotate the electric field that was naturally present. When an observer atop a tower spotted a shark swimming in a straight line, Kalmijn would slowly rotate the field in one direction or the other. Whether he turned the field to the left or the right, the shark would turn in the same direction. Since a shark creates an electric current in its body when it swims through the earth's magnetic field, we believe that it must use the earth's magnetism, as well as electric fields generated by ocean currents, to guide it on long journeys.

Wherever the mature sharks go when they leave the lagoon, some return each May. At this time I begin to capture two types of female sharks: pregnant ones and ones with fresh scars indicating that they have recently mated. During courtship, the male sharks savagely tear at the females with their teeth, inflicting bloody wounds that heal rapidly, leaving almost no trace the following year.
internal, accomplished by the insertion of a male organ called a clasper. The sex of a shark is immediately obvious from the presence or absence of these paired organs beside the pelvic fins. (The name derives from Aristotle's belief that males used the claspers to hold the females during mating. We now know that the teeth perform this function and that the clasper—only one at a time—serves to funnel sperm into the cloaca of the female.)

The gestation period is nearly a year, during which time the embryos are nourished first by egg yolk and then by a placenta nearly identical to that found in mammals. This maternal–fetal connection is common to all members of the requiem shark family while other families of sharks may be oviparous (egg laying) or ovoviviparous (bearing live young nourished from egg yolk, without a placental connection to the mother). We found that after the female delivers her pups she leaves the lagoon, not to return for courtship and mating until the following year. A litter is born every other year, so the actual birth rate averages only 5 pups per female per year, or 2.5 per adult shark, a tiny number compared with the millions of offspring that can be produced by a single bony fish or crustacean.

These life history characteristics show the lemon shark to be a very strongly K-selected species. The only characteristic of the "ideal" K-selected species that is lacking in the lemon shark is parental care of young. In most other aspects of its life history—long life, delayed maturity, internal fertilization, placental connection
between mother and embryo, production of small numbers of well-developed young—the lemon shark is much more similar to marine mammals than to bony fishes. The nourishment of the embryo through the placenta is of particular interest since this arrangement evolved in sharks millions of years before it did in mammals.

This K-selected life history is highly successful in a stable environment, but if conditions change radically, populations may collapse. Reproduction and growth rates are evolutionarily fixed at very low levels. Like animals with similar life history characteristics, such as Galápagos tortoises, great whales, and the green sea turtles of the Caribbean, hundreds of years after being nearly hunted to extinction by humans most populations have not recovered. In this century alone the Scottish-Norwegian stocks of spiny dogfish, which once supplied the fish and chips industry of England are gone, as are the basking sharks of Scotland, the porbeagles of the North Atlantic, the soupfin sharks of California, and the school sharks of Australia. Unlike cod or hake, these large and complex animals simply cannot withstand sustained commercial harvest.

Fishermen now slaughter sharks and their kind at the rate of 100 million a year, and some governments, including our own, actively promote expansion of shark fisheries. Sport fishermen in the United States catch more than the commercial fishery, at least 11,000 tons a year. Deep-water sharks, cold-water dwellers that are especially slow to grow and reproduce, are also being caught and processed for their oil, which is rich in squalene, highly sought after for pharmaceuticals and cosmetics. Recovery will be difficult even after the fishing stops.

In the Bimini lagoon, as in the ocean, sharks sit atop the food pyramid where they play the same role as wolves or lions do on land. Without such predators, prey populations become subject to starvation, epidemics of disease, and catastrophic fluctuations in numbers. Sharks drive the evolution of the lower species and so are responsible for much of the diversity of life in the sea.
A mature lemon shark at Dutchman's Bank in North Eleuthera, a deepwater reef in the eastern Bahamas, some 200 miles away from the Bimini lagoon. Mature sharks move out of the shallows, out onto the Bahama Banks, and eventually out into the Atlantic Ocean.
Scholars amid Squalor

"I would not live in the stink, grease, filth, ordure, lice, leprosy, syphilis, and rotten food of a Gilyak house for a whole winter, for all the income of the Museum."

by Stanley A. Freed, Ruth S. Freed, and Laila Williamson

The origin of the American Indians is "the biggest of the unsolved anthropological and ethical problems" and "alive with human and historic interest," stated the New York Times in a March 1897 editorial. The Times was responding to an announcement that the American Museum of Natural History was about to launch an ambitious, multidisciplinary investigation of the relationship between the peoples of northeastern Asia and northwestern North America. The venture, which would involve six years of fieldwork among the principal tribes of those regions, was funded by Museum president Morris K. Jesup (1830–1908), a rich banker with a taste for public service and the desire to have his name attached to important scientific discoveries. Franz Boas (1858–1942), assistant curator in the Museum's Department of Anthropology—later to become the most distinguished American anthropologist of his time—directed the project.

Boas wanted to address three questions: the origin of the early inhabitants of America, "the relationship between the American race and the Asiatic race, and the relationship between American culture and Asiatic culture." Although Jesup and the popular press were interested principally in the question of origin, Boas seemed little concerned with it, probably in the belief that the Asiatic origin of American Indians was obvious. "My plan is to make the relationship between the neighboring peoples the focus of the whole study," he wrote. "The physical affinity as well as the cultural connection will be systematically studied and both the living peoples and the archaeological remains will be included in the scope of the study."

The Jesup North Pacific Expedition did not answer these questions once and for all, but then neither has subsequent research. Natural History's recently concluded series "The First Americans" shows that the prehistoric relationship of Old and New World populations remains just as lively an issue as it was ninety years ago. The expedition remains a stimulating source of alternative points of view. Especially intriguing, given the difficulties of organizing research there today, are the contributions of the men and women who worked in Siberia. Field conditions were often dangerous and filled with hardship, yet the scientists involved managed to collect voluminous data and superb ethnographic artifacts. The monographs they issued are now considered classics, while many of the most interesting objects they brought back are on exhibition in the Gardner D. Stout Hall of Asian Peoples at the American Museum.

Three field teams explored Siberia, one in the south and two in the north. Berthold Laufer and Gerard Fowke formed the southern team, operating along the Amur River and on Sakhalin, while the two northern teams were headed by Waldemar Jochelson and Waldemar Bogoras. All three groups concentrated on tribes closest to the New World.

Berthold Laufer, born in Cologne in 1874, was an East Asian specialist recommended to the American Museum by the Academy of Sciences in Berlin. Educated in Germany, Laufer came to the United States in 1898 specifically to participate in the Jesup Expedition. He began with the Gilyak and Tungus (Evenki) in northeastern Sakhalin and was enthusiastic about the results, writing to Boas on September 18, 1898:

I have spent two months and a half on the east coast of Sachalin and succeeded in getting large vocabularies and a great deal of grammatical observations on three languages, Gilyak and two very distinct Tongus idioms, as well as a series of texts in the two latter ones, whereas there were not Gilyak interpreters able to speak Russian. I have taken about [a] hundred measurements and carried on investigations on the physical types and the culture of those tribes, particularly regarding their deco-
A camp of Reindeer Koryak. Turn-of-the-century scientists scrutinized these and other northeastern Asiatic peoples for linguistic, cultural, and biological resemblances to Native Americans.

narrative art, of that I have obtained interesting specimens together with good explanations, daily life, fishing and hunting, social organization, shamanism, medicine and so on; as to their healing methods, I got a very important collection of amulets protecting from diseases and representing the figures of various animals.

Laufer also used a phonograph to record songs. He wrote, "A young Gilyak woman who sang into the instrument said, 'It took me so long to learn this song, and this thing has learned it at once, without making any mistakes. There is surely a man or a spirit in this box which imitates me!' and at the same time she was crying and laughing with excitement."

After delaying his departure from northeastern Sakhalin for two and a half months while recovering from influenza and pneumonia contracted among the Gilyak, Laufer then headed south to investigate the Tungus and Ainu of central and southern Sakhalin. The journey by horseback, reindeer sled, and dog sled was difficult. Once he broke through the ice and would have drowned had not his guide witnessed the accident and saved him. None of the Ainu knew Russian, but the linguistically gifted Laufer was able to communicate in Japanese.

Laufer crossed to the mainland on March 21, 1899, and settled in Khabarovsky on the Amur River to study the Goldi (Nanai). By the end of May, navigation opened on the Amur, and Laufer descended the river visiting Goldi and Gilyak villages on the way. About this work, Laufer wrote to Boas:

'The trip during the summer on the lower Amoor was really more trying than the winter campaign on the island of Sakhalin. Nobody who has not been there can have an idea of the dreadful horrors one has to undergo on account of the insect-pest combined with heat and sixteen months' loany life in wilderness, which resulted into an extraordinary state of nervousness I never experienced before.

Laufer started for home in October but had to spend some time in Japan to arrange for the transshipment of collections and to recover from a bad infection. "I beg you...to grant me kind permission to prolong my stay till the 26th of January," he wrote to Boas from Yokohama in December. "The reason is, that I could not yet get rid of a bad eruption of skin I brought from Siberia, probably the result of my sojourn in the filthy huts of natives where I was in continual contact with vermin of all kinds."

Laufer's published work for the Jesup
Expedition was somewhat thin, consisting of a monograph on the art of the Amur tribes and an article in the American Anthropologist. Boas was quite pleased, however, with how Laufer conducted his research in the field. The same could not be said of Fowke's work. Boas regarded it as useless and declared in a letter to Laufer: “I am delighted to hear of your good success. It is too bad that Fowke did not know better how to make use of his time. I wish I had all the money that I spent on him for your use, but that cannot be helped now.”

Fowke was an itinerant, largely self-educated adventurer who was attracted to archeology and geology, partly because these fields enabled him to indulge his love for outdoor life and taste for exotic customs. Born in Kentucky in 1855, Fowke was orphaned before he was fifteen years old. Compelled to earn his own living, he worked as a bookkeeper, farmhand, and as a grammar-school teacher for about fifteen years. Along the way he took courses in mathematics and geology at Ohio State University, afterward alternating research in archeology and geology with his teaching. At about the age of thirty, he abandoned teaching to pursue his other interests, excavating and surveying numerous sites, principally in the eastern United States.

In 1898, Fowke worked for the North American branch of the Jesup Expedition, investigating stone cairns near Victoria, British Columbia. Boas then tapped Fowke for the Siberian expedition to pursue such archeological problems as Laufer designated and also to collect somatological data in conjunction with Laufer. Boas foresaw the necessity for Laufer and Fowke to work in separate areas and therefore placed “all practical arrangements for conducting archeological work... in your [Fowke's] hands, such as hire of men, exact location of places where it seems most advantageous to dig, etc.”

Upon his arrival with Laufer in Vladivostok in mid-June, Fowke was stunned at the high cost of living. “Everything costs outrageously,” he complained to Boas. “A ‘square meal’ $1.00 to $1.50... The con-

founded ‘tourists’ have led people to believe Americans have unlimited wealth, and prices have gone ‘kiting.’” This first letter set the tone of Fowke’s communications from Siberia. He complained constantly of expenses, working conditions, lack of (or too many) instructions, and Laufer. Laufer, for his part, took the responsibility of his leadership seriously and maintained a professional relationship with Fowke. On June 29, 1898, Laufer instructed Fowke to “start [from Khabarovsk] by steam-boat for Nikolajewsk this Friday, on the 1st of July, to carry on archeological investigations on the banks of the Amoor River.” Laufer’s suggestions went on for two pages, concluding with: “The preceding remarks are not intended to limit or confine your activity in any way, but they will merely serve for a gen-

Principal Tribes Studied by the Jesup Expedition, 1897-1902

Asian Exploration Routes
- Laufer
- Fowke
- Jochelson
- Bogoras
- Khabarovsk
- Nikolajewsk
- Vladivostok
- Korean Border
- Manchuria
- Mongolia
- Siberia
- Bering Sea
- Arctic Ocean

Legend:
0 500 miles

Joe LeMonnier
eral direction. You have unconstrained liberty and responsibility.”

Fowke accordingly went to Niko-
layevsk to make arrangements for his sur-
vey of the Amur. He bought a large open
boat—a “canoe” that, he later noted, was
unsuited for the work—picked up the rest
of his equipment, and hired an old, “half-
witted” German sailor as interpreter and
assistant. He took the steamer 330 miles
up the river to Verkhne-Tambovsk, hired
a Tungus as a general helper, and the
three men started out to explore the river
under conditions that Fowke described as
miserable:

Where timber grows it is like a tamarac
swamp in Michigan after a forest fire suc-
cceeded by a hurricane. Out of the timber,
the grass was from four to seven feet high
and thick as timothy in a meadow; where
gas did not grow, weeds flourished as in a
Mississippi bottom . . . Flies that bite like
mosquitoes . . . swarmed in millions: mos-
quitos were in clouds.

In terms of his charge, which was to
unearth the remains “of the ancient pre-
historic culture of this country,” Fowke
found nothing of any interest and wrote
long letters to Boas excusing “the dismal
fizzle of my part of the work.” A two-page
note and a relatively long journal article
are Fowke’s only publications concerning
his research on the Amur River; it is easy
to see why Boas was disappointed.

Oddly, it was Fowke, the resourceful,
self-educated orphan and experienced
outdoorsman, who was more adversely af-
fected by conditions in Siberia than
Lauffer, the university-educated son of
wealthy German parents. Fowke com-
plained constantly about conditions, while
Lauffer seemed to take inconveniences in
stride, mentioning them principally to ex-
plain a specific illness or delay. He de-
scribed his brush with death from drown-
ing almost in passing. Fowke paid Laufer
a perhaps unintended compliment when
he noted the horrible conditions under
which Lauffer was working: “I would not
live in the stink, grease, filth, ordure, lice,
leprosy, syphilis, and rotten food of a
Gilyak house for a whole winter, for all the
income of the Museum.”

Boas entrusted the fieldwork in north-
ern Siberia to scientists who, unlike
Lauffer and Fowke, were already veterans
of several years of Siberian research when
they joined the Jesup Expedition. Joch-
elson (in overall charge) and Bogoras were
Russian intellectuals and revolutionaries
who in their youth had been exiled to
Siberia. Lawrence Krader writes, in the
International Encyclopedia of the Social
Sciences, that “they belonged to Nar-
dnaya Volya (Peoples’ Will), a radical,
populist, and terrorist political party that
was connected in a general way to
narodnichestvo, the identification of the
intellectuals with the simple folk, from
whom, according to their doctrine, na-
tional strength arose.” Ethnography for
Jochelson and Bogoras represented the
intellectual path to populism.

Waldemar Jochelson, born in Vilna in
1855, fled Russia in 1875 to avoid arrest.
Settling in Berlin, he worked in factories
for two years; in the evenings he attended
free university lectures and courses ar-
 ranged by the Social Democratic party.
He wrote on Russian topics for the party’s
newspaper and also for the Russian revolu-
tionary journal Fpered (Forward).

In 1879, Jochelson went to Zurich to
study in the agricultural division of the
Polytechnikum. He was poor and ate only
one meal daily, provided by a Swiss patron
to Russian students on the condition that
his pensioners repay him when they found
positions. After a year of study, Jochelson
taught for four years in a school for Rus-
sian children and also gave private lessons.
He thus acquired funds to help support
antigovernment Russian publications.

In 1884, he tried to enter Russia under
an assumed name to continue his revolu-
tionary work but was recognized at the
border and arrested. After serving three years in solitary confinement, he was exiled for ten years to northeastern Siberia. He spent his time in ethnological and linguistic studies of the native tribes, writing articles for various Russian scientific societies. His articles led to an invitation to head the Yakut division of the 1895–97 Siberian Expedition, sponsored by the Russian Geographical Society.

Bogoras, too, was in frequent political trouble from an early age. Born in the Ukraine in 1865 and exiled to Siberia in his youth, he was permitted to undertake ethnographic research through the intervention of influential members of the Russian Imperial Academy of Sciences. So remarkable were his powers of observation that he, like Jochelson, was appointed to the Siberian Expedition to northeastern Siberia.

Jochelson and Bogoras came to New York in March 1900, before their departure for Siberia. On March 24, Jesup wrote a long letter to Jochelson officially giving him charge of the work of the expedition in northern Siberia, describing its purposes, and detailing its finances. Jochelson and Bogoras, whose wives were to accompany them, would each receive $100 per month. Although Jesup noted the contribution that would be made by the wives, whose “scientific work . . . must be considered as part of the results of the expedition,” they would receive no separate support or payment for their work. In April, Jochelson and Bogoras left from San Francisco for Vladivostok, where they arrived in May. There they were joined by their wives, who had made the trip on the Trans-Siberian Railroad.

Bogoras and his wife reached Mariinski Post at the mouth of the Anadyr River on June 13, 1900. Mariinski Post consisted of a detachment of Cossacks housed in barracks near a small village that was the southernmost settlement of the Maritime Chukchi. Bogoras hoped to travel onward to the tribe’s more northern villages, but owing to an epidemic of measles then raging in the Chukchi villages, he could not hire a crew for a boat. Instead, he spent the first four months of fieldwork at the mouth of the Anadyr, visiting the reindeer Chukhi who camped along the seashore during the summer. He collected artifacts, took photographs and anthropometric measurements, and also studied the Asiatic Eskimo language with the aid of two Eskimo families living with the Chukchi. He laconically described conditions that summer as “unfavorable” due to the measles epidemic, which in some places caused the death of about 30 per cent of the population.

Meanwhile, on August 16, 1900, Jochelson’s group arrived in Kushka, a small village at the mouth of the Gizhiga River. There he planned to study the Koryak, but none were to be found. During the previous winter, 179 persons out of a population of 500 had died of measles at the nearby village of Gizhiga, and the Reindeer Koryak, who usually wintered there, had moved far into the mountains to escape the epidemic. In order not to lose the rest of the summer, Jochelson decided to try to reach the villages of the Maritime Koryak on Penzhina Bay. Travel presented a problem, because adequate boats were not available and summer travel across the tundra by dog or reindeer team (the regular means of transportation in winter) was impossible. Jochelson therefore set out, on September 10, with horses.

The trail across boggy tundra and over hills was difficult, and the party averaged only ten miles a day. The horses became mired, and time was lost in extricating them. One day, the Jochelsons and an assistant became separated from their guides. After wandering for two days, without food or protection, they finally signaled for help with a smoky fire. Eventually they reached the villages of the Maritime Koryak, where they spent the first half of the winter of 1900–1901, living most of the time in native underground dwellings. Jochelson reported to Boas:

It is almost impossible to describe the squalor of these dwellings. The smoke, which fills the hut, makes the eyes smart. It is particularly dense in the upper part of the hut, so that work that has to be done in an upright position becomes almost impossible. Walls, ladder and household utensils are covered with a greasy soot, so that contact with them leaves shining black spots on hands and clothing. The dim light . . . is hardly sufficient for writing and reading. The odor of blubber and of refuse is almost intolerable; and the inmates, intoxicated with fly agaric, add to the discomfort of the situation. The natives are infested with lice. As long as we remained in these dwellings we could not escape these insects, which we dreaded more than any of the privations of our journey.

The second half of the winter was spent in the interior, among the Reindeer Koryak. The native tents were unsuitable for work, so the Jochelsons pitched their own tent, furnished with a small iron stove. On the trail, they slept on the snow, covered by fur blankets. “Several times we were exposed to snowstorms, and had to wait under our blankets, covered with snow, until the gale was over.”

On August 15, 1901, after a brief stay in Kushka, the Jochelsons traveled northwest, first by horseback and then by boat, to Verkhne-Kolymsk, to study the Yukaghir. Jochelson reported:

This journey was the most difficult one that it ever was my fate to undertake. Bogs, mountain torrents, rocky passes and thick forests combined to hinder our progress. . . . Heavy rain . . . caused the provisions to rot. Therefore we had to cut down our rations from the very beginning. After crossing the [mountain] passes . . . we reached the upper courses of the Korkodon River.
By this time our horses were exhausted, and it was necessary to take a long rest.

The temperature was dropping daily, and Jochelson knew that they would have to hurry if they were to reach Verkhne-Kolymsk before the river froze. Leaving the horses with their four packers, the Jochelsons and their guides prepared to float down the Korkodon River by raft to a Yukaghir camp where they could obtain a boat. Numerous rapids, rocky banks, and jams of driftwood made the river dangerous. Because the guides said that the descent could be made in two days, the Jochelsons reduced their own food allowance to a three-day supply, leaving the rest with the packers. Instead, the journey took nine days; for the last six days, each person received two cups of flour daily and a little tea without sugar. They spent four days among the Yukaghir of the Korkodon and then set out in a boat for Verkhne-Kolymsk. But the river froze while they were still forty miles away, and they had to walk for two days to reach the settlement. The trip from Kushka had taken them fifty-six days.

The Jochelsons worked among the Yukaghir until March and then made their way to Irkutsk, where they took the train to Saint Petersburg. From there, they returned to New York.

Among the materials they collected on the Koryak and Yukaghir were 3,000 ethnographic artifacts, measurements of 900 individuals, 41 casts of faces, 1,200 photographs, phonographic cylinders, skulls, archeological materials, and some zoological specimens. Jochelson published five massive monographs on the Koryak and Yukaghir, as well as a useful handbook, *Peoples of Asiatic Russia* (1928). Dina Brodsky Jochelson, later to take a degree in medicine, had handled all the anthropometric and medical work and most of the photography. She published two works based on her efforts.

With the Jochelsons engaged in their research, Bogoras had at first stayed in Mariinski Post, but soon he too was on the move, collecting scientific information over a wide territory, remaining no more than four weeks in any locality. In the meantime, his wife spent her time traveling between Mariinski Post and Markovo, accumulating the greater part of the collection for the American Museum.

Bogoras and his companions—a Cossack and a native guide—traveled almost exclusively by dog sled, each man driving his own team of twelve animals. They could move fast enough when weather and snow conditions were favorable, but could not carry heavy loads. They therefore relied on dried fish, reindeer meat, and seal and walrus blubber, commodities they could obtain locally.

The winter of 1900–1901 was very severe. After visiting the Kamchatka Koryak and the western Kamchadal, Bogoras was returning to Mariinski Post when he caught influenza. His illness became so alarming that his Cossack companion asked where to deliver his body and official papers in case he died en route. Bogoras survived, however, and arrived at Mariinski Post on March 26.

After a two-week stopover, he headed north to visit the Maritime Chukchi and the Asiatic Eskimo. By the end of June, he was back at Mariinski Post, in time to take the annual postal steamer to Vladivostok. He shipped the collections to New York and traveled by rail to Saint Petersburg, where illness delayed his planned departure for the United States. He arrived in New York in April 1902 and stayed there two years with the support of the American Museum.

In the fall of 1904, Bogoras was back in Saint Petersburg, where he settled in for a winter of writing. The Jochelsons were due to arrive in a few days, bringing Bogoras’s manuscripts and books from Zurich. “Then I shall be able to recommence my ethnographical work,” Bogoras wrote to Boas on October 23, 1904, “and immediately after shall send you the plan and estimates for the third part of the book. I hope also to write this winter the linguistic sketch we were talking about.”

The October letter is of interest in the light of the social upheaval that was to shake Russia the following year. Bogoras wrote, “The circumstances in Russia are evidently changing and we hope that the change will be for our common good.” In 1905, the unrest reached new heights as troops fired on peaceful demonstrators outside the czar’s palace, killing and wounding hundreds. The rest of the year was marked by a general strike, mutinies in the armed forces, seizure of lands by peasants, and armed uprisings, events that presaged the final overthrow of czarist rule a dozen years later.

To Boas, who was trying to extract completed manuscripts from Bogoras and
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Jochelson, the social disturbances in Russia were a threat to the timely fulfillment of the work. He kept gentle pressure on Bogoras in a carefully worded letter of February 15, 1905, in which he complained of having heard nothing from him for a long time. Bogoras replied from Saint Petersburg:

I am afraid that you are right and I feel myself guilty of much neglect to all dear friends in America. But you will understand that an epoch like this happens only once in many centuries for every state and nation and we feel ourselves torn away with the current even against our will.

My work on sociology of the Chukchee is going on but slowly and when I think what you could say about its progress, my heart falls down and that is the reason that I write to America more rarely than I did before. Still I am doing something, but little.

He concluded with the hope of doing better in the future and signed himself “Yours very truly and contritely.”

Boas was upset with Bogoras’s letter and immediately wrote to him rejecting the idea that exciting social events were a valid excuse for neglecting science:

The letter was disappointing in so far as you tell me very little about what you are doing. I fully appreciate the excitement of the present time, and the difficulty in concentrating yourself on scientific work; but if events like the present happen only once in a century, an investigation by Mr. Bogoras of the Chukchee happens only once in eternity, and I think you owe it to science to give us the results of your studies.

The last of Bogoras’s spring letters to Boas reported some progress with a manuscript, but Bogoras’s heart clearly was in politics: “You must believe us, that we here do not forget our good friends in America nor indeed anywhere. But the events of the time are so stirring. The blood is flowing, the best blood of the country, and no result is to be seen so far.” Bogoras apparently did not write to Boas again until late November, when he declared that his only present interest was the Russian situation. He pointed out that he was young (forty) and there would be plenty of time for science later. He expected that events would soon run their course and then “we shall have more leisure and quiet.”

The hoped for leisure and quiet were to be delayed, for on November 27, Bogoras was arrested in Moscow, possibly for participating in the Farmers’ Congress. Two days later, he dispatched a cablegram to Boas, “Am arrested, reasons unknown.” Boas wrote to Jochelson and tried to enlist the American Museum in an effort to free Bogoras. None of this activity was effective, but Bogoras was to spend only two weeks in prison before the Literary Artists’ Society of Moscow obtained his release by posting bail of 15,000 rubles.

After withdrawing for a time to Finland, Bogoras returned to Russia, where he spent the rest of his life engaged in scientific and literary work. After the revolution, he became director of the Institute of the Peoples of the North, an
Reindeer teams helped transport collections destined for the American Museum. Expedition members brought back artifacts, photographs, phonograph recordings, plaster casts of faces, and skeletal specimens.

agency concerned with education and developmental work among the northern tribes of Siberia. His work for the Jesup Expedition resulted in five monographs on the Chukchi; one on the Siberian Eskimo; and one on the Yukaghir, the Lamut (a Tungus subgroup), and the Russianized natives of eastern Siberia. He and his wife had collected ethnographic data, linguistic notes and 150 texts, 5,000 ethnographic artifacts, skeletal material, plaster casts of faces, archeological specimens, 95 phonographic records, and somatological measurements of 860 individuals. Modern anthropologists, much more specialized than those working at the close of the nineteenth century, would never collect such a diversity of data.

Based on the results of the Jesup Expedition, Boas discerned a close cultural affiliation between eastern Siberia and the region of southern Alaska and British Columbia, a cultural "break" between the east Siberian tribes and the Eskimo, and a "fundamental break" between the north-east Siberian tribes and the Tungus and Yakut to the west. "Comparisons of type, language and culture make it at once evident that the Northeast Siberian people are much more closely akin to the Americans than to other Asians," he wrote. The "Chukchee, Koryak, Kamchadal, and the Yukaghir must be classed with the American race rather than with the Asiatic race."

Boas believed that these Siberian tribes were an offshoot of the American race. According to his theory, Asians first migrated into the New World during a period of reduced glaciation. Advancing ice then separated the Asian and American populations for a long enough time to allow for physical differentiation; when the ice melted, there was a reverse migration of American Indians to Siberia, where they came into contact with other Asians moving northward with the retreat of ice.

Jochelson gave the name "Americanoids" to the people descended from these hypothetical reverse migrants. He was intrigued by Boas's ideas and attempted to support the close affiliation of the Americanoids and American Indians with evidence from mythology and folk-
lore. Jochelson made a detailed comparison of Koryak and American mythologies based on 122 episodes. The striking feature of the analysis is that seventy-five of the Koryak episodes had American Indian counterparts, but only eight could be identified in Old World mythology and only ten among the Eskimo. A reasonable interpretation of this situation is that the Koryak migrated to Siberia from the New World, for if they were originally residents of the Old World, their mythology ought to correspond more closely to that of the Old World.

Bogoras made the same point in his analysis of another 500 or so tales collected among the tribes of northeastern Siberia. In his article "Folklore of Northeastern Asia, As Compared with That of Northwestern America" (1902), he wrote:

The mythology and folklore of northeastern Asia are essentially different from the Uralo-Altaic mythology [of western and central Asia], and point to a group of conceptions and a mode of expression which have little relationship to those of the interior of Siberia; on the contrary, they possess affinities eastward along the shores of Bering sea to the northwestern part of America. The differences of both mythological cycles are so distinct and important that one may almost assume that, from an ethnographical point of view, the line dividing Asia and America lies far southwestward of Bering strait, extending from the lower part of Kolyma river to Gishiga bay. In the whole country east of this line, American ideas, or, more properly speaking, ideas characteristic of the North Pacific coast of America, prevail.

The Jesup Expedition established the close relationship of the populations of northwestern North America and northeastern Asia and strongly supported the view that the ancestors of the American Indians came from Asia. The effort of Boas, Jochelson, and Bogoras to go beyond these currently accepted points has not gained favor. The Americanoid theory never attracted attention and is today largely a historical curiosity. Yet with many aspects of New and Old World relationships currently hotly debated, the conclusions of Boas and his colleagues might still inspire reflection.

The classic ethnographies and the irreplaceable Museum collections, however, are the enduring monument of the Jesup North Pacific Expedition. This work can never be duplicated. For Boas and his colleagues, their contributions to the expedition went a long way toward establishing their scientific reputations. Jesup may not have been fully aware of his death in 1908, but he did succeed, as was his wish, in attaching his name to scientific work of major importance.
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17. Joseph Van Os Nature Tours, Inc. Travel and photography in the tiny kingdom of Nepal amidst the grandeur of the Himalayan Mountains. See page 84.

18. Newfoundland Tourism. Department of Development and Tourism sends brochures on request. Facts about the province; auto travel; accommodations; hunting; fishing; annual events; attractions; Newfoundland and Labrador history. Telephone 1-800-563-6353. See page 17.

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Houdini’s Watch and Other Baubles

Mrs. Abraham Lincoln’s pearls; Harry Houdini’s pocket watch, with its chain made of miniature gold handcuffs; and a canary diamond weighing 128.54 carats are among the jewels featured in a special exhibition, “Tiffany: 150 Years of Gems and Jewelry,” opening March 30 in Gallery 1 at the American Museum of Natural History.

The relationship between the internationally renowned jeweler and the Museum goes back to 1890 when Museum trustee J. P. Morgan purchased a collection of precious North American stones through Tiffany’s first gem expert, George F. Kunz. Kunz began collecting minerals from the Palisades Sill near his hometown of Hoboken, New Jersey, when he was only fourteen years old. He sold his first mineral collection to the University of Minnesota for $400 in 1876 and subsequently sold collections to the Field Museum of Natural History in Chicago and inventor Thomas Alva Edison. It was while serving as curator of the American Museum’s fossil exhibit at the Philadelphia Exposition of 1876 that he met C.L. Tiffany, who hired him soon afterward.

For Tiffany & Co., Kunz began traveling around the world in search of the finest quality gems. Among his contributions to the Museum’s permanent collection are 12 rubies, 166 sapphires, thousands of natural pearls, and a 10-pound garnet found during a sewer excavation at 35th Street and Broadway in New York City. Kunz served on the U.S. Geological Survey, as well as on the U.S. Fish Commission, when it studied native freshwater pearls.

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QANTAS

At the American Museum

Native American Month
March is Native American Month at the American Museum's Leonard People Center. Each weekend there will be performances of dance, music, and storytelling. Lecture-demonstrations will feature weaving, basketry, toolmaking, tepee construction, and herbal traditions of Native American cultures. These programs are free and open to the public. Seating is on a first-come, first-served basis. For a complete schedule of events call (212) 769-5168.

Wanted: Dinosaurs Dead or Alive
Songs, skits, and other activities will be used to present the latest dinosaur discoveries in a program recommended for children ages 4 to 10. The audience will play Dinosaur Bingo, make Tyrannosaurus masks, and help Sherlock Bones, Dinosaur Detective, solve a prehistoric mystery. Admission is $4 and open only to Museum members. Performances will take place in the Kaufmann Theater on Friday, March 18, at 6:30 P.M., and on Saturday and Sunday, March 19 and 20, at 11:00 A.M., 1:00 P.M., and 3:00 P.M. For more information call (212) 769-5600.

Planetarium Concert
The Paul Winter Consort returns to the Hayden Planetarium with concerts on Thursday, March 24, at 6:30 and 9:00.
spodumene was named kunzite in 1903. A Paloma Picasso necklace containing an unusually large kunzite specimen (396.30 carats) is part of the visiting collection. The exhibition will remain at the Museum until June 5. More than 100 gems and pieces of jewelry showing the evolution of jewelry design in America will be on display, as well as ornamental objects from the turn of the century, such as vases, an agate scent bottle, orchid brooches, and an enameled peacock necklace with rubies, emeralds, sapphires, and other stones. Most of the pieces are from private collections and many have never before been shown in public.

—Renee Bacher

A pendant made of an unusually large piece of kunzite hangs on a strand of South Sea pearls, above. The necklace was designed for Tiffany by Paloma Picasso. Left: Naturalistic enameled and jeweled gold orchids were first exhibited by Tiffany & Co. at the 1889 Paris Exhibition Universelle.

P.M. Featuring saxophonist Winter, cellist Eugene Friesen, and percussionist Glen Velez, the group will be accompanied by lasers and other special visual effects projected on the Sky Theater dome. Tickets are $16 for members and $20 for non-members. For more information call (212) 769-5600.

The African Elephant
Naturalist-filmmaker Simon Trevor’s popular chronicle of the African elephant’s life cycle will be shown in the Main Auditorium on Tuesday, March 15, at 7:30 p.m. The screening is free and open only to members. For more information call (212) 769-5600.
Our Brilliant Sister, Venus

by Thomas D. Nicholson

Venus seemed to burst into the sky last month to become a spectacular evening star, yet the planet has been in the evening sky since last August. Bright enough and more than far enough to the sun’s left to be seen, it was in the wrong, or southern, part of the ecliptic (the plane of the earth’s orbit around the sun) for easy viewing in the Northern Hemisphere during the latter part of 1987.

Venus was south of the equator during the winter, and its path across our sky was a low, flat one, leaving it barely above the southwestern horizon during evening twilight. Now, however, it is north of the equator and will move still farther north in April and May, when it will be at its brightest and at its farthest distance from the sun in the evening sky.

Of all the starlike objects we see in the nighttime sky, Venus easily wins the award for brightness. On the scale of brightness used in astronomy, the magnitude scale, Venus’s brilliance is now about −4.2 and will be −4.5 magnitude for most of April and May. That’s about sixteen times brighter than the brightest star we see in the sky (Sirius, at magnitude −1.5) and about 15,000 times brighter than the dimmest star we can see with the unaided eye. It will be bright enough in April and May to be seen in daylight with binoculars if you know where to look and if the sky is sufficiently clear. It may even be visible then without binoculars.

Venus repeats its pattern of visible visits to our evening sky often enough for it to be remembered, and its evening displays last for several months, long enough to provide ample viewing time. Its position in our sky is always tied closely to the sun’s because the planet revolves inside the earth’s orbit.

The period in which it repeats its cycle of configurations in our sky, nineteen months, displaces successive evening appearances to opposite seasons, but the extra month over the year and a half results in a longer-term cycle of about twelve years in which evening appearances are at their best.

Venus leaves the evening sky even more quickly than it appeared. Still splendid in mid-May this year, it will be gone by the first of June. Its next bright visit will take place in the autumn of 1989, but the planet will be very low in the southern branch of the ecliptic, setting early as an evening star.

Events in the calendar below are given in local time unless otherwise indicated.

March 1–2: The gibbous moon, up at sundown each night, plays leapfrog with Leo’s bright star Regulus. On the 1st (when the moon is at apogee, farthest from the earth), the moon is to Regulus’s right; on the 2d it is about the same distance to the star’s left. The bright planets close to each other in the west are Jupiter and Venus (the brighter of the two).

March 3: Full moon is at 11:01 A.M., EST, still in Leo when it rises tonight. A partial lunar eclipse (the first of four lunar eclipses this year) occurs over much of Eurasia and Africa and can also be seen in Alaska and Hawaii.

March 4: The rising moon (in Virgo) is located almost precisely at the autumnal equinox, about midway between Regulus (above it) and Spica (rising below) early in the evening.

March 6: The moon and Spica, less than half a diameter away, rise together just before 8:00 p.m. Venus and Jupiter, still close to each other in the west, change places as Venus moves to the east (left) of the more distant planet.

March 8: Mercury is at its greatest westerly elongation (distance from the sun), placing it in its best position as a morning star during this cycle of configurations. But spring morning elongations are not favorable for viewing.

March 10: Rising after midnight, the moon is near Antares, Scorpius’s bright star. Later, at about 10:00 A.M., EST, it occults the star over the southern part of the world. Saturn and Mars rise later in the morning, well below the moon.

March 11: Last-quarter moon occurs at 5:56 A.M., EST. It moves into Sagittarius shortly after rising in the morning sky.

March 11–12: As the crescent moon moves through Sagittarius, it passes four
plants within twenty-four hours: Uranus late on the 11th; Saturn, Neptune, and Mars on the 12th. Saturn and Mars rise to the moon’s left before dawn on the 12th. Saturn is the higher planet.

March 16: Mercury is in conjunction with the moon at midnight, EST, and the moon is at perigee (nearest the earth) later in the day.

March 17: The Irish do not need more cause for celebration today, but day and night will be of equal length—twelve hours each—and there is a new moon at 9:02 P.M., EST. The perigee of late yesterday will prime the spring tides.

March 21: Spring begins in the Northern Hemisphere at 5:39 A.M., EST, when the sun’s center arrives at the vernal equinox in the constellation Pisces. Jupiter is below the crescent moon tonight, probably setting too early to be seen, but Venus, to the moon’s left, is brilliant.

March 22–23: The moon is in Taurus, up in the southwest as night begins. The reddish star below it is the Bull’s Aldebaran, almost gone after its long winter visit in our evening sky.

March 24: First-quarter moon, at 11:41 P.M., EST, is in Gemini. The Twin’s two bright stars, Pollux and Castor, are to the moon’s left.

March 26: The early evening moon, slightly gibbous in shape, is virtually in line with Pollux and Castor, but moves slowly off line to the left during the night.

March 28: Apogee moon will be in Leo, which is just to the left of the moon after nightfall.

March 29: The bright star near the moon is Leo’s Regulus. The moon led the star across the sky last night, but follows it tonight, slowly increasing the distance between them.

March 31: The gibbous moon is up in the southeast at dusk, in Virgo, about midway between the constellation’s brightest star, Spica, and Regulus in Leo.

Editor’s Note: The Sky Map in the January issue shows the evening stars and constellations for this month and gives the dates and times for use.
Family Portraits

by John F. Eisenberg

I, like so many others, saw my first living elephant in a zoological park and soon after was introduced to the spectacle of fifty performing elephants in the three rings of a major circus. As a child one is not only overwhelmed by the elephant’s size but also amazed by its “trainability” and physical versatility. The trunk is a marvel of prehension and strength, a sensitive organ of tactile perception, as well as a versatile “limb” for this massive land mammal.

As an adult I encountered my first wild African elephants in Tsavo National Park, Kenya, in May 1966. At the time I was interested in developing a project to investigate the social behavior of elephants. I felt that to better understand the selective pressures that resulted in the formation of complex social organizations found in higher vertebrates, a study of a long-lived, social herbivore was essential. The Tsavo experience was profound in its impact when for the first time I counted 110 elephants in a single assemblage. Tsavo was followed by Amboseli, in Kenya, and then by Queen Elizabeth Park, in Uganda. I was hooked on wild elephants.

On my return to the States, ready to set up a project on African elephants, I was diverted by an opportunity to work with wild Asian elephants in Sri Lanka, a task I undertook with great enthusiasm. In the last twenty years, research on the Asian elephant has increased dramatically, ow-

ELEPHANT MEMORIES, by Cynthia Moss. William Morrow and Co., Inc., $18.95; 320 pp., illus.

ing in part to the availability of large groups of domestic work elephants that are used to establish important data on physiological norms, diseases, and sensory physiology.

Aside from a small domesticated group of elephants in Zaire, domestic herds are not accessible to researchers in Africa, who have to undertake the painstaking tasks of field experiments and long-term observations. The members of the re-

Elephants in Kenya’s Amboseli National Park

Photographs by Cynthia Moss
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NHV-2
Foraging elephants

search team must develop a sense of identity with the animal's habitat and an empathy with the annual cycle and seasonal productivity of the land. To study a population of animals demands a commitment and dedication uncommon in academic circles, where, for example, a three- to four-year study is the norm for a dissertation. And those having custodianship of long-term projects must also seek helping hands and sympathetic funding agencies.

In her book Elephant Memories, researcher Cynthia Moss gives an account of her thirteen-year study of elephants in Kenya. She has overcome all hardships, financial and otherwise, and I admire her perseverance. Elephant Memories is not a monograph on African elephant biology. It is Moss's very personal account of an elephant population inhabiting one of the more spectacular regions of the world, Amboseli National Park. Her accounts are laced with beautiful vignettes describing individual elephants as they are born, mature, and die. Moss offers a glimpse into a marvelously complex society where kinship is the thread connecting the lives of elephants.

Today the emerging consensus is that the two extant elephant species, Asian and African, are remarkably similar in behavior and physiology. This statement may seem trite, yet twenty-five years ago there was considerable academic controversy over such a simple matter as the sexual behavior of male elephants. For hundreds of years mature Asian elephant males had been known to experience an annual period of sexual readiness termed musth. At the time of musth they secrete a dark viscous substance from the temporal gland, situated between the eye and the opening to the ear, they urinate frequently, and are very irritable. The dark secretions are unknown from the females.

The situation with male African elephants was more difficult to ascertain. All agreed that olfactory signals were important in the social life of an elephant. Temporal gland secretions clearly had some role in communication. The data from Asian males were derived from captives, supplemented with observations in the wild. But very few mature male African elephants had been closely studied in captivity, let alone allowed to breed. A confounding fact concerned the capacity of both male and female African elephants to secrete a clear fluid from the temporal gland when excited. By recognizing individual males, Cynthia Moss (together with Joyce Poole) was able to establish beyond doubt that the temporal gland of African elephants secretes two substances: the clear, watery secretion common to both sexes, and the dark, viscous substance secreted by mature males when in their annual rutting period.
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But Moss’s account of the elephants of Amboseli does much more than clarify some arcane points concerning the reproductive biology of African elephants. It places in perspective a species that has had a long history of successful existence as a herbivore. The lives of humans and animals have an age-old, intertwined destiny, and elephants have figured prominently in human history. There is no doubt that elephants have been actively hunted for the last 50,000 years. Elephants have been domesticated and used as sources of traction and in military operations. They have been both venerated and ruthlessly exploited. We have only lately come to appreciate the lessons that long-lived, social animals can teach us. We too are potentially long-lived and exhibit generational overlap.

Both the African and Asian elephants have similar social organizations. The females are organized into groups of related individuals. Half-sisters and their progeny move either as a large group or subordinate along kin lines to forage independently, only to come together again at some time in the future. Individual recognition is manifest in all phases of interaction. Indeed, the author’s first task at the beginning of the study was to develop an accurate photographic record whereby she could identify individuals. The male elephants, when they reach maturity, depart from the matriarchy and either form loose groups or move in a solitary fashion. A male, after his twenty-fourth year tends to come into breeding condition on an annual basis. During this time he has a very high status and actively seeks out cow groups in order to mate with any female that happens to be in estrus.

Clearly, the older elephants know the topography of the region and can actively seek out preferred feeding areas during times of stress. Thus the kin unit passes down information concerning availability of water and food to the younger members. The author takes us through the drought when water and nutritious food are limited. At these times individually acquired information becomes critical to survival. As if drought were not enough to contend with, there are incidents of poaching. We read with amazement about how the older females cope with human intrusion. Moss makes a point of the flexibility in social structure. Kin groups can subdivide in a variety of combinations only to reassemble again. The overriding fact here is that they remember and recognize one another. Thus the matriarchy can be the core unit and yet exhibit astonishing adaptability to varying environmental circumstances.

I was deeply moved by Moss’s book. Upon reading this account one is forced to consider the parallel between human social organization and that displayed by elephants. Humans stand at the point of global domination as a species. We strive to maintain a decency in our conduct toward nations, cultures, and tribes. We attain the best in ourselves when we reach out to others of our species, guided by models formed during our upbringing as part of a kinship system. How far do we extend the feeling of kin and community? How much time is left for wildlife?

John F. Eisenberg is Ordway Professor of Ecosystem Conservation at the Florida State Museum, University of Florida, in Gainesville. He is also an associate editor of Behaviour, an international journal of ethology.

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Where Are the Apples of Yesteryear?

The good old days of multiple varieties are over

by Raymond Sokolov

The apple trees in the orchard that surrounds us here in the mid-Hudson Valley are bare now, but soon they will be blooming and our Eden will be given back to us. The trees are small, hybridized to be that way for efficient picking, and the fruit they produce is redder than it is delicious. But I am happy with the scene nonetheless. I would be happier if the trees were sprayed less, but this is "paradise now." Besides, the main alternative seems to be paradise lost: real estate development. So I am ready to fight to keep that orchard there, but you can't blame me for feeling wistful the other day when I came across an almost mint copy of S. A. Beach's two-volume record of real paradise, The Apples of New York (1905).

Apples is the greatest of a series of fruit handbooks published by the State of New York Department of Agriculture Experimental Station in Geneva, way upstate. These handsome yet businesslike tomes catalog, in practical terms grounded in serious horticultural science, all the varieties of fruit then current in the state. Beach describes some 700 named varieties of apples, many of which are displayed in tantalizingly beautiful color plates.

I use the word tantalizingly in its root sense, coming from the name of the ancient malefactor Tantalus, the first food martyr. As you will recall, this Lydian king stole ambrosia and nectar, the food and drink of the gods. The divine meal made him immortal; so his punishment was everlasting. The best description of it is Homer's. When Odysseus visits the underworld he sees Tantalus immersed in water up to his beard. But when the poor man bends his neck to drink, the "daemon makes it vanish, swallowed up, leaving behind black earth." There are also trees near Tantalus, "pouring fruit from their leafy crowns, pears and pomegranates and bright-ripened apples, sweet figs and flourishing olives. And each time the old man stood up to grab at them, the wind blew them away to the shadowy clouds."

So when I see the bright-ripened color plates of apples in Beach, I am properly tantalized, because most of the varieties depicted are gone with the wind. Take, for example, the Winter Banana. It sounds dazzling in Beach's description:

Fruit large, clear pale yellow with beautifully contrasting pinkish-red blush, attractive in appearance, characteristically aromatic, of good dessert quality, but too mild in flavor to excel for culinary uses. The tree is a pretty good grower, comes into bearing young, is almost an annual bearer and yields moderate to rather heavy crops. In ordinary storage the fruit is in season from mid-November to the first of April, but its safe commercial limit in this climate probably would not extend much beyond December. In cold storage it ranks as a keeper with Rhode Island Greening, but is not equal to Baldwin. It could perhaps be used to advantage commercially to follow the Maiden Blush and extend the season for fruit having the general appearance of that variety. As compared with Maiden Blush this is larger, neither as uniform nor as symmetrical. ... Its color is such that it shows bruises more readily than do red apples like Baldwin or Tompkins King. It is sufficiently promising to be worthy of further testing where an apple of this color is desired.

The Winter Banana originated on the farm of David Flory, near Adamsboro, Cass County, Indiana, about 1876. By 1890, Greening Brothers, the influential nursery at Monroe, Michigan, had introduced it to commerce. But the Winter Banana did not take off. By 1905, it had not gained much of a foothold in New York. And today, the apple is available only outside normal channels.

I've never tasted a Winter Banana. Perhaps it isn't worth the trouble. Undoubtedly many of the hundreds of abandoned apple varieties this country produced from the seventeenth century on were not worth growing. Beach deliberately included varieties he didn't like or approve, to provide a useful contrast to the fruit he deemed successful. Today, his successors at the Geneva station still have hundreds of varieties to compare and contrast, but the commercial market has become much more uniform. People who only buy apples in supermarkets are normally limited to three or four insipid varieties selected for their redness, size, and sweetness. Today's commercial standards are brutally narrow. A supermarket buyer would probably blanch at precisely those features of Beach's description of the Winter Banana that tantalize me.

To an apple marketer, the Winter Banana would doubtless seem to have only disadvantages, apart from its size. It is, for one thing, not red, and not even brightly colored, but pale yellow. Its flavor is delicate. It shows bruises and it is not regular in shape. That the apple comes into season late hardly recommends it to a system dependent on intense spurts of picking by migrant laborers in midfall but not later.
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½ cup sugar
½ teaspoon salt
Zest of 1 lemon, cut into large strips

1. Preheat oven to 350 degrees.
2. Peel the top third of the apples and core.
3. Put the sugar, salt, and lemon zest in a small pan with ½ cup water. Bring to a boil, stir, and remove from the heat.
4. Set the apples upright in a baking dish and pour the syrup over. Cover (use foil if there is no lid that fits) and bake for thirty minutes or until the apples are easily pierced with the tip of a knife. Spoon some of the syrup over the apples and sprinkle a little sugar over the top. You may put them under the broiler for two to three minutes to brown. Serve warm with cream.

Yield: Four servings
Darwinian nothing seems what the planting.” said, “recommended for commercial planting.”

Even in Beach’s day, then, the apple market exerted a Darwinian counter-pressure on the creative offspring of nurserymen and other hybridizers. Even in 1905, size and color seem to have been the key qualities for success. But documents provided by Beach show that the New York apple market had been in dynamic flux since as early as 1845, with a strong trend favoring a few varieties apparent from the start. By 1904, when Beach did a market survey with one C. P. Close, the triumph of the Baldwin was almost total. “Probably more Baldwin apples are put upon the market than all other kinds in the state put together,” Beach wrote. “Rhode Island Greening ranks next. . . . It is doubtless speaking within bounds to say that these two varieties supply at least two-thirds of the apples grown for market in New York. Next in general importance comes Northern Spy.”

Beach goes on to list almost thirty other important varieties, almost none of which have stood the test of time. Their names are quaint testimony to the fickleness of taste and the flexibility of fruit producers in meeting changing market demand. Nowhere on this colorful list of Esopus Spitzenburgs and Fameuses, of Blue Pearmain and Black Gilliflowers, do we see the great names of today. Delicious, Golden Delicious, and Cortland apples were too new to have established themselves. At the turn of the century, the Baldwin held sway. Fittingly, the frontispiece of Apples of New York shows a little girl in a white dress dwarfed by rows of majestic Baldwin trees.

New York still produces 5.7 million pounds of Baldwins, somewhere, somehow. I never see them. Probably they end up as cider or canned applesauce. Is this bad? Were Baldwins really that good? Were the good old days really that good? If so, what can the right-thinking, apple-hungry person do about it. Next month, we visit an articulate apple grower with some answers, many regrets and complaints, and a lot of unusual and, excuse the pun, delicious apples.

Raymond Sokolov is a writer whose special interests are the history and preparation of food.
The Natural Moment

A Drop to Drink

On the dunes of the Namib Desert on the southwest coast of Africa, the sand is so fine and fluid that beetles are said to dive and swim in it. There is little water—less than half an inch of rain falls each year—and on the lee side of the dunes the temperature often reaches 100°F. But ocean breezes stirred by a cool offshore current blow across the west faces of the dunes and keep temperatures there in the fifties or sixties. The meeting of warm and cold air masses above the dunes provides the only source of water for many creatures of the Namib: a fog that condenses on the sand and rocks. Survival depends upon being able to make use of the dew. Since moisture will only condense on a surface colder than the air, a coldblooded creature has an advantage. Some two hundred beetle species live on the dunes and feed on windblown detritus. Darkling beetles, like the *Onymacris* shown here, burrow into the sand at night and by morning have used up much of their body heat. They emerge slowly from the sand and make their way up to the crests of the sculpted slopes where, with hind legs on the crest and forelegs downslope, they raise their backs to the sea and bask in the incoming fog. Water droplets form and run down the beetle’s back to its mouth.—B.D.S.

Photographs by Anthony Bannister
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“What does it mean to be a marsupial?” To find out Andrew Cockburn and Anthony K. Lee (page 40) have spent a lot of time in the past fifteen years in the wet forests of eastern Australia. Their discoveries about the unusual life history of the shrewlike antechinus have shed light on some of the current issues in evolutionary ecology. Cockburn (right), a lecturer in zoology at the Australian National University in Canberra, A.T.C., uses the antechinus as a model to study natural and sexual selection in the wild. He is also at work on a long-term study of cooperative breeding in Australian birds. Lee (below), an associate professor of zoology at Monash University in Clayton, Victoria, has recently spent two months in Chile, extending his research to the marsupials of South America. He also plans to investigate leaf eating in marsupials such as the koala. An advocate of communicating science to the public, Lee has successfully adapted a biological sciences curriculum for use in Australian schools. His book The Koala: A Natural History, the first authoritative popular account of this mammal’s biology, is currently in press at New South Wales Press. Lee and Cockburn, who have coauthored a text, Evolutionary Ecology of Marsupials (New York: Cambridge University Press, 1985), also recommend The Australian Museum Complete Book of Australian Mammals, edited by Ronald Strahan (Sydney: Angus & Robertson Publishers, 1983), which contains numerous photographs of the continent’s diverse mammalian life.

Authors
Carthage! The very name conjures up images of Roman soldiers attacking lofty citadels, mighty ships sailing out to high adventure, and altars reeking with incense. Carthage's long and turbulent history as a superpower of the ancient world is the focus of an extraordinary book created by the American Museum of Natural History. *Carthage: A Mosaic of Ancient Tunisia* provides tantalizing glimpses of the glory that was Carthage and will be lavishly illustrated with photographs of artifacts, scenes of Tunisia's ancient ruins and present day landscapes. The authors—both American and Tunisian scholars—trace the history of Carthage from the arrival of legendary Princess Elissa/Queen Dido to find "Kart-Hadasht," the rise of Carthage as a sea power and military giant, and the destruction of Carthage by Rome to its reemergence as a commercial, trading and administrative center and a showplace of lavish villas, amphitheaters, baths and arenas. Lively text and spectacular illustrations bring the Carthage of antiquity to vivid life and ensure that, for the modern world, the story of Carthage will never be destroyed.

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Back in October of 1903, the *American Museum Journal* (as *Natural History* was then known) published a report by anthropologist Franz Boas on the Jesup Expedition, which had been organized to explore the relationship between the native peoples of northwestern North America and northeastern Asia. Drawing on the original correspondence in the archives of the American Museum, Stanley A. Freed, Ruth S. Freed, and Laila Williamson (page 60) offer a fresh look at the adventures of the expedition's Siberian contingent. Stanley A. Freed is a curator and Ruth S. Freed a research associate in the Museum's Department of Anthropology. Together they have done fieldwork on Washo, Mohave, and Navajo Indians, as well as in the village of Shanti Nagar in India. Their previous contributions to *Natural History* include “Origin of the Swastika” (January 1980, pp. 68–75). Finnish-born Laila Williamson, who has held various positions in the Department of Anthropology, was recently appointed scientific assistant. She holds a master's degree in anthropology for a comparative study of the ecological adaptations of Lapp and Chukchi reindeer herders. For further details, including a bibliography on the Jesup Expedition in Siberia, see the authors' contribution to the March 1988 issue of *American Anthropologist*, “Capitalist Philanthropy and Russian Revolutionaries: The Jesup North Pacific Expedition (1897–1902).” To the Ends of the Earth: Four Expeditions to the Arctic, the Congo, the Gobi, and Siberia, by John Perkins and the American Museum of Natural History (New York: Pantheon, 1981), includes a section on the Jesup Siberian venture. For the expedition's Northwest Coast activities, see “The American Museum and Dr. Boas,” in Captured Heritage, by Douglas Cole (Vancouver and Toronto: Douglas and McIntyre, 1985), and From the Land of the Totem Poles, by Aldona Jonaitis (New York and Seattle: American Museum of Natural History and University of Washington Press, 1988).

**Anthony Bannister**'s first date with his future wife was spent observing darkling beetles emerge from dunes in the Namib Desert (page 90). "It was lovely," he recalls, "sitting and watching them arise in the first faint light of the morning, crawl to the tops of the dunes, and wait as the fog rolled in." At the time, Bannister was working on a film for the BBC and his wife, Barbara, was a researcher studying the Namib Desert. They now live in South Africa and have three children. Bannister pursued photography as a hobby for many years before turning to it as a full-time occupation in 1974. Since then he has published ten books of wildlife photos, worked on films of African life, and developed a photo library of 150,000 pictures of African landscapes and wildlife. He took the pictures for this month's "Natural Moment" with a Nikon F2 fitted with a Nikor 200-mm macro lens.
Nuclear energy can help America find a way out of our dangerous dependence on foreign oil

Oil imports are increasing to dangerous levels. As the uncertainty in the Persian Gulf continues, the ability to rely on America's nuclear energy becomes more important than ever.

During the 1973 embargo, when we were importing 35% of our oil, prices skyrocketed as supply nose-dived. In the last 18 months, America's dependence on OPEC oil has increased dramatically. We're even more dependent now than we were in 1973. Oil imports have risen by over 25% while domestic oil production has fallen nearly 10%. Looking to the future, the situation is even worse.

In fact, if projections from the Department of Energy are correct, America may be importing as much as 50% of our oil by 1990. That would seriously jeopardize our national energy security.

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Electricity generated from America's 108 commercial nuclear electric plants saves us over 750,000 barrels of oil a day. Every day. Without nuclear energy's contribution, we would need to import even more foreign oil than we already do.

**Nuclear Energy for the Future**

America's use of electricity has been growing steadily to fuel our growing economy. At current growth rates, electricity demand will overtake supply in the early 1990s.

New nuclear electric plants should be in planning now. But they are not, despite the fact that most Americans believe that nuclear energy is important and that we will need more.

Too many financial, political, licensing, and regulatory uncertainties stand in the way of America's being able to fully utilize its nuclear energy resources. For example, it has taken some plants as long as 12 years to be completed. If nothing changes, that means that a plant begun now might not be operating before the year 2000.

As America's economy continues to grow, America must find ways to keep pace with its growing electricity needs. Nuclear energy can play a major role in meeting those needs as well as keeping us less dependent on foreign oil.

For a free booklet on energy independence, write to the U.S. Council for Energy Awareness, P.O. Box 66103, Dept. NS11, Washington, D.C. 20035. Please allow 2-3 weeks for delivery.
The last opportunity to acquire prints direct from John James Audubon's 150 year old original plates.

In the Ornithology Department of the American Museum of Natural History, there is one room which is only open by special arrangement.

It is called the Audubon Hall.

Among the display of Audubon’s watercolors, prints, drawings, guns and buckskins, nothing is more treasured than the artist’s copper plates that hang on the walls. To mark Audubon’s bicentennial, the Museum has decided to issue a new edition of 6 prints struck from these original double-elephant, folio-sized plates, last used in the early 19th century.

The first new edition since the 1830s.

These prints are therefore the only ones to have been struck from the original plates for over 150 years.

The 6 prints in the new edition are: the Wild Turkey; the Female Turkey and Young; the Snowy Owl; the Mallard Duck; the Canada Goose; and the Great White Heron.

Five years ago, the Museum began looking for a firm which retained the old 19th century skills of copper plate printing and coloring.

After a long search a firm was selected, Alecto Historical Editions of London.

An edition which is closer to Audubon’s intentions.

What may surprise many who appreciate Audubon’s work is that the artist, although delighted with the superb quality of the original engravings, was terribly disappointed with the coloring of many of the prints.

Indeed in one of Audubon’s letters recently uncovered, he writes to his printer: “These recent proofs are no more like my drawings than a chimney sweep is to your beautiful wife.”

The Museum and the printer therefore went back to Audubon’s original watercolors, notes, letters and even bird specimens to produce this edition.

The results have not only surpassed our expectations but have also met with outstanding recognition among curators, art historians and Audubon experts.

The well-known British naturalist David Attenborough wrote, “These new impressions of the 150-year-old plates could well be judged to be a finer representation of Audubon’s intentions than any produced during the artist’s lifetime.”

Living Bird Quarterly, a scholarly journal published by Cornell University, commented, “Many experts are judging the new edition to be superior to Havell’s original prints.”

Less than 30 sets remain.

Because of the extremely high value of the original plates and the possibility of stress to them, the museum is limiting the edition to just 125 sets worldwide.

The plates will then be retired for at least half a century.

The set of six prints costs $36,000. (19th century set from the same plate fetched over $145,000 at auction at Sotheby’s in 1983.)

Already most of the edition has been claimed, the majority going to important collections in North America including the Library of Congress, the National Library of Canada, the Boston Public Library and the McIlhenny Collection in Baton Rouge, Louisiana.

Some sets have also been purchased by major corporations, including Dow Jones, Morgan Stanley and the Southland Corporation. We are pleased to be able to offer the few remaining sets to individuals throughout the nation.

If you would like to receive a prospectus please write to the Museum at the address below or call Ms. Sherry Goodman at (212) 245 5753.

The prints will be available for viewing for the last time in major cities throughout the country during the next few weeks.

The plates will be coming back to the museum where they will remain untouched for at least 50 years.

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Cover: A common langur with its young, in Rauthambhor, India. A special report on the debate over whether animals influence the sex of their offspring begins on page 63. Photograph by Günther Ziesler; Peter Arnold, Inc.
Dinosaurs’ Speculative Social Life

While our understanding of dinosaurs has certainly evolved (“Evolving Views of Dinosaurs,” December 1987), portraits of social, cooperative, and herdlike behavior within populations of Triceratops, Styracosaurus, and Deinonychus may represent fanciful speculation. Dense aggregations of bones in sedimentary strata can be easily misinterpreted. Rather than being “snapshots” of local, contemporaneous individuals, such deposits contain specimens that lived at different times or in different places. The activities of predators and scavengers further complicate the analysis of “bone beds.” Going from dinosaur fossil data to dinosaur social behavior requires quite a leap.

J. Franco Cantilli
San Diego State University
San Diego, California

Tunisian Tigers

I am puzzled by the depiction of a tiger in one of the mosaics from Tunisia (“The Treasures of Ancient Tunisia,” December 1987). I thought there were no tigers in Africa, only in Asia. It surely looks like a tiger, bites like a tiger; it must be a tiger. How come?

Herbert Susmann
Palo Alto, California

According to David Soren, the curator of the American Museum’s current exhibition “Carthage: a Mosaic of Ancient Tunisia,” exotic animals were popular on Tunisian mosaics and were often based on copybook depictions of famous mosaics from Greek Asia Minor.

Hollow Trees Are Born Not Made

“This Land,” Robert Mohlenbrock’s column, is my favorite “first stop” when I receive Natural History each month. But in the January 1988 issue I saw an error I wanted to bring to your attention. The water tupelo tree is indeed usually hollow, particularly when growing in swamps, but these trees are born hollow and do not later “become hollowed out near their base” as your columnist stated.

Having grown up in southern Illinois near the numerous cypress swamps, and later having returned as a botanist, I wondered about the cause of the hollowness. The answer ultimately came when a friend and I went on a seed-collecting expedition in Karnak, Illinois. The seeds of the water tupelo were not found anywhere except on floating logs, where they germinate with great regularity. Their roots travel laterally across the top of a log and then descend to the bottom of the pond in which the log is floating. The log eventually decays, leaving the tupelo standing on a wide-buttressed base that surrounds the space once occupied by the log. An inspection of the tupelo’s cavity shows bark inside as well as out, and no signs of decay are evident.

Interestingly, nurse logs have long been understood and easily observed in the Pacific Northwest (see “This Land,” March 1986), but little, if anything, has been written about them in regard to the water tupelo.

John J. Sabuco
Flossmoor, Illinois

A water tupelo surrounds the swamp maple it sprouted on. Both trees are healthy.
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BERMUDA IS YOU. ISN'T IT?
Eyes on the Eskimo Curlew

On May 24, 1987, Billy Jacobson, an Inuit guide and trapper in Canada’s Northwest Territories for thirtyfive years, glimpsed something special among the thousands of shorebirds nesting on the open tundra. He stopped his snowmobile and for about a quarter of an hour he studied the bird, careful to make a positive identification. It was an Eskimo curlew, a shorebird so rare that, on and off for fifty years, many ornithologists have believed it to be extinct. Sporadic sightings periodically regenerate hope for the species’ survival. When Jacobson restarted his Skidoo, a second bird flushed and flew off with the first. Although no nest was found, the presence of the birds together on the traditional breeding ground of their species suggests that they may have been mates. Every summer since 1972, Tom Barry of the Canadian Wildlife Service, with Jacobson as his guide, has systematically searched for Eskimo curlew nests on the grassy tundra drained by the Anderson River and its tributaries. This is where Roderick MacFarlane found the last Eskimo curlew nest, 122 years ago.

In August 1980, when Paul A. Johnsgard wrote on the Eskimo curlew for *Natural History* ("Where Have All the Curlews Gone?") the spotty sightings of the bird had fallen off. He reported that although there had been at least fourteen sightings of the bird between 1932 and 1976, ornithologists were once again starting to doubt that the species still existed.

The daunting migration route of Eskimo curlews was perhaps linked to the decline of the great flocks that once crossed two continents. After breeding in the Arctic, Eskimo curlews flew southeast across Canada, stopping at Labrador and other eastern edges of Canada, where they batten on snails and the abundant crowberries (also known as curlewberr). Continuing over open water, they were occasionally swept in great numbers onto the shores of Cape Cod and Nantucket by storms. The next and most demanding leg of their journey took them across the Caribbean to Venezuela and the Guianas. From there they headed to unknown wintering grounds in the Argentinian pampas. On the return trip, they made their way to Central America, then to Texas, and up through the Plains states, where they gorged on grasshoppers, reaching the Canadian tundra in late May. In 1929, Arthur Cleveland Bent, believing the birds to be extinct, dismissed habitat destruction and storms or other natural catastrophes as roots of their disappearance: "There was only one cause, slaughter by human beings . . . . The gentle birds ran the gauntlet all along the line."

Also known as doughbirds—their plump breasts sometimes split on ground impact when they were shot down—the succulent Eskimo curlews were a popular, easily obtained game bird. They were so abundant that a thick flock might stretch for more than half a mile in flight or cover fifty acres on the ground. The density of their flocks and the birds’ fatal habit of circling back through the line of fire, calling to fallen flock mates, quickened their decline. By the 1890s the flocks were gone, and the Eskimo curlew has never recovered.

Whether this bird can ever make a comeback is unknown, but two likely identifications, besides Jacobson’s, were made in 1987: one in April in Nebraska; the other in early September in Maine. With greater public awareness, protection, and luck, could the extremely endangered Eskimo curlew prove to be a phoenix?
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Down in the Dumps

Where abandoned domestic dogs must turn wild to survive

by Thomas J. Daniels

TP, a German shepherd mixed-breed pup, was sitting alone one morning be-
neath a piñon pine, some thirty yards from the smoldering trash heaps of the dump
outside Navajo, New Mexico. Snow had fallen overnight, but did little to hide the
formidable piles of refuse that dotted the land. The day promised to be sunny and
warm for mid-January, and the snow, even at an altitude of 6,300 feet, would soon
disappear. I thought it unusual that TP was not foraging amid the garbage or
playing with her siblings, for early morn-
ing was typically a time of much activity
for both pups and adults. I scanned the
hillside with my binoculars, and the rea-
son for TP’s solitude became clear: scat-
tered about the ground were the bodies of
her mother and littermates; they, along
with the pups of another litter, had been
shot and killed the night before. The ma-
cabre scene impressed upon me the dan-
gers an abandoned dog like TP faces in
making the transition to life in the wild.

People may have domesticated the dog
15,000 years ago, but dog behavior out-
side the laboratory or living room re-
mains poorly understood. My work on the Na-
voajo Reservation, which extends from
northeastern Arizona into New Mexico
and Utah, was part of a larger study in
which I investigated how domestic dogs
became wild. (Feral dogs may look like
pet dogs, but they exist largely independ-
ent of humans.) In Ciudad Juárez, a
large Mexican border city just across the
Rio Grande from El Paso, Texas, and in
Newark, New Jersey, I observed the be-

davior and social organization of free-
ranging urban dogs. I was interested in
comparing these dogs with dogs on the
Navajo Reservation that became feral
without ever having been in close touch
with people.

The 25,000-square-mile reservation
where I studied the dogs is the largest in
the United States; nearly 150,000 Navajo
live there, in 110 communities called
chapters. Each chapter may have as few
as a couple of hundred residents or more
than 5,000, depending on the availability
of jobs. Within chapters, concentrated
blocks of housing result in dense human
and dog populations that rival or exceed
those of any urban center in the United
States. I estimated, for example, that 228
free-ranging dogs inhabited a fifth of a
square mile housing area called Window
Rock. (Free-ranging dogs may be aban-
donated animals or pets allowed to run
loose.) Some 600 dog bites per 10,000
residents are reported here each year,
equivalent to bite figures in cities like Bal-
timore, Maryland, and Saint Louis, Mis-
souri. Yet the reservation is rural in most
other respects.

The Navajo are sheepherders by tradi-
tion, and virtually every family retains
grazing rights to some parcel of the semi-

arid land. Beyond community borders,
many Navajo live in isolated homesties
that serve mainly as sheep camps. Closer
to the communities, however, just one to
two miles beyond the houses, are the open,
windblown garbage dumps that are criti-
cally important to the lives of the feral
dogs. Marring the stark beauty of the
land, these eyecores are the gateway to a
feral existence.

My goal at the Navajo dump was to
chart the abandoned dogs’ metamorphosis
into wild canids. By surveying the number
of dogs that came to the dump each day, I
came to know the individual dogs in the
community and could identify newcom-
ers. This was how I spotted TP and her
mother and siblings some ten days before
the massacre. She was four to five weeks
old, the age at which domestic dogs are
just beginning the four- to five-week wean-
ing process. TP and her sibs, however,
were busy scouting for anything edible
among the trash piles.

As I approached TP, two female adults
sprang farther into the dump where they
watched my activities from a hillside van-
tage point. One had her own litter of ten
seven- to eight-week-old pups foraging in
the dump. When I was twenty feet away,
the older pups retreated, joining their

Photographs by Thomas J. Daniels

Feral pups on a hillside near Navajo, New Mexico
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NEWFOUNDLAND AND LABRADOR
mother amid a chorus of growls and threats. TP and her siblings, still too young to have developed a fear of the unfamiliar, ignored me and continued to forage. This naiveté fades at about seven weeks of age when pups leave the den where they were born and go off to forage on their own.

Fear appears to start the feralization process. Feral dogs avoid people. Neither of these litters was yet completely wild and this probably led to their easy slaughter. TP’s mother may have been a pet and, accustomed to humans, may not have fled her assailant. Only the other female survived. I saw her later coming down off a plateau that rose some 200 feet above the dump. She began to forage while the dump was quiet, stopping every thirty feet or so to sniff the air and look around before proceeding. TP, who had been ambling between the piles of refuse and a rest site beneath a tree, moved quickly toward the returning female, stood in a submissive posture, and made several attempts to suckle, but was shunned. Although both adult females and their litters had lived together at the dump for ten days before the massacre, the visiting female now gave no indication that she recognized TP and retreated from the pup’s every approach.

On the reservation, abandoned dogs older than about three months avoid other dogs; at the sight or sound of another dog entering the dump they often lower their heads behind an object or remain quite still. Pups like TP, however, that have been separated from their mothers and suffer what might be termed separation anxiety, often invite other dogs to play or greet them with high-pitched cries and attempts to lick their mouths.

TP’s failure to elicit care from the unrelated female did not surprise me. Because parental care means expending a great deal of time and energy, the providers are highly selective. In mammals, the female parent incurs the greatest expense and so expects the one being cared for to meet certain requirements. One obvious, generally easy-to-meet, requirement is that the receiver be related to the provider. To this end, some manner of discerning kin from non-kin has evolved in social species.

Hormonal mechanisms and the physiological condition of the mother also influence care giving. For instance, while females may lactate for up to ten weeks after the birth of pups, environmental or nutritional stress can bring nursing, along with other parental behavior, to a sudden stop. Nursing females rarely adopt unrelated young in the wild, although females in communal dens have been known to nurse the pups of other females. But this female was not TP’s mother and had probably stopped lactating. TP was destined to remain alone that night when the adult female finished feeding and trotted out of the dump.

Dogs social organizations, even on a small, very localized scale, are quite variable. In late fall and early winter I saw packs of single females and their pups, adult females living alone, and also a pair of females living together just beyond community boundaries. Feral dog populations are shaped, in part, by the local attitudes toward domestic dogs. For instance, Navajo dog owners believe that males are better than females for guarding sheep or herding, so females are most often abandoned, especially if they are pregnant. (There is no reservation-wide animal control program, and dogs are rarely spayed or neutered.) While domesticated dogs can breed year-round, they most often have litters in the spring and fall and abandonment increases at these times.

A female member of a large pack may leave the pack to give birth and raise her young in relative seclusion. Twice I saw pregnant females move about a quarter mile away and maintain occasional con-
tact with pack members. Among other canids that form packs, such as the wolf and the African wild dog, subordinate females often leave the pack to give birth. What prompts a female to leave, and whether or not she returns, is not known.

To see if TP would be integrated into another group, I decided to follow a pack, with as many as seven adults, that lived in a canyon near the dump. Two adult females, two adult males (one was at least seven years old), and ten pups that were three to four weeks old made up the main group. The adults were easily identified by their coat patterns, but since the pups’ fur was still changing, I attached an ear tag to each pup so that I could identify it from a distance. Since I also succeeded in radio collaring one of the females, a large German shepherd mixed-breed, I could locate the dogs at any time.

I knew the adults visited the dump at night and that they would almost certainly run into TP. Unlike the female abandoned with TP’s mother, both pack females were still lactating, so I assumed the pups were from two litters that were being reared communally. I also thought TP might therefore be integrated into the group.

During the next three weeks TP increased her home range to include all of the dump and occasionally ventured near the canyon mouth, a short distance from the resident pack’s primary rest site. She still spent most of her time close to her only reliable source of food, the continuously growing heaps of trash. Life in the wild requires many changes, especially in those animals that have been socialized to humans. One reason the dog, although technically a carnivore, is so successful in adapting to new areas is that it is not fussy about its diet. Dogs on the reservation will

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eat anything—from rodents, insects, and carrion to vegetables, cardboard, and sheep wool—depending on how hungry they are and what is available.

While the reservation dumps may provide supplemental food to potentially feral animals, they do not provide enough to maintain even a small population of dogs for very long. Competition may also limit the amount of time any one dog can forage. As they approach parts of the dump where food is concentrated, the incoming groups of dogs often bark, which warns the foragers present that competitors are arriving. Consequently, the early arrivals, which are typically outnumbered by the incoming group, move off. Also, the steady flow of people in and out of the dump often frightens off foraging dogs.

For an abandoned animal, the dumps provide a measure of insurance. They can buffer the dog from the forces of natural selection for a while, allowing it time to adapt to its new surroundings. In mid-February, nearly a month after the massacre, and the morning following the first heavy snowfall, TP sat beneath a tree surveying the dump and her all-but-buried food supply. A short time later the lone adult female survivor of the shooting again meandered in view. TP approached, greeted her and begged for food by licking the female’s mouth. Again she was rebuffed. After assiduously following the adult to take advantage of the older dog’s foraging skills, TP finally retreated a short distance and began feeding on the still frozen remains of her siblings.

The solitary period of transition had been hard on her, and her growth seemed markedly stunted compared with that of the canyon pups. TP’s mother had been a big dog. Although about two weeks younger than TP, the canyon pups were nearly as large. They had left the security of the hillside cave where they were born and now wandered about on the sandy floor of the canyon during ever-longer periods of exploration. But most of their time was still spent either playing or resting. The adults now spent about half the day away from the pups. The females played with the pups, responded to their cries, and brought back scraps from the dump to the den site. The males’ contribution to the care of the pups was limited to lying unseen, resting but alert, among the hillside trees, barking challenges at intruders. Territoriality protects resources and keeps the resident group closed to outsiders. But when the group moves to a neutral area, such as the dump, to forage, the possibility for positive social encounters increases. An abandoned, solitary pup and a lactating female might meet and stay together. This, in fact, was to be TP’s fate.

TP’s actual initiation into the canyon pack was rather rapid. Like most abandoned dogs, she at first remained right where she was left. The presence of the canyon pack may have inspired her to begin moving about, first exploring the dump and then moving to piles of trash along its outer edges where the canyon dogs ranged. One day in late February, after I had spent weeks watching her attempt to associate with the dogs foraging in the dump, TP moved down into the canyon with them. After that the only notable difference between her and the rest of the group was in their reactions to people. At my slow approach up the canyon one morning, the adults, as usual, fled from sight, the canyon pups moved off and sat in the shadows fifty feet away, and TP sat twenty feet away, watching nonchalantly as I went about my business. Repeated exposure to people at the dump, even in the absence of extended physical contact, had resulted in some degree of socialization to humans.

Over the next months TP became more integrated into the new pack and her new life. Soon, I rarely saw her apart from the group. Older, and consequently better coordinated, she at first dominated the canyon pups. Within weeks, though, her adopted siblings were as large as she was and less likely to relinquish a tasty morsel or let her more rambunctious style of play intimidate them. Occasionally, she led one or two of her adopted siblings into the dump during the day for some brief foraging. Without reinforcement, her trust of humans waned and her increased wariness became a useful survival skill.

TP ultimately established herself near the top of the tenuous hierarchy that characterizes pup life. As the pups grew, the pack ranged over a much wider area, and visited the dump less frequently. Instead, they roamed areas in search of the remains of animals that may have died during the winter or, in the case of sheep, during the spring lambing. Dog scats I collected at the pack’s homestite contained mouse fur and bones. Birds may also be a part of the feral dog’s diet.

With the approach of summer, the canyon pack began moving farther up into the surrounding mountains and I rarely saw TP. How long would she survive now that the difficult transition to a wild existence had been made? Most abandoned dogs do not survive long. Some try to resume a life with humans by moving into the nearby community, going from house to house attempting to find food and shelter. A few will be adopted as pets. Others remain at the dump and ultimately become the victims of parasites, disease, or human violence. The successful few appear to behave much like other nondomestic canids living in similar circumstances. Domestication and the making of man’s best friend have not abolished those behaviors essential to survival in the wild. Feralization is a race to behave appropriately under a completely new set of rules. TP’s successful transformation to a wild domestic dog beat the odds.

Thomas J. Daniels is an assistant professor of biology at Marymount College in Tarrytown, New York.
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Despite wicked curves, detours, and delays, the rocky road toward scientific truth is a great trip

by Stephen Jay Gould

Discovery, like its soul mate love, is a many-splendored thing. Stumbling serendipity surrounds some great finds—like Archaeopteryx, the first bird, unearthed by a quarryman at Solnhofen, or the Burgess Shale, discovered when Mrs. Walcott’s horse tripped on a crucial block of stone. Others are the product of dogged purpose. Consider Eugen Dubois who, as a Dutch army surgeon, posted himself to Indonesia because he felt sure that human ancestors must have inhabited East Asia. There he found, in 1893, the first human fossils of a species older than our own—the Trinil femur and skull cap of Homo erectus (“Java man” of the old texts).

The most beautiful specimens in my office, which I happily share with about 50,000 fossil arthropods, rest in the last cabinet of the farthest corner. They are head shields of Eurypterus fischeri, a large, extinct freshwater arthropod related to horseshoe crabs. These exquisite fossils are preserved as brown films of chitin, set off like an old rotogravure against a surrounding sediment so fine in grain that the background becomes a uniform sheet of gray. They were collected in Estonia by William Patten, a professor of biology at Dartmouth.

When I first came to Harvard twenty years ago, I made a reconnaissance of all our 15,000 drawers of fossils—an adventure surely surpassing anything ever achieved by the smallest boy in the largest candy store. I found some of the great specimens of my profession—Agassiz’s echinoderms, Raymond’s collection from the Burgess Shale. But I got a particular thrill from Patten’s eurypterids because I knew exactly why he had gathered them. Patten, like Dubois, had collected with a singular purpose. I had read his 1912 book—The Evolution of the Vertebrates.
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and Their Kin—one of the curiosities of my profession. Patten's book represents the last serious defense of the classic, though incorrect, theory for vertebrate origins—the attempt to link the two great phyla of complex animals by arguing that vertebrates arose from arthropods.

Patten identified eurypterids as the arthropod ancestors of vertebrates—hence our collection. But Patten was even more interested in a group that occurred with the eurypterids in some localities—jawless fishes of the genus Cephalaspis (meaning head shield). We now recognize these jawless fishes (class Agnatha) as the oldest vertebrates and precursors of all later forms, ourselves included. The Agnatha survive today as a small remnant of naked eel-shaped forms—the lampreys (genus Petromyzon) and the hagfishes (genus Myxine). But the original armored agnathans, popularly called ostracoderms (shell skinned), dominated vertebrate life for its first hundred million years and included a large array of diverse forms. Patten's fascination with ostracoderms arose from his misinterpretation of their anatomy. Patten viewed Cephalaspis and its relatives as intermediary forms between arthropods and true fishes.

We usually tell the history of a profession as a pageant of changing ideas and their proponents. But we can also render a different and equally interesting account from the standpoint of objects studied. One could provide a fascinating history of astronomy from the moon's point of view, and genetics receives a different, multifaceted account through the eyes of a fruit fly. Cephalaspis may be our best standard bearer for evolution.

The history of ideas about Cephalaspis—from its original misinterpretation as the head of a trilobite in the early 1800s to its present status as the archetypal ostracoderm for all aficionados of the group—provides more than a synopsis of evolutionary thinking. It also illustrates, in an unusually forceful way, the fundamental process of scientific discovery itself.

Popular misunderstanding of science and its history centers upon the vexatious notion of scientific progress—a concept embraced by all practitioners and boosters, but assailed, or at least mistrusted, by those suspicious of science and its power to improve our lives. The enemy of resolution, here as nearly always, is that old devil Dichotomy. We take a subtle and interesting issue, with a real resolution embracing aspects of all basic positions, and we divide ourselves into two holy armies, each with a brightly colored cardboard mythology as its flag of struggle.
The cardboard banner of scientific boosterism is an extreme form of realism, the notion that science progresses because it discovers more and more about an objective, material reality out there in the universe. The extreme version holds that science is an utterly objective enterprise (and therefore superior to other human activities), that scientists read reality directly by invoking the scientific method to free their minds of cultural superstition, and that the history of science is a march toward Truth, mediated by increasing knowledge of the external world.

The cardboard banner of the opposition is an equally extreme form of relativism, the idea that truth has no objective meaning and can only be assessed by the variable standards of different communities and cultures. The extreme version holds that scientific consensus is no different from any other arbitrary set of social conventions, say the rules for Chinese handball set by my old crowd on 63d Avenue. Science is ideology, and scientific "progress" is no improving map of external reality, but only a derivative expression of cultural change.

These positions are so sharply defined that they can only elicit howls of disbelief from the opposition. How can relativists deny that science discovers external truth, say the realists. Cro-Magnon people could draw a horse as beautifully as any artist now alive, but they could not resolve the structure of DNA or photograph the moons of Uranus. How, reply the relativists, can anyone deny the social character of science when Darwin needed Adam Smith more than Galápagos tortoises, and when Linnaeus matched his taxonomy to prevailing views of divine order.

These extreme positions, of course, are embraced by very few thinkers. They are caricatures constructed by the opposition to enhance the rhetorical advantages of dichotomy. They are not really held by anyone, but partisans think that their opponents are this foolish, thus fanning the zealousness of their own advocacy. The possibility for consensus drowns in a sea of charges.

The central claim of each side is correct, and no inconsistency attends the marriage once we drop the peripheral extremities of each attitude. Science is, and must be, culturally embedded; what else could the product of human passion be? Science is also progressive because it discovers and masters more and more (yet ever so little in toto) of a complex external reality. Culture is not the enemy of objectivity but a matrix that can either aid or retard advancing knowledge. Science is not a linear march to truth but a tortuous road with blind alleys and a rubbernecking delay every mile or two. Our road map is not objective reality but the patterns of human thoughts and theories.

My position, as a variety of apple pie, is easy to state. It is also empty and tendentious as an abstract generality. It can only permeate our understanding by example. Cephalaspis provides one of the best demonstrations I know because this fish played a central role in three important and sequential views of nature's order. Each view embodied its cultural context, but each also provided a framework for new and genuine objective knowledge about Cephalaspis. The new knowledge then helped to establish a revised view of natural order. Speaking of rhetoric in the best American tradition, culture and knowledge are rather like liberty and union—one and forever, now and inseparable.

Cephalaspis, as its name implies, enclosed its head in a thick, bony shield. Much thinner scales covered everything behind, from front fins to tail. Since the scales usually disarticulate at death and are rarely preserved at all, most fossils of Cephalaspis include only the head shield. By itself, the shield is a peculiar and decidedly unfishlike object. It looks much like the head end of many trilobites (fossil ar-
thropods), and was so classified until Louis Agassiz established the true affinity of *Cephalaspis* in his great monograph *Les poissons fossiles* (Fossil Fishes), published in five large volumes between 1833 and 1843.

Agassiz confessed his wonder and puzzlement in his first paragraph on *Cephalaspis*:

These are the most curious animals that I have ever observed; their features are so extraordinary that I had to make the most careful and scrupulous examination... in order to convince myself that these mysterious creatures are really fish.

Agassiz reached the correct solution to his puzzle because his collection included some unusually well-preserved specimens, with the characteristic head shield indubitably attached to an undeniably fishy posterior. Yet while Agassiz began the modern history of *Cephalaspis* by placing this genus properly among the vertebrates, he could never resolve its relationship with other fishes for lack of crucial evidence. Agassiz particularly bewailed his failure to find any specimen exposing the lower surface of the head shield, where, he surmised (correctly), the mouth would be located. Thus Agassiz could never recognize the chief character of jawlessness in *Cephalaspis*, and could not identify the ostracoderms as structural precursors of all later vertebrates (jaws evolved from bones that supported gill arches behind the mouth of these jawless fishes). *Cephalaspis*, to Agassiz, remained an unplaceable oddball among fishes.

Although Agassiz could not fully resolve the status of *Cephalaspis*, he used this most peculiar of fishes as a linchpin for his theory of biological order. *Les poissons fossiles* is no simple list of old fishes; it is, perhaps most of all, a closely reasoned brief for Agassiz’s creationist world view—a theory that embodied the cultural consensus of 1830, but that Agassiz maintained doggedly to his death in 1873, long after its scientific demise in Darwin’s favor.

Agassiz rooted his version of creationism in a complex analogy with his favorite subject, comparative embryology. Agassiz viewed embryonic growth as a tale of differentiation—more complex and specialized forms develop from simpler and more generalized precursors. These later specializations may proceed in several directions from a common initial form. Thus, a single vertebrate prototype might differentiate along several pathways into advanced fishes, reptiles, and mammals.

Agassiz then argued that the geological history of a group should match the embryological development of its latest and most advanced members. Early (historically oldest) forms should be few, simple, and generalized; later relatives should be specialized and differentiated products of these primordial archetypes. This scheme might sound evolutionary, but Agassiz explicitly rejected such a heresy. The geological sequence of separate creations paralleled embryological growth within each group because God’s orderly and benevolent plan permeated all developmental processes in nature.

Agassiz remained loyal to the classification of his mentor, the great French zoologist Georges Cuvier. He arranged all animals in four great groups: radiates (a hodgepodge by modern standards, but including such radially symmetrical forms as corals and echinoderms); mollusks; articulates (segmented worms and arthropods); and vertebrates. The four trunks are coequal and do not coalesce at life’s dawn, for they represent separately created plans for anatomy, not ancestors and descendants. But since geological history mimics embryological differentiation, prototypes of the four trunks from the oldest strata should be more similar than their modern representatives—for embryology is a tale of divergence from generalized roots.

Agassiz used *Cephalaspis* as a primary illustration of his embryological vision for geological history. As a representative of the oldest fishes, *Cephalaspis* fulfilled all expectations for a primordial creature in Agassiz’s vision of differentiation as the guiding principle of history. Agassiz located two different supports for his theory of differentiation in “the bizarre characters of this genus” (les caractères bizarres de ce genre). First, he viewed the single solid head shield (not divided into separate cranial bones linked by sutures) and the few, simple scales covering the body as marks of a primitive generality—a source for later differentiation of separate bones and more complex scales. Second, he twisted to his advantage the old bugbear of superficial resemblance between the shield of *Cephalaspis* and the head of trilobites—for this similarity indicated that the major trunks of animal life did draw closer to a common seed at life’s source.

Finally, Agassiz delighted in the great age of *Cephalaspis*, for its antiquity proved that all four trunks lived simultaneously at the dawn of life. The most complex group of vertebrates did not arise later as a possible evolutionary descendant (heaven forfend) of a simpler trunk.

Agassiz’s theory of a God ordering his creation by embryological rules of differentiation was clearly not an interpretation logically entailed by objective facts of nature. It was a vision rooted in a cultural context still unable to embrace evolution, and in the personal psychology of Agassiz’s own interests and training. Agassiz imposed his theory upon *Cephalaspis* and highlighted only those facts most congenial with his preferred views. Yet his use of *Cephalaspis* cannot be read as a vindication of relativism. Agassiz may have exploited *Cephalaspis* in the interests of his vision, but he also unearthed the primary fact that fueled all later discussion. He proved that *Cephalaspis* was a vertebrate by discovering the body of a fish behind a head shield that had confused all earlier observers.

When William Patten used *Cephalaspis* as the centerpiece of an important theory eighty years later, the context of science had changed irrevocably. Evolution had triumphed, and *Cephalaspis* would now be invoked in the interest of genealogical claims. Our cardboard rel-

A drawing from Patten’s 1912 books shows the superficial resemblance of the head shield of an ostracoderm (left) to a trilobite head (right).
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Ativist might argue that since Cephalaspis had played no notable part in fomenting this great revolution in thought, any evolutionary interpretation must be viewed as a new convention impressed upon old information—a new set of rules like the annual updates of the Mah-Jong board, imposed upon the same old tiles. But a realist would rightly reply that the tiles had changed as well. Agassiz had not resolved the anatomical status of Cephalaspis among the fishes; he could only affirm that the genus was both old and aberrant. Several of the greatest nineteenth-century evolutionists then studied Cephalaspis—including T. H. Huxley, E. R. Lankester, and E. D. Cope. From all their arguments and disagreements, one strong theme emerged: Cephalaspis and the ostracoderms were not just a grab bag of peculiar fishes. They formed a coherent group, with a large and consistent set of features all pointing to an anatomically primitive status among fossil vertebrates. Cephalaspis therefore became a prime candidate for theories about the ancestry of higher vertebrates. Evolution set the context, but new information about Cephalaspis fueled the debate.

Patten presented the most sophisticated case for the oldest theory of vertebrate origins—the attempt, dating to Geoffroy Saint-Hilaire in the early nineteenth century, to derive vertebrates from an invertebrate annelid or arthropod, a “worm that turned,” so to speak. Arthropods run their main nerve cords along their ventral (bottom) surface. The gut lies above, and the esophagus must therefore pierce through nervous tissue to end in a ventral mouth. In vertebrates, on the other hand, the main nerve tract, the spinal cord, is dorsal (on top), and the gut lies below. Turn an arthropod upside down, and you get the right order for vertebrates—nerves above guts. You also obtain a set of additional correspondences that some scientists have read as superficial and analogical, and others as deeply meaningful signs of evolutionary affinity.

But this act of inversion also produces some horrendous problems for the theory of arthropod ancestry. In particular, the vertebrate mouth does not pierce the brain and open on top of the head—though the old arthropod mouth would take this path in its supposedly inverted position. Proponents of the arthropod theory must therefore argue that this original mouth atrophied, and that vertebrae opened a new ventral version below the brain. No one has ever provided a good explanation for how such a topological transformation might plausibly occur.

The arthropod theory, though venerable, suffered another major impediment that Patten tried to remedy. It was an abstract argument based on a theoretical transformation without hard evidence in the form of intermediary creatures from the fossil record. Patten therefore went back to the oldest folk wisdom about Cephalaspis—the basic observation that had been judged false and treacherous ever since Agassiz. Maybe that first idea about a relationship with trilobites had some validity after all. Maybe Cephalaspis looked like an arthropod because it wasn’t all fish, as its back end seemed to proclaim. Maybe the head shield truly possessed some arthropod characters. Maybe ostracoderms did represent that long-sought intermediary group between arthropods and vertebrates.

Patten eventually argued himself into this position. He identified the marine...
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arachnids (eurypterids and horseshoe crabs) as arthropod ancestors, and he classified ostracoderms, not as primitive jawless fishes, but as a transitional group between the two great phyla. He wrote in 1912:

We may now confidently affirm that the ostracoderms belong neither to the arthropods nor to the vertebrates, but constitute a new class standing midway between them, the ancestors of the one and the descendants of the other, the long sought missing link between the vertebrates and the invertebrates.

Patten was more than a vertebrate anatomist; he also fancied himself a philosopher and moralist. As such, he used his theory of vertebrate origins as a centerpiece for one of the widest (and wildest) claims ever made for the sweep of evolutionary theory. In a series of works, including published class notes for Dartmouth courses in the late 1920s, and in his general book The Grand Strategy of Evolution (1920), Patten tried to establish evolution as the source of all morality, proper conduct, and good human relations. He therefore becomes a convenient foil for our cardboard relativist who wishes to see little of the external world (if such a concept be intelligible at all) and much of social context in the claims of science. I could not be more out of sympathy with Patten’s wider effort. I have never read a more tendentious or vainglorious attempt to establish a preferred social morality as the pathway and dictate of nature. I have no particular quarrel with Patten’s beliefs—a compendium of unsailable apple-pie virtues, featuring the value of service to others and the wisdom of self-restraint in a world of temptation. But I’ll be damned if nature can validate, or even address, such cultural hopes and preferences.

Patten argued that nature could instruct us if we learned her patterns and followed them in all our beliefs and dealings. He wrote in 1920:

The universal end, or purpose in life, and in nature, is to construct, to create, or grow. The ways and means of accomplishing that end are mutual service, or cooperative action, and rightness. This universal growth occurs along three cosmic axes—time, space, and rightness. The three-dimensional result is linear and necessary progress:

There is an abiding compulsion to the action of all these factors which is cumulative, or progressive, producing that increasing architectural organization that we call nature-growth, or evolution.

The direction of evolution also sets a moral imperative, for it “compels man to accept nature’s constructive rightness as his ethical standard, and to adopt her constructive methods as his moral code.”

But if nature’s progress is the source of our morality, then we had better be able to find an unambiguous direction in evolution. Patten bravely surveyed the entire tree of life, with its complex and ramifying branches shooting forth in a thousand separate directions, and managed to realign this intricate meshwork, with bold upper case, as “The Great Highway of Organic Evolution which leads from the lower forms of animal life up to man.”

To produce this remarkable change, Patten had to extract one lineage from life’s tree and depict it as a straight, central highway. He then had to view all other groups as side roads leading to the dirt of nowhere. But how can a central artery be discovered (with humans on top) if, as generally held, vertebrates go back into the mists of time and do not arise directly from any other complex phylum (but share closest ties with the lowly echinoderms? How can we specify a Great Highway if arthropods, representing some

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80 percent of animal species and including the most structurally complex invertebrates, do not lie firmly upon it? We can’t very well call one branch a trunk line if it contains four-fifths of everything.

Obviously, then, a direct linkage of lower arthropod to higher vertebrate must be established if we are to speak of a Great Highway at all. And if no highway can be found, then we have no natural basis for morality and no primacy of evolution among the disciplines. Patten therefore called upon Cephalaspis and the ostracoderms to perform the greatest of all services—to form the link that would secure both the direction of life and the laws of moral conduct. Patten explicitly cited his arthropod theory of vertebrate origins as the key to his entire system:

It shows that the great vertebrate-arthropod-arthropod phylum forms the main trunk of the genealogical tree of the animal kingdom; that, emerging from unsegmented, coelenterate-like animals, as though driven by some mysterious internal power, moves with astonishing precision, through broad, predetermined channels—from which neither habit, nor environment, nor heredity, can cause it to diverge—towards its goal.

Patten even thought that he had finally found a mechanism, in his theory of necessary progress, for that most improbable claim of the arthropod theory—the closure of the old mouth above the brain and the opening of a new one below. He argued that progress must be marked by increasing size of the brain, and that expanding nervous tissue would choke off the old brain-piercing esophagus, forcing construction of a new mouth:

The progressive constriction of the esophagus, by the growth of the surrounding brain, ultimately compels all those with relatively larger brains to suck their food in liquid form through the narrowest possible opening, or give up eating altogether . . . . Without this closing up of what had come to be a very inconvenient gateway to the gut, the growth of the brain, as we see it in the higher vertebrates and in man, would have been a physical impossibility.

Our cardboard relativist may now exult. Patten’s personal need to find moral answers in evolution, and the early twentieth-century vogue among paleontologists for reading life’s history as a tale of linear progress, surely fueled his improbable interpretation of ostracoderms as transitional between arthropods and vertebrates. But our realist shouts “wait!” A factual question must still be resolved. People may believe correct things for the damnest and worstest of wrong reasons. We still have to know the zoological status of Cephalasps—for this genus goes some-

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where in life's genealogy no matter what cultural blinders we may wear at any moment. We still must find out whether Pat- ten was right or wrong.

This question can be answered definitively, for Cephalaspis then had the good fortune to become the subject of this century's greatest work in observational palaeontology—a treatise so stunning in care and detail that I thrill every time I pick it up, even though its unrelenting technical detail scarcey forms the usual stuff of inspirational literature. In 1927, Erik Andersson Stensiö, professor of palaeontology at Stockholm, published his monograph on "The Downtonian and Devonian Vertebrates of Spitsbergen, Part 1, Family Cephalaspidae" (Downtonian is an old name for strata now termed Upper Silurian).

One hardly expects revolutionary work after such a humdrum title in the conventional form of a taxon from a time and a place. But Stensiö chose understatement as an antidote to Patten's quest for ultimates. Stensiö had found some exceptionally well-preserved head shields of Cephalaspis and other ostracoderms on the island of Spitsbergen. He realized that the unusually heavy ossification of the shield suggested an exciting possibility for research—for bone permeated and tightly surrounded all soft anatomy of the head, including delicate blood vessels and cranial nerves, not to mention the more prominent brain and eyes. The soft parts had decayed after death, and had been replaced by matrix of a much lighter color than the surrounding bone. By distinguishing bone from matrix, Stensiö could reconstruct the soft anatomy of Cephalaspis in astounding detail.

Stensiö used two basic methods for resolving the anatomy of ostracoderms. First, he dissected head shields enlarged thirty to fifty times under a binocular microscope. He worked with fine needles on specimens immersed in alcohol or Canada balsam, for these liquids enhanced the contrast between bone and matrix. Each specimen required up to two months of work, but Stensiö managed to remove bone and leave the matrix behind as a perfect cast of soft anatomy. Second, Stensiö ground serial sections at intervals of one-fifteenth of a millimeter through the head. By lining up this long series of parallel cuts, and tracing the pathways of matrix and bone, Stensiö could reconstruct the soft parts. He then made wax models of this internal anatomy. By coordinating these methods, Stensiö was able to trace all the cranial nerves, identify all major arteries and veins, and provide a detailed reconstruction of the brain. My mind boggles at the thought that human ingenuity can identify the wandering pathways for all three branches of the trigeminal nerve in fossils of the earliest vertebrates. I can hardly even remember the mnemonic—on old Olympus' topmost top (one of those t's must be trigeminal). (If I may be excused one short tangent on the subject of narrow-mindedness in science, we taxonomists and comparative morphologists are often derided as second-class citizens, not quite true scientists, by colleagues who work with more familiar accoutrements of the scientific method—numbers and experiments. A study without formulæ or controls seems to lack the necessary rigor of the stereotype. Let those mired in such myopia try to duplicate the work of Erik Andersson Stensiö. Let them spend months with fine needles, separating matrix from bone, grain by grain. Let them try their hand at serial sections, not through the usual wax and tissue, but through bone and stone. And let them try to interpret the resultant mosaic of holes and connections. Stensiö's work is the most elegant, the most beautiful example ever produced of care and rigor in another dimension. And his results are as firm as anything rooted in numbers and experiment. He was not right about everything; who can be? He misidentified as electric organs, for example, two areas that probably form part of the sensory system for responses to pressure. But the intricate details of his reconstructions for parts of the brain and cranial nerves have been upheld again and again in repeated studies.)

Stensiö's work proved that Patten had been entirely wrong. Cephalaspis was all fish, and included not a whiff of arthropod. Moreover, the cranial anatomy of Cephalaspis showed detailed similarity, part after part, with the living lampreys—jawless fishes beyond a doubt. After 380 pages of text, Stensiö wrote as his last paragraph and final conclusion: "It is clear now that the Ostracoderm, though very lowly organized, are true craniate vertebrates which have nothing whatever to do either with the Arthropoda or with the Annelida."

In establishing the position of ostracoderms, Stensiö had also resolved the order of early fishes. Lampreys and hagfishes had no jaws, and embryological evidence indicated the homology of gill-arch bones with later jaws. But before Stensiö's treatise, ichthyologists didn't know whether the lampreys and hagfish were correctly degenerate lines of jawed fishes or remnants of a primordial jawless group. By showing that the ostracoderms were a genealogically coherent group of jawless fishes, pre-dating all jawed vertebrates by tens of millions of years—and by demonstrating the anatomical relationship between lampreys and Cephalaspis—Stensiö both established the pathway of early vertebrate evolution, and proved that two lineages of the primordial group had survived.

What then can our realists and relativists make of this tale? The relativist correctly identifies three sequential and mutually incompatible world views behind the history of change—Agassiz's creationism, Patten's linear progressivism, and Stensiö's branching tree. Yes indeed, each man read Cephalaspis in the light of his world view. Yes again, Cephalaspis did not fashion the world view, but found its inevitable slot in a preconceived structure. Yes once more, the world views were products of surrounding culture and personal psychology: Agassiz's accident of birth in a pre-Darwinian world; Patten's need for moral answers in nature.

But this history is not only a tale of social fashion—a story of varying dress lengths, tie widths, or degrees of abstraction in painting. Each world view was a cultural product, but evolution is true and separate creation is not. Cephalaspis may have been buffeted from one social construction to another, but paleontologists also learned important facts about its anatomy at each step—and I don't know what to call this accretion of genuine in-

In his 1920 book, Patten places ostracoderms between arthropods and vertebrates on the Great Highway of animal evolution.
formation about the external world if not scientific progress. Agassiz proved that Cephalaspis was a fish, but knew nothing of its internal structure. Patten had resolved enough anatomy to know that ostracoderms were a coherent group of primitively fishes, not a hodgepodge of unplaceable oddballs. Stensiö mapped the brain, the cranial nerves, the blood vessels—while Agassiz could not even find the mouth.

World views are social constructions and they channel the search for facts. But facts are found and knowledge progresses, however fitfully. Fact and theory are intertwined, and all great scientists understand the interaction. As Darwin wrote in one of his most famous lines: "How odd it is that anyone should not see that all observation must be for or against some view if it is to be of any service!"

The debate of realists and relativists, when expressed as ends of a dichotomy vying for victory, is silly and tendentious. Science progresses by establishing facts about the world out there—and science is, and must be, socially embedded. The history of interaction between paleontologists and Cephalaspis is both a pageant of ideas and a growing compendium of information. I exult in the ideas, but I confess to a special love for the rock-hard primacy of Stensiö’s dissections and for Patten’s beautiful eurypterids in the corner of my office.

Isaac Newton mused on the interaction of fact and theory in his most famous passage:

I do not know what I may appear to the world; but to myself I seem to have been only like a boy playing on the seashore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me.

We would love to fathom that distant ocean, but it is no shabby thing to fondle those pretty pebbles on the shore.

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.

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Winds that build the sand dunes on Oregon's Pacific coast leave a lower-lying area (upper right) known as a deflation plain.

David Muench
Almost 40 percent of Oregon's 340-mile Pacific coastline consists of sandy shores and dunes that form an ever-changing system of ridges and depressions. An example of this habitat, known as Umpqua Dunes, lies in the Siuslaw National Forest, between Heceta Head and Coos Bay. A popular place for swimming, boating, fishing, gray whale watching, and other seaside activities, most of Umpqua Dunes has been set aside as a National Recreation Area.

Alfred Wiedemann, a biologist at Evergreen State College who has been studying the Oregon dunes for nearly twenty-five years, has pieced together their geological history. About 53 million years ago, he reports, there was a downward bending of the earth's crust all along the Pacific coast. The land was submerged under the sea and began to be covered by sediments of sand, silt, clay, and volcanic material that were washed into the ocean. In particular, along what is now the Oregon coast, feldspar and quartz sand were deposited by erosion of an uplift of sandstone to the south, in the region of northern California.

Thirty million years into this continuous process of deposition, there was an uplift inland that formed the Coast Range (Cascade Mountains), visible east of the dunes today. Rivers and streams flowing from these mountains have swept additional materials into the sea. This action was especially intense during Ice Age times (1.8 million to 10,000 years ago), when periodic glaciation caused the sea level to rise and fall, encouraging rivers to cut trenches across the continental shelf and carry sand and other erosional products to the ocean. These and earlier deposits of sand are now being washed up by wave action and blown by the predominantly landward winds into the various types of dunes we see today.

A short distance inland, parallel to the shoreline, is a ridge of sand known as the foredune, which may be twenty-five feet high. Foredunes were absent along this part of the Oregon coast until half a century ago, when people introduced European beach grass in an effort to stabilize the sand. With its extensive root system,
Still lower-lying areas, twelve to eighteen inches above the water table, where water stands for three or four months during the winter, support a dense growth of rushes, golden-eyed grass, springbank clover, and California aster. The bright pink heads of the clover and the purple blossoms of the aster provide vivid color in this rush meadow community. A marsh, where water may stand for six months of the year, occupies the wettest part of the deflation plain. Slough sedge, the most common plant, is joined by the yellow-flowering silverweed and creeping buttercup in this habitat.

The sand that has been scooped out by the wind during the formation of the deflation plain piles up eastward into a series of low, undulating ridges, about 75 to 150 feet apart. These ridges are oriented at right angles to the northwesterly summer winds and thus generally run at a transverse angle to the coast. Because the sand is continuously moving, no vegetation can become established. When the wind shifts during the winter and comes from the southwest, the ridges themselves are partly obliterated, only to re-form the following summer.

The terrain gradually rises eastward until it comes in contact with forest, two to two and one-half miles inland. Here the sand is deposited in dunes known as precipitation ridges, which may be as much as 165 feet tall. They are created as the sand-laden wind strikes the trees of the adjacent forest and is deflected upward, losing its velocity and depositing sand on the side of the ridge toward the forest. When the lee slope reaches an angle of 33° the sand slips down this steep face and invades the forest, burying part of it.

A stable plant cover sometimes becomes established on the precipitation ridges. Seashore bluegrass and large-headed sedge, two species with large seeds that are readily spread by the wind, are often the pioneers. Once germinated, these plants anchor themselves with extensive roots, slowing up the movement of the sand. Shade from their leaves lowers the temperature of the sandy surface and raises the moisture content, allowing for the invasion of other species. Not long after, colorful plants such as the seaside tansy, seashore lupine, and others become established. As the decaying parts of these herbaceous plants build up an organic soil over the sand, the seedlings of woody plants are able to survive. Coast pine, Douglas fir, and Sitka spruce seedlings are common, as are the young plants of the shrubby salal and evergreen huckleberry, two members of the heath family.

As these woody plants grow to maturity, a Douglas fir forest with an entangled understory of salal, huckleberry, and western rhododendron dominates the once barren locations. Eventually, even the Douglas fir gives way to a forest of western hemlock and western red cedar. The complete succession of plants takes more than one hundred years. Meanwhile, more sand is washed up on shore, creating new expanses of beach and dune west of the encroaching forest.

“This Land” highlights the biological phenomena of the 154 U.S. national forests. Robert H. Mohlenbrock is Distinguished Professor of Botany at Southern Illinois University at Carbondale.
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Thomas Sprat, The Royal Society of London for Improving Natural Knowledge, 1667

The Society's motto, "Nullus in verba," is appropriate for the twentieth-century tourist in Great Britain. It may be translated: "Take no one's word for it—see for yourself." Names from the history books—Isaac Newton, William Shakespeare, Francis Bacon and the Brontë sisters—pique curiosity. Where did they live and how? What was the atmosphere in which they worked and grew?

From the teeming and vibrant city of London, which still owes so much to the genius of architect Sir Christopher Wren, through the quiet thatch-roofed cottages of Shakespeare country to the mysterious landscape of Wales and the mist-covered hills of Scotland, Great Britain is a delight: History, traditions, legends, inspiring structures, and tranquil landscapes beckon. You will have to look hard to find even the tiniest corner not filled with surprises and excitement.
London

Why, Sir, you find no man at all intellectual who is willing to leave London.
No, Sir, when a man is tired of London, he is tired of life, for there is in London all that life can afford.

Samuel Johnson, 1777

You cannot visit London without being struck by the city’s history. Londinium—built by the Romans in the first century A.D.—expanded, swallowing up other towns and villages.

For the archeologically oriented traveler, London offers a veritable treasure hunt. The Roman remains are mostly underground, but in a few places, they break the surface. A massive slab of Roman wall can be found near the Tower and another in a city churchyard.

We owe to William the Conqueror of the eleventh century the Tower of London. The White Tower, the oldest building in London, was the beginning of what would be—at various periods in history—a fortress, a palace, a prison, a mint, and an arsenal. It now is a museum—and a repository for the crown jewels.

The Great Fire of 1666 virtually destroyed medieval, Tudor, and Jacobean London. From that disaster rose St. Paul’s Cathedral, Sir Christopher Wren’s masterpiece, which managed to survive the fire bombing of World War II centuries later.

Between forays to London’s stores and eclectic restaurants, explore the museums and galleries that preserve Great Britain’s past—the British Museum (Natural History), the Science Museum, and the Geological Museum. Set aside a major part of your time to explore the British Museum. Here are Britain’s most notable publications—the Magna Carta, the cornerstone of English law; a fifteenth-century manuscript of Chau-

Opposite page: Trafalgar Square.
Top left: St. Martin’s In The Field
Top right: Leeds Castle, Kent.
Center: The Houses of Parliament.
Left top: The Palm House, Kew Gardens.
Left bottom: The Whale Room, Natural History Museum.
As he lay dying—felled by a poisoned arrow—King Bran the Blessed commanded that he be buried beneath White Hill (where the Tower of London now stands). He believed this act would ensure that England would never crumble.

The way John Wilmington, current ravenmaster of the tower, tells it, "Bran" is Welsh for raven. So ravens were brought there in the belief that they—like the mythical king—would protect the Commonwealth from attack.

Today, the ravens, like the Crown Jewels, are considered national treasures. They even hold rank in Her Majesty's Army.

Nearly all of London's attractions hold unexpected stories. Big Ben—the world's most recognized timepiece—is kept accurate with the help of two old pennies strategically placed on the pendulum. Scotland Yard, made famous by Sherlock Holmes, was built on the site of the Palace of Scottish kings.

Or browse through the Old Curiosity Shop. Built in 1567, this antique shop is an antique itself, and was the model for the Dickens novel.

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Some say it turns a page of its stone book on moonlit nights. The unexpected sights overflow into the countryside as well. So Pan Am Holidays created 18 British vacations. "The Best of England" is an 8-day independent vacation from $999 to $1199 including airfare, rooms with private bath, breakfasts, plus four dinners.

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When you get to London, make it a point to visit the Tower. And don't forget to tip your hat to the ravens—Cedric, Charlie, Hugine and Katie. They're always there.

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**Britain · We Speak Your Language**
The Cotswolds

...the noble woods, the perfect flowering of the architecture, that make these villages so notable an enchantment.

J. B. Priestley, 1931

To the west of London lie the Cotswolds, the gentle and tidy countryside that is the very heartland of England. Here you find Oxford and Eton, those bastions of academic enlightenment and cultural tradition, as well as Stratford-on-Avon.

Wander through Oxford, a collection of colleges that have nurtured Isaac Newton, Christopher Wren, Robert Hooke and John Wilkins, among many others. "That sweet city with her dreaming spires," poet Matthew Arnold wrote of Oxford, "has molded the minds that have enlightened centuries." The university is comprised of 35 independent colleges founded in different periods.

Stratford-on-Avon is the tourist center for any exploration of the English Midlands. Even without its strong ties to William Shakespeare, the town of Stratford would attract visitors with the charm of its half-timbered houses and its historical links with American history. Harvard House in High Street was built by the grandfather of John Harvard, founder of Harvard College, and the Red Horse Inn is the site where Washington Irving worked on *The Sketch Book of Geoffrey Crayon, Gent.*

Take a short journey from Stratford to Warwick, a superb example of an English castle. Visit Nottingham and Sherwood Forest, Robin Hood's stamping ground. In your tour, include Lichfield for its cathedral and the 1495 grammar school where both Samuel Johnson and David Garrick were students.

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The West Country

This Cornwall is very primeval; great black jutting cliffs and rocks . . . and a pale sea breaking in. . . . It is like the beginning of the world, wonderful: and so free and strong.

D.H. Lawrence, 1916

The West Country is rich in prehistoric remains reflecting the influence of the Druids and legends of King Arthur and his court.

Stonehenge stands alone in the Salisbury Plain, an assemblage of massive upright stones, originally placed in two concentric circles. It dates back, probably, to the Bronze Age, and its origin and purpose remain a mystery; some believe it was a Druidical temple, while others consider it to have been a Saxon sepulchral monument. But archaeologists can only speculate. Other circles, henges, and standing stones can be found in Avebury, Merivale, Hurler, and as far to the north as Scotland and as far to the east as Wales.

For a look at Camelot—in Arthurian legends, the place where King Arthur had his palace and court—travel to Winchester. Winchester Castle was begun by William the Conqueror, and in its great hall is what is purported to be the original "Round Table"—a thick oak circle in which the names of Arthur's bards are carved. Nearby to the west is Salisbury, the subject of many of Constable's most beautiful paintings. The area is one of Great Britain's oldest inhabited regions.

Among the country's most important Roman remains are those found in Bath. Mineral springs, the warmest in Britain, were the original attraction, and the Romans built here extensively, constructing an elaborate six-acre health resort called Aquae Sulis. You can stand on the gallery of an ancient building and see one of the original Roman pools—40 by 50 feet. Later structures indicate Saxon and then Norman influence. The area is an archaeologist's paradise, with current excavations unearthing new finds.

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Natural History/Special Advertising Section
The North Country

The ground it selve for the most part rough, and hard to be manured, seemeth to have hardened the inhabitants, whom the Scots their neighbors also made more fierce and hardy...

William Camden, 1610

The Pennine Chain of mountains, the “backbone of England,” characterizes the personality of the North Country—strong, rugged, and enduring. The countryside ranges from the wild Yorkshire moors, immortalized by Emily Jane Brontë’s Wuthering Heights, to the walled medieval cities of York and Chester and the romantic ruins of Fountain Abbey.

York’s beginnings go back to the Roman conquest in 71 A.D. Through the centuries, it has been influenced culturally and architecturally by the Anglo-Saxons, the Vikings, and the Normans. Today this proud city cherishes the remains of its medieval heritage. Its crown jewel is York Minster, the largest Gothic cathedral in England, built between 1220 and 1472. York is best explored on foot. The two-mile circuit of the fourteenth-century walls offers a panorama of the city—and a convenient approach to its many historical museums. No matter where you may wander in the city, you can orient yourself by the cathedral’s majestic towers.

If you can visit only one city of the North Country, let it be Chester. The older part of the town is still completely encircled by masonry dating from the fourteenth century and built on Roman and Norman foundations. The city’s medieval rows—arcaded, timber-framed two-storied shops—are unique to England. Within an easy drive of Chester are tourist high points of northeastern Wales—the Isle of Anglesey, Snowdon, and Caernarvon.

Wales

So it must have been after the birth of the simple light
In the first spinning place, the spellbound horses waling warm
Out of the shining green stable
Onto the fields of praise.

Dylan Thomas, 1946

Wales is a land of legend and tradition, poetry and music, and ancient ruins and medieval monuments of unknown origin. Here are cromlechs like those found in Stonehenge.
(The Stonehenge stones are believed to have come from Wales; how they were transported to the Salisbury Plain is a matter for speculation.) The Isle of Anglesey, off northwestern Wales, delights the traveler with its castles, windmills, seaside towns, and magnificent cliffs. This is where the Druids made their last stand against the Romans, and traces of their stone monuments remain, their purpose still shrouded in mystery.

The island will delight the naturalist as well as the historian. It attracts an extraordinary number of birds—puffins, terns, cormorants, razorbills, and petrels—just to mention a few. Visitors to its beaches are fascinated by rock pools, estuaries, and a host of plants and wildlife. Snowdon, in the interior, is another delight for the naturalist with its five peaks; one is the highest mountain in Wales.

But Wales is known above all for its castles. Wandering around the remains of any Welsh castle takes you back to the days of chivalry, sieges, and romance. In 1283, King Edward I built Caernarvon Castle in northwestern Wales for his son, the first Prince of Wales. It remains the site for the investiture of each succeeding Prince of Wales. Prince Charles carried on this tradition in a 1969 ceremony that was broadcast worldwide. On the western coast of Wales is Harlech Castle, an imposing fortress that epitomizes Edward’s concept of an “iron ring” of castles to contain the rebellious Welsh.

Not all Welsh castles were constructed during medieval times. To the south, Castle Coch, an enchanting construction of conical turrets, round towers, and Gothic extravagances, was designed by Victorian architect William Burges.

Whether you choose to wander

A Puffin, one of many birds found on the island.

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Scotland is a baffling country to describe. You think that you have summed her up, that you have assessed her values and reached a decision about her when without warning she suddenly flings a surprise at you.

H. V. Morton, 1929

Scotland is one of the most beautiful sections of the British Isles, with glaciated topography somewhat resembling that of Norway. Its people cling with affection to their past and are proud of their intellectual achievements. The roots of steam power, logarithms, anesthesia, modern philosophy, and capitalist economics may be found in this Gaelic bastion.

Edinburgh, Scotland's capital, is one of Europe's most beautiful cities and deserves its nineteenth-century title, "The Athens of the North." Located on Castle Rock, Edinburgh Castle, once the residence of kings, dominates the city. Edinburgh is home to the Royal Scottish Academy, the National Gallery of Scotland, and the Museum of Childhood.

North of Edinburgh lies the ancient town of St. Andrews, famous for its university, its ancient monastery, and its superb golf links. The town is often called "the capital of golf," its Royal and Ancient Golf club, founded in 1758, decides the rules of the game. The countryside surrounding St. Andrews resembles one continuous golf green interrupted sporadically by human settlements.

Perth, nestled on the Tay, was the capital of Scotland until the middle of the fifteenth century. It is a medieval town graced with eighteenth-century Georgian houses. The castles of Elcho and Huntington Tower are nearby.

Inverness, by some considered the "capital" of the Highlands, is best approached by train. The Royal Highlander thunders through forests of spruce and larch before pulling into this seaside city ringed by hills. Loch Ness (and the mythical Nessie) is only a short distance away. From Inverness you can drive to Cape Wrath, the very tip of Great Britain, in only a few hours.

To the northeast lie the Orkney and Shetland Islands. Their coastal cliffs and marshes shelter an astonishing variety of shore birds. Dedicated spotters generally regard tiny Fair Island, the most southerly of the Shetlands, as the most important observatory in Europe; more than 335 species of birds have been recorded here.

In Lewis, one of the Outer Hebrides to the northwest, the deep past lives on. At Callanish, on the island of Lewis, a circle of stones, erected 3,500 years ago, may be aligned to the sun, stars, and moon; it possibly may be traced to the Druids. In Harris, you can find Gaelic-speaking farmers making the famous tweed, using the procedures followed by their ancestors.

Glasgow, the second largest city in Scotland, is home to the Botanic Gardens, the Scottish Opera, and the Scottish Ballet. This year, it will host Scotland's biggest event, the Glasgow Garden Festival, from April 29 to September 26, culture, horticulture, history, and science will all be celebrated at this international festival. Because of its central location, Glasgow is an ideal spot from which to set out on day trips to Scotland's many fascinating tourist spots.
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The bus belonging to El Vaquero (the cowboy) is for sale, complete with its decorations.
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In Panama City, painting takes to the road

Text by Moira F. Harris
Photographs by Leo J. Harris

A tradition of embellishing buses began in Panama City back in the 1920s, when the popular means of motor transport was just a pickup truck with two rows of seats added in the back. These small vehicles, known as chivas, were painted with the name of the owner and the route served. Chivas soon received pet names and other simple decorations to distinguish them and to attract customers. By the early 1960s, American-built school buses had become the standard vehicles, offering a far larger canvas for the artists.

Painting buses helps them stand out in the congested streets. Panama City has no public transportation system as such; instead, there are private buses—some 2,760, according to Nelson Romero, head of the syndicate, or association, of owner-operators. The buses follow principal thoroughfares, stopping anywhere along their chosen routes (often without warning) to pick up or discharge passengers. A destination sign on the front of the bus indicates the two terminal points, which are usually car parks on the periphery of the city. A subtle variation in color choice, from a palette consisting principally of red, white, and blue, also helps identify bus routes to those who know the code.

The first bus painter to achieve recognition is remembered by his artistic nom de plume, El Lobo (the wolf). He worked in the 1940s. There are at least a dozen artists active today, among them Ramon ("Monchi") Enrique Hormi, Andres Salazar, and Jesus Teodoro de Villarue, better known as Yoyo. These men charge from $1,500 to $3,000 for their work, depending on their status (Yoyo is regarded by many as an old master) and the complexity of the job. Owners lavish other options on their buses as well: plastic streamers to fly from the sideview mirrors, stainless steel exhaust pipes, blinking colored lights on the grillwork, and a tape deck from which salsa music emanates. Considering that a bus may need to be repainted after three or four years of driving, all this represents a considerable investment.

A prominent spot for decoration is above the windshield. According to Yoyo, many bus owners prefer something
Windows spray painted with place-names,
buses.

below, adorn

owned
"Miami Vice" star Don Johnson helps attract

the side of one of Panama City 's

2, 760 privately

customers to another bus, bottom.
"natural" for this space

—

a country cottage, a mountain lake,

or some other restful scene. Others choose such exotic

landmarks as the

Eiffel

Tower or the Statue of Liberty.

The side windows of the buses are often spray painted with
signs of the zodiac or names of girlfriends, while on the
corrugated steel side panels, fire-breathing dragons stretch
their scales, monsters cavort in lunar landscapes,

Moses casts

down the tablets, or a stretched semitruck carries its load into
the mists. Next to these murals, cartoon figures indicate the

And

location of the twelve-volt battery or the diesel fuel inlet.

above the side windows of the bus there is just enough room for
some elongated birds, animals, or geometric shapes.

The primary space where painters can display their talents,
is on the emergency door at the rear of the bus. Most

however,

often the subject

is

—a popular

a single figure

television star, a saint, or a

singer or

member of the owner's family.

Posters, record-album covers,

and religious art are often

enlarged for this purpose. Often the

name of the subject is also

included, so that passengers will not forget to ride on the Tina

Turner, Lucia

Mendez, or Mr. T bus in the future.

Is it art?

The Museo de Arte Contemporaneo of Panama City
organized a competitive exhibit of bus art in 1 983, offering
prizes for paintings that occupied the rear emergency door.

(Twenty-four artists entered their work; the winners were
those

who used religious and patriotic themes.)

Decoratively lettered inscriptions are also part of bus

art.

A

973 study by Julio Arosemena of the University of Panama
included more than 1,700 examples. These slogans, titles, and
1

macho boasts, usually placed above the rear bumper, on the
side windows, or above the windshield, are similar to those

found on vehicles in other parts of Latin America. Titles of
movies and songs are common, but by far the most popular
inscriptions are dichos (sayings) that deal with
faith.

(the

life,

love,

and

Juan, for instance, styles himself el aventurero del amor

vagabond

lover).

Other bus drivers have chosen tiempos

mejores (better times), hablay tesalvas (confess and save

a mi suavemente (come to me gently), decidete
(make up your mind), and "I love you, baby." D

yourself), ven

46

Natural History 4/88


The back of the Tina Turner bus, above, also features the popular motif of a tranquil country scene.
Master artist Yoyo de Villarue and his crew take credit for painting this bus, whose bumper inscription means "better than nothing." Right: The archangel Michael triumphs over Satan, above a promise of "better times."
Panther Diary

When the patient is a wild, endangered animal, no medical procedure is routine

by Steven A. Osofsky

The call came at 7:30 A.M. on June 17, 1987. A radio-collared Florida panther had been hit by a truck on a state road north of Big Cypress National Preserve. I was about one hundred miles to the south, in Everglades National Park, where I was working as veterinary assistant to Melody Roelke, wildlife veterinarian for the Florida Panther Project, an effort initiated in 1976 by the Florida Game and Fresh Water Fish Commission to save this native cat from extinction. The accident brought something unexpected: a seven-week-long association with a single animal—Florida panther male No. 20.

The Florida panther is one of twenty-seven subspecies of cougar, also known as the puma, or mountain lion. Subspecific populations of cougar are thought to exist in pockets from western Canada to southern South America, although reliable information on current distribution is lacking. Hunted intensively for skins, for sport, and as a perceived threat to livestock, North American cougar populations were greatly reduced by the early twentieth century. In the United States, native populations of the cat are now confined to the mountainous west, parts of Texas, and southern Florida, where the numbers are down to thirty to fifty animals.

Since 1972, fourteen Florida panthers are known to have been hit by motor vehicles and eleven of these animals died. The majority of all known panther mortalities is due to motor vehicles, while the second leading cause of death is shooting, even though hunting of this cat has been outlawed since 1958 and it is now listed as endangered by both the federal and state governments. In addition, the cat's habitat is under siege, threatened by land development and by a citrus industry that creeps farther south each year. The Florida panther is a signal animal, an indicator, and saving it means saving entire wilderness areas.

When the news came through that Florida panther No. 20 had been hit, Dr. Roelke, tracker Roy McBride, one of Roy's tracking dogs, two wildlife biologists, and several hundred pounds of capture and rescue equipment were dispatched in two helicopters to the site of
Veterinary students and zookeepers carry Florida panther male No. 20 out of the operating room after a bandage change and a root canal procedure. The author is at right.

C.W. Griffin, Miami Herald

the accident. Meanwhile, I drove ahead to the Miami Metrorzoo, its hospital being the best place to bring the cat for treatment. Within two hours, a helicopter carrying the injured panther landed in an unused parking lot at the zoo. Several of us carried him into the back of a pickup truck, draping him on our laps to keep him off the hot metal truck bed. Dr. Roelke had gotten an intravenous line into one of the animal's hind legs soon after the team had captured him. She could see that he had several large road burns on his back and left forelimb.

Apparently No. 20 had kept running after being hit; the capture team caught him when the tracker's dog chased him up a tree. They immobilized him by dart with the anesthetic ketamine hydrochloride—using just enough to get him safely down to the ground.

On arrival at the hospital, the animal weighed in at 134 pounds. Radio collared only three months earlier, he was estimated to be three to four years old. Then he weighed 148 pounds and was the largest cat the team had ever radio collared.

The cat seemed to be breathing without difficulty and his heart rate was normal. At first he was overheated, so we cooled him down with ice. After we put him on gas anesthesia (halothane) to keep him anesthetized while we evaluated his wounds, his temperature dropped to below normal, so we took him back to the warm pavement. Eventually we stabilized his temperature at a normal 102.4° F.

To handle this cat, we always had to anesthetize him. Procedures that could be done on a typical house cat without anesthesia—a bandage change, for instance—could only be done on Florida panther No. 20 if he was unconscious. Large wild animals (and most large zoo animals) are simply too dangerous to themselves and to others to be medically evaluated without chemical restraint.

The main concern was a deep abrasion with punctures over the left carpus (wrist), exposing some extensor tendon. Scott Citino, the zoo veterinarian, also suspected possible involvement of metacarpal bones, but when the limb was radiographed from several angles, no fractures
were revealed. The cat’s right front leg, sides, and back also had many areas of badly abraded skin. We later found out that the truck had dragged the cat fifty feet before it could stop. Florida panther male No. 20 would need to be anesthetized nine more times during his stay at the Metrozoo as the carpal wound required a lot of work as it healed.

We continued to administer intravenous fluids, as well as a corticosteroid to reduce trauma-induced swelling and to deal with the potential onset of shock. We also gave antibiotics: 1400 mg of oxytetracycline intramuscularly and 1920 mg of a trimethoprim/sulfa combination subcutaneously, as some of the animal’s wounds were badly contaminated. Dr. Citino thoroughly flushed the wound over the left carpus with a povidone-iodine solution, dressed the area with a protective silver sulfadiazine cream, and bandaged the leg.

The cat’s lungs did not sound normal: with my stethoscope, I could hear hoarse crackles as he breathed. Thoracic radiographs revealed several areas of increased density within the lungs, most likely signifying that the impact of the truck had caused pulmonary contusions. At one point the cat’s respiration seemed seriously compromised, and the doctors decided to place a tube in his trachea to aid his breathing and to facilitate removal of fluid from his airways with a suction device; a bloody mucus was withdrawn. Fortunately, by irritating its larynx with the tube, we elicited a coughing reflex, which brought up a fair bit of clotted blood and mucus. His breathing sounded much better after that.

At that point we decided to let the cat rest under observation. We drove him to a concrete enclosure normally used as a bear-cubbing den and put him down on the hay-covered floor. This enclosure was all that was available and not ideal for a wild panther. Number 20 did a lot of damage to his teeth, mostly by chewing on the concrete walls, during his stay. Eventually we put a heavy rubber covering on the main areas he was chewing.

Although contrary to official Panther Project protocol, No. 20 acquired a nickname, “Animal.” Upon spotting tracks, Mexican trackers out west reportedly refer to a big cougar as animal and the concept was simply transliterated to Florida. Animal had been given this name by the people who first tracked him because he was so big.

Animal did not eat in captivity for more than a week. According to tracker McBride, this is not unusual. Even healthy cougars may not eat for two weeks after they’ve been brought into captivity. For the first few days, Animal looked as though he was indeed in pain. He was depressed and breathing heavily. He’d gotten his bandage off by himself the first day. By the third day, the skin around his carpal injury looked yellow, necrotic. We gave him some more time. His breathing and attitude slowly improved. We had to keep in mind that this was a wild animal. To do anything with him would involve general anesthesia and its inherent risks. Often doing very little except observing is the best medical option when handling is so stressful for an animal.

On Animal’s fifth day in captivity, he was darted with 1400 mg of a long-acting form of the antibiotic oxytetracycline. We began giving him Valium (diazepam) because he started trying to escape and abraded his face. The Valium, initially 3 mg once or twice a day as needed, was intended to keep him calm so he wouldn’t hurt himself and to stimulate his appetite. When Animal started to eat and to get progressively stronger, he needed larger doses of Valium. We soon had on him it every twelve hours—by mouth if he was eating, blow darted in if he wasn’t. He was most active early in the morning before sunrise. His drive to free himself was amazing; he seemed to sense no pain when he repeatedly rammed his head into a corner. This was a wild animal that had never been confined before. What could have been going through his mind? I thought about that quite a lot. When it was light out, he’d instinctively jump toward the tiny windows. An intrinsic desire to be free, a will so strong, so driving. I wished I could explain to him that he’d be free again, but of course, I couldn’t. Valium was the best thing we could offer. The week before we released him, his seventh week in captivity, he was on 15 mg of Valium twice a day.

Six days after his accident, Animal was anesthetized via dart with 350 mg of ketamine for reevaluation. That works out to only about 3 mg per pound, a low dose, but enough, given Animal’s debilitated state. He’d lost seventeen pounds in one week—he was down to 117 pounds. Dr. Citino cleaned out the wound over the carpus and removed the contaminated tissue at the perimeter of the injury. The defect left was three inches long and two inches wide. A drain was put in place, silver sulfadiazine cream was applied, and the leg was rebandaged. At one point the cat’s body temperature had fallen to 96°F, so we warmed the intravenous fluids to above 100°F before administering them. We also used heating pads and bags of hot water to bring his temperature back up to normal. Before we brought Animal back to his enclosure, we took the opportunity to administer B-vitamins, a vitamin/amino acid supplement, and iron dextran. We brought his hydration status back up to normal with subcutaneous fluids, as he was still not drinking on his own.

We took a swab from within the wound for culture and sensitivity to tell us what bacteria were within the tissues and which antibiotics might be effective against them. A β-hemolytic Streptococcus, Proteus mirabilis, Klebsiella pneumoniae, and Aeromonas hydrophila were all isolated. These bacterial organisms were all only sensitive to chloramphenicol and a trimethoprim/sulfa combination. We decided to put No. 20 on trimethoprim sulfadiazine (960 mg intramuscularly, twice a day by blow dart). Another culture and sensitivity two weeks later showed that we needed to modify our antibiotic regime,
When first seen and photographed on March 10, 1987—three months before the accident—male No. 20 was the largest Florida panther to have been radio collared by the panther project capture team.

David Maehr

rarely showed much interest in meat simply put in his enclosure: he got used to eating it off the stick.

A reevaluation of his leg eleven days post injury revealed a clean wound on its way toward healing. By this time the cat had badly damaged his canine teeth on the concrete enclosure and on the bars in the chute where we shifted him for meals. And his claws were completely worn down.

Why were we keeping him in captivity? That's a valid question, one we constantly asked ourselves. Could he survive if we let him go right now? What if we had never brought him into captivity? His leg wound, which was very deep and very prone to infection, had been caused by humans, not by another cat or prey animal. If he had not been taken in, his leg could easily have become gangrenous. A wild panther with three legs isn't going to last too long. We couldn't take that chance, and we did have excellent facilities available to treat him. Still, he did seriously damage his teeth in the enclosure. By the end of his stay in captivity, he needed endodontic (root canal) procedures to prevent infection in all four canine teeth. We believe he will still be able to use these teeth effectively to kill prey. His tremendous jaw strength is unimpaired. Every decision we made with this animal involved a cost/benefit analysis. Now that he is back on his own in the wild, only time will tell how well we did. We'll know more when the cat is anesthetized in the field again for a complete biomedical evaluation. Radiotomography data indicate no problem thus far.

On July 2, sixteen days after the accident, we found that No. 20's wound was granulating in, filling with connective tissue as the healing process progressed. He had gotten his bandage off several days earlier. We cleaned and rebandaged the wound. This time the bandage was anchored to the leg by sutures that went through pieces of rubber tubing stitched to the leg, which served to minimize tension directly on the animal's skin. If the wound could have been kept clean, we might have left it open. Not being able to handle this animal without anesthetizing him made bandaging the best option.

During No. 20's stay at the zoo, we evaluated his heart. Initial chest X-rays had hinted at some enlargement of the right heart. Two-dimensional ultrasound, as interpreted by a University of Florida veterinary cardiologist, showed an enlargement of the right atrium, and bubble contrast studies pointed to regurgitation from the right ventricle into the right atrium. An electrocardiogram was consistent with the possibility of right heart enlargement. I did find microfilaria of an innocuous nematode in the panther's blood, but we never found any evidence of adult heartworm. Putting all this together, and given that No. 20 is a relatively young animal, the cardiologist suspects a congenital right atrioventricular valve defect. We can't prove the problem was congenital. Nor can we prove that it is genetically based. Roelke strongly suspects, however, that there may be an inbreeding problem, given the other characteristics of this subpopulation of cats—kinked tails (found in No. 20 to be due to a deformed coccygeal vertebra), cowlicks on their backs, palpable umbilical hernias, and cryptoorchidism (only one descended testicle). Roelke, with Drs. D. E. Wildt and J. G. Howard of the National Zoo, has demonstrated a high percentage of abnormal spermatozoa in the semen of male Florida panthers. She hopes to clarify the genetic situation of this subpopulation and, in collaboration with Dr. S. J. O'Brien of the National Cancer Institute, compare it with that of other subspecies of cougars in the United States as part of her ongoing isozyme and DNA analyses.

Three weeks after Animal had been injured, Dr. Roelke was able to bring the edges of the wound a bit closer together using horizontal mattress sutures anchored on rubber tubing. Endodontic work on the upper canine teeth was also done at this time. In addition, radiographs confirmed what we thought was a fracture of a midtail vertebra—related to the accident—in the process of healing. Animal was starting to feel better:

"This is not a zoo animal. This is a wild animal, and his constant attempts at escape remind us daily of that. We have to
cover up the windows when he gets in one of his 'escape moods'. He'll jump, claw, and bite anywhere he sees light breaking through. I can't blame him. I hope we can soon have him back where he belongs. His Valium dose is being increased. It's a relatively safe drug, and it may be the only thing that keeps him from doing too much damage to the tools of his trade—his teeth and his claws."

One month post injury, Dr. Citino was finally able to close the wound over the carpus using three tension-relieving incisions that allowed the wound edges to be brought together. Overall, the leg looked very clean. Citino thoroughly debrided and flushed the area and freshened the wound edges. Excessive granulation tissue had to be trimmed down. He then pulled the edges of the skin on both sides of the wound together with large mattress sutures oversewn with a simple interrupted pattern. At this point, the bandage mainly served to keep the cat from pulling out the sutures. Of course, Animal got the bandage off in two days anyway.

On July 20, thirty-four days post injury, Animal was anesthetized again to have more work done on his leg and teeth. The ends of the suture line had come undone. Citino freshened these exposed wound edges and put in some more sutures. The leg was put in a fiberglass cast—a bandage that the cat did not remove.

By July 27, forty-one days post injury, Animal weighed 137.5 pounds, several pounds more than his weight at admission. We were able to remove the remaining sutures. The carpal defect was completely closed. A final cast was applied to keep the cat from constantly licking the area, although he soon got this bandage off.

It was the management of this animal even more than the actual medicine that made this case such a valuable learning experience for me. If a domestic cat had been injured like this, we could have handled it every day, and it would most likely have healed without so many confinement-related complications. Close attention to doses of the sedative and to the animal's responses were needed to keep him at just the right level.

The end product of all this, the goal of all our work, was a successful release back into the wild. The day before the release, Animal was obviously ready to go:

"This weekend Scott had to up No. 20's day dose of Valium to 15 mg. So, now he's on 15 mg bid [twice a day]. Scott thinks he may need to go up to 20 mg tonight. We noticed a sudden increase in the cat's activity after he was taken off of cefadroxil. Citino thinks that perhaps the antibiotic has been interfering with the Valium at some level. Perhaps now the Valium is being metabolized/excreted more rapidly and hence the cat is more alert. Makes sense. He's been pulling the rubber off the walls. He looks great."

On Tuesday, August 4, 1987, Animal was released:

"Animal is gone. The release was everything I thought it would be."

"We loaded him into the crate at 3:00 A.M. at first he was a bit hesitant, but he eventually walked from the chute into the crate. We had to tilt the crate on its side to get it into Melody's truck. It was a three-hour trip to an area about twenty miles north of Big Cypress. The actual release took place on private property. The landowner raises cattle and grows citrus in this area of Hendry County within Oklawaha-Sloough. Several panthers live on the ranch, but they've never preyed upon the cattle, apparently preferring the abundant deer and wild hogs.

"The panther was pretty good during the trip. He spent most of it lying down on his side. He occasionally got up, banged around, got himself excited; sometimes open-mouth breathing with a respiratory rate of around 120 breaths per minute. The truck's air conditioning was always on high. Using a flashlight, I periodically peered in through the crate's air holes.

"The drive through the undeveloped part of the ranch to the release site was quite scenic. Palms, swamp, hardwood hammocks, open fields, cattle—even a wild hog and a deer.

"The chosen release site was a wet, open area surrounded by forest. We unloaded the crate and the press proceeded to get organized. They were directed to line up in a row about forty feet in front of the crate. I was surprised. I thought we'd have to stay in vehicles or behind trees. To the left of the crate was a tree line several hundred yards away. Directly in front of the crate, and behind the reporters and cameramen, was a closer tree line, about fifty yards away. The thought was that he'd come out, see all the people, and run the other way. Nice theory. That's not what happened.

"The cat was lying down in the crate when Melody opened it. He immediately leaped up and darted out. He was understandably disoriented and headed . . . right toward where I was standing. I had been looking through my camera when I saw the panther was going in the 'wrong direction.' I temporarily dropped the camera away from my eye and looked at Animal head-on. I backed off a bit and he veered to the left. He then ran straight toward the line of reporters, who quickly became disoriented themselves. The cat darted right between two of them. He ran into the woods behind us and, surprisingly, stopped and turned around. He looked at us, and all I could think of was how confusing these past weeks must have been for him.

"After glancing back at the assembled crowd, he trottled off into the woods at a less hurried pace. Perhaps he felt safe in the woods. Perhaps he already knew where he was. The release site is within his known home range area. Radiotelemetry revealed that he didn't wander off too far while we were there—perhaps a few hundred yards into the woods. A game commission plane later circled overhead to determine his precise location.

"I kept looking at where he had run into the woods, but of course I didn't see him again. I'll never forget his run back into the wild. Never."
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WOULD HAVE TO RESHAPE AND REBUILD
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There's substance here, in the design, the ride, the power. It's classic, it's timeless... the Premium American Motor Car.

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The results are here today, as seen in the cars and trucks introduced to the automotive world at the Waldorf-Astoria in New York early this year. It was a progress report, featuring our new products with the quality our customers demand and the value they expect.

But there's more to come—and soon. An example: Saturn, a new General Motors car company dedicated to a "clean sheet" approach to designing, building and selling cars in America. The first Saturn car will be seen in 1990, but already the advantages of Saturn's unique approach to car-building are evident in the GM cars you see today.

The job is not yet finished—there's more to be done. But today, the people of GM can proudly say—the vision is paying off.
Can parents influence the sex of their offspring? New research indicates many creatures, including humans, do change the odds to favor Daughters or Sons.
by Sarah Blaffer Hrdy

"May you be blessed with eight sons." This traditional benediction at a Hindu marriage is symptomatic of a preference for sons deeply felt across much of the world. Soon after the new wife conceives, the marriage blessing is followed up by a second ceremony. Mantras are chanted so that if, by some mischance, the fetus is female, she can be magically transformed into a son. In the words of one ethnographer in India: "A daughter's birth makes even a philosophic man gloomy... whereas a son's birth is like sunrise in the abode of gods."

Today more than mantras are available to assist parents in their quest for the desired sex. For a brief period last year Americans could have purchased from certain drugstores "Gender Choice Child Selection Kits" for a mere $49.95. The kits contained directions, thermometers, and paraphernalia for monitoring vaginal mucus, all so as to determine the best moment for conceiving a son or a daughter. That was before the U.S. Food and Drug Administration decided that the implied claims of the packages, some of which were pink, some blue, had not been substantiated. All these kits should by now have been pulled from drugstore shelves.

More reliable than the kits are newly announced methods for separating sperm carrying the X chromosome from that bearing the Y. This high-tech approach, pioneered at the University of Tokyo, requires artificial insemination and, for that reason, may be less appealing to many prospective parents. It is also simply beyond the means of most people. Currently, the most widely practiced procedure for choosing the sex of offspring is prenatal sex determination followed by selective abortion. The British journal Nature recently published statistics, provided by a Bombay social worker, on abortions at Indian clinics: out of a sample of 8,000 abortions, 7,997 involved female fetuses. Nevertheless, nowhere is sex-selective abortion officially sanctioned. In fact, Maharashtra has just become the first state in India to ban prenatal sex determination for precisely this reason. In traditional societies, infanticide has always been the option of last resort. University of Colorado psychologist Leigh Minturn has estimated that sex-biased infanticide has characterized some 9 percent of the world's cultures, and more often than not, the unwanted sex has been female.

Infanticide and abortion are extreme measures. More often, the discrimination is more subtle. The little boy is

Worldwide, boy and girls are born in approximately equal numbers, but in many cultures, sons are preferred.

Photograph by Irving Penn © 1960 by The Condé Nast Publications Inc.
pampered and fed; the girl is more or less neglected. In cultures as far apart geographically as twentieth-century Lebanon and Ecuador, we find evidence that boys are suckled twice as long as girls, a pattern also documented for parts of medieval France. Only in a minority of the world’s cultures, many of them matrilineal gardening societies, do we find widespread sentiments leading to the preferential treatment of daughters.

Many reasons are offered to explain why sons are so desirable: their strength and potential contributions as laborers, warriors, or hunters; their role in perpetuating the family name or performing special rites when parents die; and the requirement in some societies that daughters, but not sons, bring expensive dowries to their marriage. But regardless of the reason, and totally apart from ethical considerations, the fact remains that the bias in favor of sons dates back many generations. The birth of a son or the birth of a daughter ... on the outcome has hung many a mother’s reputation—and occasionally the fate of a nation. And this is precisely where the problem becomes an interesting one for evolutionary biologists. Here we have a species that produces notably costly offspring. Nine months of gestation at a cost of some 80,000 calories, followed by a potentially hazardous delivery, and after all this, the parents neglect or dispose of the baby. From an evolutionary point of view, this is puzzling inefficiency. Why hasn’t natural selection led to a race of parents who automatically produce the desired sex?

A survey of the planet’s life-forms suggests that the feat might be possible. For an assortment of fishes, reptiles, worms, and plants, sexual identity can be determined by something as seemingly simple as where on the beach a mother lumbers up to lay her eggs or where seeds happen to fall. In many turtle species, eggs in sunny spots develop into females; those in the shade, males—a rule of thumb that also holds for some orchids, which only produce female flowers in full light. The rule is reversed for many other species.

In at least one species of fish, sex is determined by a combination of genetic and environmental factors. David Conover and Stephen Heins, both of the Marine Sciences Research Center at the State University of New York at Stony Brook, studied the Atlantic silverside, a fish found as far north as the Canadian Provinces and as far south as Florida. They found that in southern populations, sex is determined by temperature: most offspring born early in the breeding season, when the water is relatively cool, are females; those born later, by which time the water has warmed up, are mostly males. Dividing things up this way may be adaptive: fish born early in the season have a longer time to grow, and being big appears to be more of an advantage to females than to males—large females are more fecund than small ones. At higher latitudes, sex is determined genetically, with temperature playing little or no role. This, too, seems to make sense: the farther north the fish are, the shorter the growing and breeding seasons, and the shorter the breeding season, the less effect birth date—that is, early or late in the season—could have on body size.

In all these cases, the question can be asked, Is there truly anything adaptive going on, either for the individuals involved or for the population at large? According to Conover, for the silversides, the answer seems to be a relatively confident yes. The reptile situation is murkier. By laying her eggs in the sun, for example, does the American alligator “intend” to skew the sex ratio of her offspring (that is, the number of sons to the number of daughters) toward females? And if so, why? Or is the association an artifact of something else?

One group of organisms for which we have some answers to these sorts of questions are the haplodiploid insects—wasp, bees, and ants. In these insects, fertilized eggs develop into daughters, unfertilized eggs into males. And in many species of bees and wasps, the mother does indeed demonstrate exquisitely fine tuned control over the sex ratio of her progeny. At the time she mates, the female stashes the sperm away in special storage chambers within her
Warm American alligator eggs hatch as males; cool ones as females.

Unlike the radically skewed sex ratios of fig wasps, most mammalian and avian sex ratios at birth fall close to 50/50. In our own species, for example, between 102 and 106 little boys are born for every 100 little girls, roughly 51 percent males, a classically conservative mammalian sex ratio. (No one is certain why slightly more boys than girls are born, but it may be to compensate for the greater vulnerability of males and their higher mortality rates at all ages.) Traditionally, two reasons have been given to explain why this should be so. First, sex in mammals is chromosomally determined. The somatic cells of all females carry two X chromosomes, while those of males carry one X and one Y. The single gene recently found to determine maleness is almost always found on the Y chromosome. During meiosis, each egg receives one X chromosome, and each sperm receives either an X or a Y. The likelihood of an egg being fertilized by an X-bearing sperm, to become a daughter, or a Y-bearing sperm, to become a son, is thought to be as random as the flip of a coin. Also, once fertilization occurs, gender is for keeps, with none of the hanky-panky some fish are capable of—changing sex if size and circumstances are favorable. Chromosomal sex determination works similarly in birds, except the configurations are reversed: the females carry two types of sex chromosomes—known as Z and W—while males carry two Z chromosomes.

The second major constraint thought to discourage birds and mammals from specializing in a favorite sex is explained by the time-honored axiom of population genetics known as Fisher’s theorem of the sex ratio. Mathematician Ronald Fisher reasoned that so long as producing sons and daughters requires equivalent amounts of parental resources, so long as outbreeding prevails (that is, so long as brothers do not routinely breed with sisters), and so long as all individuals have the same chance to breed, then equal numbers of sons and daughters should be produced.

To better understand Fisher’s insight, imagine a population in which certain parents started to specialize in producing offspring of a particular sex—say, sons. When these offspring mature and seek to breed, they will find themselves in a world with many more males than females. Too bad for them. Whereas all females will be able to breed, only a portion of males will find a mate. Too bad for their parents, too, since on average, parents specializing in sons will be penalized by having fewer grandchildren, while parents producing daughters will be rewarded, at least temporarily. Over time, natural selection favors female
specialists, with the predictable outcome: a glut of daughters. Once again the pendulum will swing back toward son producers. And on it goes, with the pendulum swinging first to daughters, then to sons. The outcome? A population with more or less equal numbers of sons and daughters.

Fisher's model helps to explain why one-to-one sex ratios should be so common among many animals. But alter the critical underlying variables—for example, step up inbreeding—and the rules of the game change. This is just what seems to have happened to some little lemmings of the north.

The wood lemming of northern Europe and the varying lemming, which ranges from Canada to Siberia, have evolved a wasplike capacity to dramatically bias the sex ratio of their offspring. In the lemmings' case, the skew is always toward daughters. Three to four times as many females as males are born in the population, with some individual mothers producing no sons at all. The lemmings' trick is accomplished by curious changes on the X chromosome. In the case of the wood lemming, a peculiarly "imperialist" version of the X chromosome has evolved with the power to overwhelm the male-producing Y chromosome. Paired with one of these "super-X" chromosomes, a Y chromosome fails to express itself and the X-Y individual develops into a female.

Just why such chromosomal oddities have evolved in these lemmings and, so far as we know, in no other mammals remains a matter for debate. But as they tunnel through moss in the dark recesses of fir forests, feeding on red wortleberries and the bark of juniper trees, these lemmings are subject to the vagaries of good and bad years, and a consensus is emerging that the boom-or-bust population cycles characteristic of these small arctic mammals play a role. According to this interpretation, lemmings in a "bust" year would find themselves scarce, isolated in pockets where brothers would have little choice but to mate with their sisters. The same local mate competition that led mother fig wasps to produce ten daughters for every son may at some point in the past have also favored the one-in-a-million wood lemming carrying the aberrant super-X chromosome.

Most other mammals, however, have never been subject to such inbred conditions, and current wisdom still rates mammals and birds as resolutely committed to more-or-less equal production of sons and daughters. Yet recently, biologists have been turning up instances after instance in which the sex ratio at birth (or shortly after) is significantly different from the expected 1/1. At issue are not the striking biases found in fig wasps, but more subtle biases on

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**Manipulating Mothers**

The jewel wasp is a consummate artist at controlling the sex of its offspring. Found throughout the world, this small parasitic wasp (at 3 millimeters, it is smaller than a fruit fly) delivers a lethal sting and then lays its eggs in the pupae of various species of blowfly. Typically, from twenty to forty young wasps develop on each host. The wasps mate immediately upon emerging from the host pupa, and mated females then disperse in search of new fly pupae in which to deposit their own eggs. The pupae relished by the wasps are usually found under carcasses or in bird nests. Despite the—to the delicate human sensibility—rather repulsive circumstances under which it lays its eggs, I have found the reproductive affairs of this little wasp to be intriguing.

Male jewel wasps have short wings and cannot fly. Since the wasps mate right after emergence, brothers and sisters sometimes have only each other to mate with. Such inbreeding occurs, for example, when all the wasps emerging from one bird nest or carcass are produced by a lone female. At other times, many females will parasitize the same nest or the many blowfly pupae patchily distributed under a carcass, and then mating is spread among many families.

Impressively, the jewel wasp can alter the sex ratio of her progeny depending on how many other females have discovered the same patch of potential hosts. When by herself, a female will produce about 85 percent daughters, with just enough sons to inseminate all her daughters and thus with a minimum of energy wasted on sons competing with one another. When she finds herself in the company of other egg-laying females, however, she changes her tactics dramatically. Now, she needs more sons to compete with males of other families, so she shifts the sex ratio of her offspring closer to 50/50.

Sometimes two females lay their eggs in the very same blowfly pupa. If that pupa is some distance away from any others, then mating competition will be restricted to the offspring of those two females. In that case, the first wasp to find such a host lays about 85 percent daughters, as expected. However, if the second female encounters the pupa within a day or two, she can detect that it has already been attacked. She accomplishes this by "tasting" chemical changes in the host with her stinger, which is also a complicated sensory organ. If she "decides" to insert a single egg into the host, it will be a son. Because of the many daughters laid by the first female, the second female's son will un-
doubtlessly have many mating opportunities. (Eggs laid within two days of each other routinely emerge as adults at the same time.) If, however, she “decides” to lay many eggs, she will produce both sons and daughters. The more eggs she lays, the more she will bias her own production toward daughters.

Understanding the intricacies of the jewel wasp’s ability to manipulate the sex ratio of its offspring is challenge enough. Complicating the picture is a recently discovered assemblage of “parasitic” genetic factors within the species that can usurp and undermine this ability. These parasitic genes (both inherited microorganisms and “renegade” chromosomes have been found) promote their own transmission by distorting the wasp’s sex ratio. One of these genes—known as the paternal sex ratio element—is carried by about 10 percent of jewel wasps and causes the female to produce all males, whether or not she has fertilized some of her eggs. (In wasps and other haplodiploid organisms, only fertilized eggs develop into females.) Males carrying the paternal sex ratio element transmit it through their sperm to eggs during fertilization. Normally these eggs would develop into females, but instead the paternal sex ratio element somehow destroys the paternal chromosomes in the egg, thus converting a diploid female into a haploid male. This amazing accomplishment is evolutionarily advantageous for the paternal sex ratio element since—unlike all other known parasitic genes—it is transmitted through males but not through females. In contrast, it is decidedly detrimental to the rest of the father’s genome. Such a gene can also cause problems for the whole population since an all male population will obviously go extinct. This system of birds parasitized by flies parasitized by wasps parasitized by genetic elements makes poignant Jonathan Swift’s famous quote:

So, Nat’ralists observe, a Flea
Hath smaller Fleas that on him prey;
And these have smaller fleas to bite ’em
And so proceed ad infinitum

*John H. Werren*
Many egg-laying reptiles are of special interest to sex ratio theory because the incubation temperature of the egg determines whether it will hatch as male or female. Temperature-dependent sex determination first gained recognition through the work of Claude Pieau in France during the 1970s. Pieau studied two species of European turtles, but scientists around the world have since investigated the phenomenon in many other reptiles. The early studies were in the laboratory; more recent work in the field has confirmed the temperature effect in nature.

Unlike birds and mammals, only some species of reptiles carry chromosomes directly involved in the genetic determination of gender; many others do not. So far, all of the reptiles known to have temperature-dependent sex determination are alike in lacking sex chromosomes. The particular effect that temperature has on the sex ratio, however, differs markedly among these species. In many
crocodilians, such as the American alligator, and in some lizards, high temperatures produce males and low temperatures produce females. The pattern is reversed in many turtles. A more complicated pattern occurs in several turtles and at least one crocodilian, where females develop at high and low extremes and males develop at intermediate temperatures. Finally, in some turtles, lizards, and snakes, temperature has no apparent effect on sex determination. Presumably, the many reptile species that do have sex chromosomes would fall into this category, but only a few of those species have been studied in this regard.

Also, unlike birds and mammals, most reptiles do not incubate their eggs or care for their young. Some crocodilians, such as the American alligator, construct mounds of rotting vegetation in which their eggs are laid and then briefly tended, but most reptile mothers simply bury their eggs in the ground and abandon them.

Nevertheless, the mother's action can play a decisive role in determining the sexual fate of her little embryos, since it is up to her to "decide" just where to lay the eggs. An alligator that builds her nest in a wet (hence cool) marsh will produce many more daughters than one that builds on an elevated (warm) levee. Freshwater turtle mothers may select sunny or shady nesting spots; these microclimatic differences can result in offspring sex ratios ranging from all female to all male.

The effect of temperature can even be felt in a single nest. The common snapping turtle typically lays thirty to fifty eggs per nest, each egg being shaped like a one-inch Ping-Pong ball. With so many eggs piled on top of one another in the nest, the bottommost eggs may be 10 cm below those on the top and may incubate at a significantly cooler temperature. The sex ratio thus sometimes varies within the nest, for example, with all females developing in the top eggs and all males in the bottom.

Is there any advantage in having sex determined by temperature rather than by sex chromosomes? We do not know yet, but one model currently under study suggests that an individual's incubation temperature affects its fitness later in life, that is, how successful it will be in producing offspring of its own. To take an extreme case, if heat renders all males sterile, then natural selection would favor the evolution of a temperature-dependent sex determination that caused all embryos developing at high temperatures to be female. Work is under way in several research laboratories to see whether the temperature effect is, in fact, tied to reproductive fitness, but scientists still have a long way to go before they will be able to fully understand the adaptive significance of this unusual mechanism of sex determination.

James J. Bull

the order of four of one sex to six of the other. In an effort to capture these elusive trends, a body of work somewhere between knowledge and sheer speculation has arrived at center stage. Inspired to a considerable degree by Hamilton's suggestion twenty years ago that different circumstances might select for different mixes of sons and daughters, sex ratio research has become one of the fastest-growing, most talked about, most exciting, and most speculative areas in all of evolutionary biology. There are many like myself who are convinced one day, skeptical the next. Sometimes I am certain that skewed sex ratios exist and that they must have some adaptive significance; then I begin to worry that we are all simply carried away, caught in the scientific equivalent of seventeenth-century Dutch tulipmania, when a whole nation was swept into bidding for an obscure, practically useless, but pretty Turkish flower bulb. All this sound and fury, one of the hottest Ph.D. topics going—surely it signifies something. Or does it?

Let us begin with Morris Gosling and the mystery of the missing coypu. Coypu, or nutria, are aquatic, guinea-pig-like creatures native to South America. Because of their luxurious fur, coypu have been exported to fur farms around the world. As prolific as they proved to be footless, descendants of escaped coypu have also become something of a pest. To deal with the problem, Britain's Ministry of Agriculture set up the Coypu Research Laboratory to control them. Enter zoologist Gosling, enlisted to help trap the coypu from the marshlands of eastern England.

As a scientist, Gosling was not content merely to eliminate his quarry; he wanted to know what was going on inside them. So he dissected 5,853 female coypu. Of these, 1,485 had embryos old enough to count and to sex. Examining them, Gosling made a curious discovery. As he studied small litters (those with no more than four embryos), he noticed that many contained mostly male embryos, while remarkably few small litters were predominantly female. After additional investigation—in which he compared young females with old and small litters with large—he came to the conclusion that his findings could be plausibly explained in only one way: mother coypu were somehow selectively aborting small, mostly female litters. Furthermore, the fatter and healthier the female, the more likely her body was to terminate such a pregnancy.

Why, Gosling wondered, should such a seemingly counterproductive process go on? Not long after Gosling presented his preliminary findings, another British zoologist was puzzling over fifteen years worth of data on the reproductive ecology of red deer on the isle of Rhum,
Among red deer, socially dominant mothers in good condition produce more sons, such as these stags, than daughters.

off Scotland. Tim Clutton-Brock, of the University of Cambridge, and his colleagues had found that year after year, the socially dominant mothers in the best physical condition were producing more sons than daughters. (For an earlier report on this study, see Natural History, November 1982.) Furthermore, these same mothers were likely to have more grandchildren by their sons than by their daughters. During this same period, low-ranking mothers (presumed to be in worse shape) were giving birth to more daughters than sons. And although the subordinate mothers generally had fewer grandchildren than did dominant females, what grandchildren they did have were more apt to have been born to their daughters than sired by their sons. All in all, mothers seemed to adjust their probability of producing a son or a daughter in line with their own condition, and Clutton-Brock suspected that the overproduction of sons by dominant females and their underproduction by subordinate ones was adaptive, with each mother bearing the sex more likely to provide her with the most grandchildren.

If the full story be told, neither Clutton-Brock nor Gosling had simply out-of-the-blue happened to look at sex ratios in relation to the mother’s condition.

Both were aware of a controversial, even notorious, paper published in Science some years before. In 1973, biologist Robert Trivers and mathematician Dan Willard—both still graduate students when they did the work—audaciously proposed that there ought to be situations in which natural selection should favor biased sex ratios, rather than 50/50. Sometimes, parents ought to be able to adjust the energy and resources that they poured into the production of offspring so as to produce more of the sex most likely to translate that parental investment into subsequent reproductive success.

Implicit in Trivers and Willard’s hypothesis was the fancy-ranging and general proposition that parents should bias investment according to the number of grandchildren they could expect to have from their sons as compared with their daughters. But the original model they spelled out was a very specific one. Their idea was that mothers in good condition should favor sons; those in poor condition, daughters. This state of affairs ought to hold for creatures satisfying two criteria. One, the mother’s rank or condition must affect the breeding potential of her offspring. Two, sons in good condition must have the potential to sire more offspring than comparably healthy daughters could produce. The latter criterion certainly applies to red deer, coypu, and other polygynous species, in which a successful male may impregnate many females, quickly outstripping even the most fertile of females.

Supposedly, a high-ranking, especially fit mother has greater access to food and is free from harassment by other group members. Her son, fast growing and well nourished, should be bigger and stronger than the average male, well equipped to compete in the free-for-all contest for mates. Such a male, the argument runs, should sire a larger than average number of offspring, providing his mother with greater than average numbers of grandchildren.

At the other end of the scale, a low-ranking mother, harassed and underfed, could at best produce a scrawny son, who would have very few, if any, opportunities to
breed. For this mother, the conservative strategy would be to favor daughters, which regardless of their condition would be likely to produce at least a few offspring. Just exactly how this bias in favor of daughters might be brought about remains a mystery, but Trivers thought the most likely explanation was greater fetal mortality for males when the mother was stressed during pregnancy.

If you buy the underlying assumptions, the Trivers-Willard hypothesis is compellingly logical. But does anything like it occur in nature? Gosling's answer, like Clutton-Brock's, was yes. His interpretation of the coypu data is vintage Trivers-Willard. "Young females in better than average physical condition . . . abort small litters of predominantly female embryos . . . . Large litters and small, predominantly male litters are retained," he wrote in 1986. "Neonate size is positively correlated with female condition (and body size). The differences in body size at birth are carried through to adult size. These data are consistent with the hypothesis that when females are in above-average condition, it would pay them to invest preferentially in offspring of the sex whose chances of future RS [reproductive success] will benefit most."

Yet many others remained far from convinced. For some, the reality of chromosomal sex determination simply ruled out the possibility that the wild Triversian dream could be true. For others, the idea that a mother's condition could affect the sex of her offspring was outlandish. Many would have agreed with Harvard biologist Steve Austad as he recounted his own first reaction: "I wanted to finish off that notion once and for all." With co-worker Mel Sunquist, Austad set about doing just that with a particularly elegant set of field experiments.
on opossums. No one could have been more surprised than they were by the results: better fed opossum mothers did indeed produce bigger babies, and those babies were indeed disproportionately male. This is when Austad switched from skeptic to the ranks of the converted.

Meg Symington's conversion took a different form. Symington, then a Ph.D. candidate at Princeton University, was studying spider monkeys in the rain forest of the Manu National Park in Peru. There she stood one day several years ago, head back, straining her eyes to peer through the heavy mists that hover over the park each rainy season. With the rains had come a peak of births in the population of monkeys she was following, and Symington was struggling for a glimpse of a new baby's genitalia in order to sex it correctly. Not that she wondered much. It was bound to be female, like all of the other births. Back at camp, she joked out loud: "Another female!"

But there was a visitor in camp that night, a young Dutch scientist, Carel Van Schaik, with a more than passing interest in sex ratio research. The visitor asked Symington the inevitable question: "But why should they all be female?" It was as if one of the Dutchman's countrymen from the seventeenth century, during the heyday of tulipmania, had just inquired of his neighbor if he had invested yet in the fabulous Turkish bulb that was going to make the people of Holland so rich. Symington was hooked.

Primateologists had long been aware that spider monkeys lived in hierarchical groups that contained mostly females. Some suggested that the males just lived elsewhere; others argued that males were more likely to die. No one seriously entertained the belief that more females were born. But by now, Symington had ceased to be blase about the run of female births in her sample. As she pored over her birth records, an answer emerged. It wasn't every spider monkey female that produced daughters, just the low-ranking ones.

Out of forty-six infants born between 1981 and 1986, twelve were male, thirty-two female, and two could not be accurately sexed. All of the twenty-one infants born to her lowest-ranking females were female. The probability that such a specialization in daughters could have occurred by chance was a staggering 1 in 10,000. Middle- and higher-ranking females produced equal numbers of sons and daughters. The highest-ranking females may have had a tendency to produce sons, but the sample size was too small to say for sure—six of eight were male. What was clear was that the dominant females who mothered these rare sons cared for them more, nursing them for a longer period than they suckled their daughters.

Why should this be? Was the answer linked to the

More Sons For Plump Possums

An entire litter of newborn opossums weighs less than a dime and fits comfortably in a teaspoon, and although they are capable of using their forelimbs to crawl the inch and a half from vagina to pouch, the little marsupial babies are virtual embryos—hairless, deaf, and blind, with little more than buds where their hind limbs and tails will eventually be. Because opossum young move to an external pouch at such an early age, they are ideal for experimentally examining how the condition of the mother might affect the number, size, and sex ratio of her offspring.

Over the course of two years, we radio collared forty virgin female South American, or common, opossums at Hato Masaguaral, a cattle ranch and biological field station in central Venezuela. The basic design of our experiment was simple: we left twenty of the radio-collared females alone; we offered supplemental food to the other twenty. In principle, this is an easy task. The animals can be traced to their daytime sleeping dens by the signal from their radio collars. Then at dusk, just before they emerge, food (in this case, the cheapest sort of smelly bait—sardines) is placed near the mouths of their dens. Every month, we recaptured all animals in order to count, sex, and measure the young in their pouches. In practice, the labor involved—ours and that of our field assistants—turned out to be immense, mainly because the Venezuelan savanna becomes flooded, mucky, and impassable to vehicles during the opossums' breeding season, and making matters worse, the dens are widely spaced.

Our results were clear-cut. First, females given extra food did invest more in reproduction. Litter size itself remained constant, but the individual young of food-supplemented mothers were larger at every stage of development than young from the controls. By the time the young opossums began to leave the comfort of the pouch, those whose mothers had dined on sardines were 50 percent larger than those whose mothers had not been so pampered.

Second, while both males and females within a litter experienced a similar increase in size when the mother was fed extra food, the additional size was especially beneficial to the males. During the breeding season, males fight vigor-
ouslly for the single mating each female allows during her reproductive cycle, and larger males usually win the fights. Female reproduction, on the other hand, was not affected by body size. We also found that supplementing the mother’s food promoted the survival of newly independent young of both sexes, but again males gained more: female survival increased by 16 percent, while that of the males rose by nearly 30 percent.

Our third result concerned sex ratios. The Trivers-Willard hypothesis predicts that our food-supplemented females should produce an excess of sons, because high-quality sons—able to outsurvive and outcompete other males and impregnate numerous females—will pass along more of their mothers’ genes to the next generation than will high-quality daughters, whose reproductive output is limited by the number of young they can themselves bear. This is precisely what we found. Food-supplemented females produced nearly 1.4 sons for each daughter, while the control females produced an equal number of sons and daughters.

This striking result led us to reexamine information we had gathered over the years on elderly females. Aged opossums—those in their second reproductive year—often develop cataracts, lose weight, have smaller ovaries, bear fewer litters, and wean fewer offspring than when they were young. Because these females are in comparatively poor condition, unable to produce high-quality offspring, we expected they might bear an excess of daughters, which would be likely to find mates regardless of their condition. And in fact, they did, producing nearly 1.8 daughters for each son. Thus, depending on their physical condition, opossums are capable of biasing the sex ratio of their young in either direction.

Steven N. Austad and Mel E. Sunquist
Boys Will Be Boys—or Girls

Many fishes lead conventional sex lives: the gender of their offspring is fixed for life at fertilization, and they produce equal numbers of male and female young. But many others display a dazzling diversity of sex determination. For some species, environmental factors, such as temperature, determine whether young will be born male or female. Some species consist only of females, perfectly capable of producing their daughters without benefit of males, while others are simultaneous hermaphrodites, each individual producing eggs and sperm at the same time. Yet others change sex during their adult lives: some start off as females and later shift to males, while others do just the opposite.

Sex change is especially common among coral reef fishes, where the direction of change and the sex ratio of a population often reflect the mating system. Where large males can completely monopolize the females, there is no advantage in being a small male. In this situation, all fish are born as females, and most remain so for their entire lives. Only the oldest and largest fish change sex to function as males. When females cannot be monopolized, the sex ratio of the population is more evenly divided. In still other species and situations, large females appear to have some advantage over males; then, the sex change is from male to female.

A good example of sex change can be found in the Caribbean bluehead wrasse, a common coral reef fish that I have studied for the last fifteen years. All reefs contain spots especially favorable to spawning. On small reefs, a few dominant males can easily control these sites and thus the females that gather at them to release their eggs. Small males are out of luck, so nearly all individuals spend their entire lives as females. On large reefs, however, where there are more wrasse and more good spawning sites, the big males lose control of the situation, and smaller males are able to join in group mating. There, many more individuals spend part of their lives as males, and the sex ratio approaches 50/50.

Other studies have shown that sex change, and the resultant sex ratio, among some reef fishes is socially controlled and that individuals can change sex quickly to take advantage of a new situation. The Pacific cleaner wrasse lives in harems consisting of a single male and several females. When the male is removed, the largest female immediately begins to transform herself into a male and is producing sperm within a week. In contrast, among the brightly colored, monogamous anemonefish, if the female of a pair dies, her mate changes sex, while a smaller juvenile in the vicinity matures to become the new male.

Simultaneous hermaphrodites have somewhat different concerns. These fish, while able to produce eggs and sperm, generally mate with other individuals. The question for
them is whether to make mostly eggs, mostly sperm, or something in between. Eric Fischer and Chris Petersen of the University of Washington have shown that this option, too, depends on the social system. In monogamous species, both partners devote most of their energy to egg production, making just enough sperm to fertilize their mate’s eggs. In species that live and mate in larger social groups, the smaller fish produce nearly all eggs, while the largest, dominant individual produces mostly sperm and mates with all the subordinates, saving energy for controlling his harem rather than for making eggs.

Robert R. Warner

The unusual social system of spider monkeys? Symington wondered. For most monkeys, the rule is for females to remain in their natal area, close to home, close to mother, living in “female-bonded social groups.” The males migrate, looking for breeding opportunities elsewhere. But in spider monkeys, and a very few other species—red colobus monkeys (Natural History, September 1981), howler monkeys (Natural History, August 1984), and two apes (the gorilla and the chimpanzee)—the females move and the males stay behind among their relatives. Symington proposed that unlike most monkey mothers, high-ranking spider monkey mothers would therefore be in a position to help their sons achieve a similar high rank, and with it the sexual perquisites that many high-ranking male mammals possess in polygynous species. Symington cautions that we do not yet know that a positive relation exists between a male spider monkey’s rank and his later reproductive success, but she speculates it might.

Well and good for spider monkeys, deer, and coypus, which all appear to fit the original Trivers-Willard model, but what about species where there are other, equally potent variables? In some species, for example, offspring of one sex stick around the den or nest in order to help their parents rear the next generation. If they could, wouldn’t mothers do well to produce more of the accommodating sex? James Malcolm, of California’s University of Redlands, has postulated just such goings-on to explain male-biased sex ratios among African wild dogs. Typically, the females migrate, while males stay on in the pack and help raise more pups. The male helpers’ contribution is substantial—they provide as much meat to the pups, for example, as the fathers do.

Not all stay-at-home offspring are helpful, however, and in some species, these homebodies are actually forced into competition with their mother and siblings for finite local resources. Mothers faced with this situation should—again, if they could—avoid such competition by producing more of the sex showing the good grace to leave home. The type case for this particular sex ratio permutation was provided by a shy, nocturnal prosimian known as the thick-tailed bush baby. About the size of a squirrel and looking a bit like a caricature of a saucer-eyed, short-legged cat, these bush babies of East and South Africa survive catch as catch can. During the wet, warm season in nearly temperate southern Africa, they cock their batlike membranous ears to detect the rustle or whoosh of their insect prey or they hang on to tree trunks, often upside down, to lick up the syrupy gum that drips into fissures in the bark. During the dry, colder months, moths, beetles, and the like disappear from the forest and the bush babies rely heavily on the gum. This
gum is rich in carbohydrates and calcium, but each little well typically yields only enough for three to four minutes of licking; after that, the animal must move on to another site. In winter especially, when the cold gum oozes slowly, it may be hours before enough has collected to make a return visit worthwhile.

Thick-tailed bush babies live in neighborhoods of loosely bonded animals of both sexes, which forage and sleep in overlapping home ranges. The ranges of females are smaller than those of males, and daughters remain in their natal ranges longer than males do, sometimes long after they reach maturity. Mothers tolerate their own daughters but may drive away other females. Intruders are especially unwelcome in the wintertime, when many females are pregnant and the gum is in scarce supply.

At the time field biologist Anne Clark first went to South Africa to study these bush babies, the general assumption was that a single big male would control an area inhabited by a number of females. Thus she was delighted when the first animal she was able to videotape, for the purpose of individually marking it, was just such a big male. She was equally crestfallen when she tripped and released her prize. She feared she might never catch another, at least not in her main study area. To her astonishment, she did. And then another. Indeed, all she ever seemed to catch were males. She was also surprised to note that in her year and a half in the field, almost all of the births she recorded (thirteen of seventeen) were also male, but her sample was too small to draw any conclusions.

Clark, now at Michigan State University's Kellogg Biological Station, returned from Africa in a suspicious frame of mind. She sent a questionnaire to all of the institutions in the world that were breeding bush babies in captivity or had collected them from the wild. Todd Olson, then a Ph.D. candidate at the University of London, contributed museum data on whole populations of bush baby specimens. The resultant sex ratios were wildly male biased—on the order of 130 to 177 males for every 100 females. By the time she received a visit from University of Utah sex ratio theorist Eric Charnov, Clark was ready to lay out her arguments. As she wrote later in Science, her explanation of the skewed sex ratio involved "a difference between male and female offspring in their use of local high-productivity areas which are essential for female reproduction." If, indeed, daughters that remain near their natal ranges would have to compete for scarce resources with each other (and their mother), might not successive production of daughters cost the mothers more than producing sons would? Charnov listened and modeled Clark's ideas mathematically. They worked. The term local resource competition was chosen in homage to William Hamilton and his concept of local mate competition, and it has been adopted by all subsequent researchers.

Since then, local resource competition has received support from far-flung quarters, as both an explanation and a predictor of sex ratio biases. Recently, Australian National University's Alexander Cockburn reported that for Antechinus, a genus of mouselike marsupials, there is an inverse correlation between the likelihood of mother-daughter competition and the proportion of daughters born to those mothers. In some Antechinus species, females produce a single litter of offspring and then die. In others, the mothers breed more than once and daughters stay close to home, even sharing their mother's nest when the next breeding season rolls around. Mother and daughter are thus potential competitors, and apparently to avoid this, the long-lived mothers produce male-biased litters (see Natural History, March 1988).

But what if a daughter were to compete not with her mother but with other, unrelated females in a large group? Such females should be especially reluctant to share scarce resources with the interloper, with whom they have no genetic interests in common. Herein lies one of the more fascinating twists to the tangled collection of sex ratio research results.

When Trivers and Willard first proposed their hypothesis, they had in mind creatures, such as the red deer, where males are the gambling sex, the players who either win big or very possibly lose out altogether in the competition for mates. Little thought was given to the possibility that females' reproductive abilities might also be quite variable and that in some species, the mother's rank matters more to her daughters than to her sons. We now know, for example, that among baboons and macaques, females belong to powerful matriline and that rank—high or low—is passed from mother to daughter over several generations. In this system, sons disperse after adolescence while daughters stay at home, fitting into the hierarchy just under their mother. Females that defer to a high-ranking mother will one day, if they live long enough, defer to her daughters. (Social rank is not, however, inherited in any strictly genetic sense. Upsets occur, and when the opportunity arises, subordinates seize the chance to rebel and establish a new pecking order.)

Members of dominant matriline form lasting alliances to maintain their high status. The flip side of this, of course, is that some other matriline is usually being shortchanged. For some populations, low-ranking females eat and drink less well. They may produce fewer offspring, and those they produce are less likely to survive. High-ranking females haze and abuse daughters born to lower-ranking females. According to University of California anthropologist Joan
Silk, the daughters of low-ranking bonnet macaque females are so severely harassed that few live. No wonder, she argues, that stressed females produce fewer daughters than sons and that after birth, they care less for their all-too-often doomed daughters than for their sons. The sons, at least, will soon emigrate, leaving behind the disadvantages of their mother’s low rank.

In two other studies of matrilineal cercopithecine monkeys—of rhesus macaques kept in a colony at Cambridge University in England and of wild baboons studied now for over sixteen years in Kenya’s Amboseli National Park—low-ranking females have produced more sons than daughters. In the eighty births at Amboseli reported by the University of Chicago’s Jeanne Altmann, the proportion of sons produced by low-ranking females was nearly twice as high as that produced by high-ranking females, results that could have occurred by chance fewer than five out of a hundred times. Furthermore, painstaking behavioral observations have confirmed that high-ranking baboon mothers care for their daughters longer than they do sons, and such daughters have a higher survival rate than sons. Most strikingly, sons born to low-ranking mothers fare better than do sons born to high-ranking mothers (see *Natural History*, September 1982).

Data from other sites raise the question of how widespread this pattern is. At one other site where Old World cercopithecine monkeys have been studied, high-ranking mothers were reported to produce significantly more sons. At four other sites, a mother’s rank had no effect. Such diversity of results has inspired heated discussions among primatologists. We do not yet know how general the Amboseli results will prove to be, but they are solid. And while the results run counter to the pattern first envisioned by Trivers and Willard (that is, overproduction of sons by high-ranking mothers), they may actually provide the sort of exception that confirms the larger rule: biases in sex ratio follow anticipated gains for parents in terms of numbers of grandchildren. In the case of Meg Symington’s spider monkeys—a population that conforms rather precisely to the Trivers-Willard model—the mother’s rank can directly influence her son’s success. But that same mother presumably has little influence on her daughters, since spider monkey females leave their natal group. Among the Amboseli baboons, however, it is sons who push off, passing forever from the maternal sphere of influence. As Jeanne Altmann points out, it is the stay-at-home daughters who stand to benefit most (or suffer least, as the case may be) from their mother’s rank and who will contribute to the future fortunes of her lineage.

The evidence appears to be mounting. Among our animal relations, mothers are better off having sons in some situations, daughters in others, depending on the social and ecological setting. And at least some of the time, some of these mothers appear capable of tilting toward the “sex of the hour.” Could anything comparable apply to our own species? Surely there cannot be any relation between human sex preferences and the sort of evolved propensity to bias sex ratios found in fig wasps and bush babies.

In fact, that possibility was very much on the minds of Trivers and Willard when they published their hypothesis and was another reason their paper was met with skepticism. While acknowledging the difficulties, Trivers and Willard nevertheless believed that their model could be applied to “humans differentiated on a socioeconomic scale, as long as the reproductive success of a male at the upper end of the scale exceeds his sister’s, while that of a female at the lower end of the scale exceeds her brother’s. A tendency for the female to marry a male whose socioeconomic status is higher than hers will, other things being equal, tend to bring about such a correlation, and there is evidence of such a bias in female choice in the United States.”
Trivers and Willard cited data indicating that wealthy
Americans produce relatively more sons than daughters.
Most scientists are more cautious on this point, and only a
few would agree, on the basis of the data currently
available, that parents give birth to disproportionately more
sons or daughters depending on their socioeconomic status.
Many would agree, however, that there is considerable
discrimination in favor of one or the other sex after birth
and that more often than not, sons are preferred. Indeed
some anthropologists are now hard at work, attempting to
use the logic of Trivers and Willard to explain nothing less
than the origins of patriarchy. These efforts are
concentrated on a small subset of human cultures: those
highly stratified societies in which women by custom and as
a matter of family honor are hypergamous, that is, marry
up the social ladder. For it is in these highly stratified
societies that parents have overcome the normally
conservative human sex ratio, albeit at a high price: the
selective neglect or even outright infanticide of daughters.

Such societies are exemplified by certain eighteenth- and
nineteenth-century castes of northern India. Using a variety
of historical materials, including records kept during the
British campaign against infanticide, anthropologist
Mildred Dickemann of California State University at
Sonoma investigated female infanticide among the
Rajputs, Sikhs, and other high-status groups. She found sex
ratios as high as four little boys for every surviving little girl.
In some high-status families, no daughter had been allowed
to live for generations.

From the dusty census records emerged the cruel
realities of life among these people, who found the means to
create sex ratios as extreme as any in mammaldom, except
perhaps those of the little wood lemming. Indeed the very
name of one of the Sikh clans—Kuri Mar—means
"daughter destroyers." After eliminating their own
daughters at birth, high-status families obtained wives for
their sons from lower-ranking families within the same
caste. These families competed among themselves to amass

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**Daughters Dearest**

“How do you tell the sex of a chromosome? You pull
down its genes.” The silliness of this riddle appeals to
students of avian sex ratios because it conveys something of
how difficult sexing young birds can be. Unlike many adult
birds, male and female juveniles are almost always indistin-
guishable, and telling them apart usually requires either the
surgical examination of the gonads or chromosomal analy-

sis.

Red-cockaded woodpeckers are a striking reversal of the
rule. In their very first plumage, males boast a bright
medallion of red feathers that covers much of their crown—
a badge that is clearly visible at all times—while females
have solid black crowns. Once the males undergo their first,
postjuvenile molt and enter adulthood, however, black
feathers replace the red crown feathers. As a result, most of
the time, adult males and females look exactly alike, with
males’ red feathers—now small tufts, or cockades, on the
sides of the crown—hidden by the black crown feathers
that cover them. Only during aggressive interactions does
the male raise his crown feathers and reveal his red cock-
ade.

These distinctive traits enabled me and my colleague
Mike Lennartz to discover another extraordinary fact
about red-cockaded woodpeckers: in the populations we
studied, almost two sons are fledged for every daughter. In
most birds, the ratio of male to female young is close to 1/1,
reflecting Fisher’s rule that because the reproductive value
of sons and daughters is equal, total investment in the two
should be the same. Thus, if Fisher’s rule holds for red-
cockaded woodpeckers, sons—the abundant sex—should
be somehow individually less expensive for parents to pro-
duce than daughters—the rare sex. We investigated how
this might have come about.

Sons and daughters are the same size. They grow at the
same rate and fledge at the same ages, so differences in size
and development do not explain how red-cockaded wood-
pecker sons might be less costly than daughters. Daughters
leave home months before sons, so, if anything, daughters
should be less expensive to raise.

The key seems to lie in the birds’ distinctive social behav-
ior. Red-cockaded woodpeckers are one of the few North
American birds with a cooperative nesting system in which
nonbreeding individuals help. The helpers at the nest, al-
most always adult sons of one or both of the breeding adults,
icubate, guard, and feed the young.

The helping habit is explained most readily by the lim-
ited habitat available for breeding, which may also account
for the species’ presence on the endangered species list.
Red-cockaded woodpeckers are found only in the few re-
maining southern forests with stands of mature living pines.
Groups of these birds excavate deep nesting and roosting
cavities in the trunks of mature trees infected with “red
heart,” a fungal disease that softens the heartwood. Thus,
a dowry large enough to win a place among the elite for their daughters. Parents who managed to marry their daughters into elite households as the wives of the well-to-do might well not have any granddaughters (for these would most likely be eliminated at birth), but their grandsons would enjoy a greater than average likelihood of surviving and reproducing. Among high-status families, harem polygyny and concubinage were common. Sons born to these families would thus be likely to sire many more children than any daughter—were she allowed to live—could bear. As for the sons of low-ranking families, few had any opportunity to marry.

The big difference between the Rajput and Sikh parents and the little wood lemmings, of course, is that the people were consciously calculating the costs of rearing male and female offspring. People in India discuss at length the size of the dowry that will be needed to marry a daughter into a family with status equivalent to, or higher than, her own. Family honor is on their minds, as well as benefits in terms of prestige to be won—or lost—for a child who marries advantageously—or fails to.

More than a century ago, when a landholder from Uttar Pradesh was asked whether privileged people such as himself were still killing their daughters, he answered simply that of course they were: “The father who preserves a daughter will never live to see her suitably married [and] the family into which she does marry will perish or be ruined.”

The concern of parents—rich and poor—went beyond immediate questions of family honor or the labor potential of sons versus daughters; they had in mind the very survival of the lineage. For as Dickemann explains, these people lived in an ecologically perilous world. Recurrent famines and disease routinely culled the dispossessed. Lineages blinked on and off in a dark and forbidding landscape. Even among landholding families able to maintain their prestige and their property, only the most fortunate would survive for many generations. By more enlightened standards, the suitable nest sites are scarce, and breeding opportunities are few. All of which encourages adult sons to stay at home and—while waiting for their own opportunity to breed—help with the nesting attempts of their parents or sometimes of brothers who have ascended to breeding status.

On average, more young birds fledge from nests with helpers than from those without. Therefore, while raising sons and daughters to fledging may seem equally expensive, a son may return some of the parents’ investment by helping them raise yet more offspring. This may reduce his own net cost and may have led, over evolutionary time, to a population sex ratio that favors sons.

At the level of the individual, the story has additional wrinkles. Breeding females sometimes move from one colony to another. When a female makes such a move and begins to breed in her new home, she either does so without any help at all or she may receive help at the nest from unrelated males, generally the sons of her new mate. In either case, the first few clutches of such a female are almost always biased toward sons. However, after she has produced enough sons so that they become her helpers, she begins producing more daughters. It seems that the female’s first need is to assure her own genetic representation in the colony, and since red-cockaded woodpecker males tend to remain at home and wait for a chance to breed there, sons are the best way to accomplish this. The production of daughters, which will almost certainly leave and breed elsewhere, must wait until this requirement can be satisfied.

Patricia Adair Gowaty
Why are the babies of low-ranking black-faced black spider monkeys almost always females?

"strategies of heirship" worked out centuries ago by these turbaned warriors in their walled Rajasthani villages may seem inestimably cruel, but given the rules of the game, their calculations were shrewd ones.

Similar ends were apparently pursued by upper-class parents in medieval Portugal, although the means to the end were more refined. As the intriguing ramifications of the Trivers-Willard hypothesis began filtering through to the social sciences, James Boone, a young anthropologist from the University of New Mexico, was finding some striking marriage patterns in the medieval Portuguese genealogies he was studying. Boone had laboriously taken data from a compendium of family histories called the *Peditura Lusitana* and translated it all into his computer so that he could analyze demographic trends for various social strata: royalty and other titled elites, the bureaucrats who surrounded the royal court, the landed gentry, and soldiers. Unfortunately, but as usual, no written records existed for the poorest, laboring classes.

For the two hundred years between 1380 and 1580, Boone traced the fates of sons and daughters from the various social classes. The graphs he came up with would have been strangely familiar to Trivers, now at the University of California at Santa Cruz. At the highest ranks, men were more likely than women to marry. Why so many elite women never married was simple enough. At any given point in time, between 10 and 40 percent of them were being sent to convents. And the elite women who did marry produced fewer recognized children than did their brothers at the same social level. At the lowest ranks for which records exist—soldiers—the opposite was the case: daughters were more likely to marry and have children. (Bastard children were rarely recorded at any social level.)

When Trivers and Willard first hypothesized that in some situations mammalian parents should sometimes have the ability to manipulate the sex ratio of their offspring before birth, many biologists dismissed the idea as just one more step in the misguided quest for adaptive explanations for what are in fact accidental or coincidental phenomena. Trivers himself was more philosophic. I remember him saying, "Even if I'm wrong, it will take them years to find out." That much at least has turned out to be prophetic. Certainly, no one could have guessed just how many and how diverse would be the multitude of scientists swept up into this wild and woolly world of sex ratio research.
Outfoxing the Fox
by J. David Henry

David Macdonald has certainly paid his dues as a field biologist. His highly readable book Running with the Fox describes his fifteen years of research on red foxes in the suburbs and farmlands surrounding Oxford, England, his principal study area to this day. Macdonald details his efforts to livetrap these elusive predators and to follow their nightly movements using radiotelemetry. It took five months of taxing work before he captured his first fox, a prime male, which he named Denman’s Dog. After examining the animal and equipping it with a radio collar, he released the fox only to watch it flee into the woods with “not so much as a crinkle emanating from his transmitter again.” Later that spring, Macdonald dug a pregnant vixen out of her den. Electronic difficulties solved, he radio tracked the vixen night after night until late April, when he decided to take a night off. The next day he discovered that “the earth had been dug in and gassed. The whole family was dead.”

These were trying moments, but Macdonald persisted, and after a few years he was capturing foxes and deciphering vulpine field signs almost as skillfully as a northern trapper; the radio collars, now equipped with beta lights and whipcord antennae, were functioning well. At one point Macdonald traveled to northwest...
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AIR INDIA

Britain to study red foxes in a radically different environment—the open, wind-swept moors of the Cumbrian fells. One day he found himself standing at an active fen in the company of Edwin and Arthur Dargue, local gamekeeper and enterprising shepherd, respectively. The brothers had brought Arthur's terrier, "a dog as hard as they come," to kill the vixen in her den; Macdonald was there to radio collar it. The three struck a hasty bargain. If Macdonald could dig the vixen out before the terrier killed it, she'd be his fox. The account of the contest that followed will not soon be forgotten! Later that night in the local pub, Edwin, in describing the events of the day to his moorland colleagues, said of Macdonald, "The lad chews nails and spits rust."

Such a glowing compliment from a Cumbrian sheepherder is not Macdonald's only endorsement; his other credentials are equally impressive. Macdonald began his fox research studying under Hans Kruuk in the Animal Behaviour Research Group of Oxford University, a group started by one of the founding fathers of ethology, Niko Tinbergen. He continues as a contributing member of that group, at present serving as the Ernest Cook Fellow in Animal Behavior at Oxford University. The combination of Macdonald's scientific acumen, field tenacity, and long-term commitment to red fox research makes this book a highly valuable work.

The central questions explored in the book are: How is red fox society organized? And how and why does it vary between contrasting habitats? The red fox is often described as a solitary species, but some of Macdonald's early observations find it acting surprisingly socially. Thus he sets off to explore the flexibility and complexities of vulpine social behavior. To do so, Macdonald studies fox populations that live not only in the rural land of Oxfordshire and on the moors of Cumbria but also in the center of the city of Oxford, as well as the desert coastal plain of the Dead Sea. Each study only grudgingly relinquishes its insights. Macdonald is a prudent man, not given to making facile generalizations, and most of the chapters are simply a record of behavioral events that he carefully documents on each of his study areas. However, at a few scattered places in the book, he synthesizes his observations sufficiently so that a tentative model of red fox society emerges.

RUNNING WITH THE FOX, by David Macdonald. Facts on File, $23.95; 224 pp., illus.
In his Oxfordshire and Israeli study areas, Macdonald finds foxes living not in exclusive pairs, with a dog fox and vixen occupying each territory, as many other researchers reported, but rather living in small groups of four to six adults with their offspring. Sometimes two adult males are present, but more typically there is one dog fox to which the vixens in the group show strong submissive behavior. Furthermore, his evidence suggests that the members of the group are usually related family members and are occupying and defending exclusive territories. The borders of these territories are sharply defined where prime foraging areas are involved, but in other, less productive parts of the home range, there is more latitude and neighborly tolerance.

Throughout the book, Macdonald's approach is to ask an important question and then to set about methodically collecting the necessary field information or conducting a behavioral experiment on captive foxes to answer it. David Macdonald and his wife, Jenny, have hand raised foxes for these experiments and some of their experiences with captive foxes are highlights of the book. Equally impressive are Macdonald's ingenious behavioral experiments. For example, he takes the
vixen Niff on leash-walking experiments to explore how a fox caches its surplus food and to discover the communication messages of scent marking. Toward the end of the book, Macdonald has moved on to releasing hand-raised foxes “to infiltrate as tame spies into wild fox populations.” “Imagine,” he says, “the possibilities of whistling up a couple of wild foxes who emerged from the undergrowth to enact their social exchanges in full view.” Few of the experiments are hastily executed. Sometimes it takes more than two years before the foxes have the correct behavioral background for an experiment. But Macdonald and his co-workers, a research team he calls the Foxlot, are committed to seeing the experiments through to completion.

In a chapter called “Fox Family Planning,” the research team uses all their field techniques to explore how a vixen’s status within her group influences her reproductive behavior. Macdonald acknowledges that over much of the red fox’s geographical range, family territories containing one male fox and one female may be the norm. But he also notes that whenever a family group with more than one vixen forms, the females normally establish a strict hierarchy and usually only the dominant vixen breeds. Groups with more than one vixen are more likely to form in areas where food conditions are stable, fox mortality is low, and vixens migrating off their parents’ territory are unlikely to find a vacant territory of their own. These factors work together as a type of vulpine social contraception. Vixens of lower rank are effectively sterilized by their status in the hierarchy. They rarely breed or whelp but rather act as “helpers,” assisting the dominant vixen in raising her litter. These low-ranking vixens remain socially sterilized until the dominant vixen dies or until one of the vixens challenges and successfully captures the dominant position from the reigning female.

Naturally, no volume is perfect, but my criticism of Running with the Fox rests more with the quality of the book’s production than with how it was researched and written. A sprinkling of typographical errors and misplaced words, a chapter given one title in the Table of Contents and a different one at the start of the chapter, several pages with incorrect chapter headings, all are distracting defects that should have been corrected. The book is generously illustrated with black-and-white as well as color photography, and with handsome sketches by Priscilla Barrett. However, some of the photographs lack resolution (the British climate abhors great depth of field), and certain of the color photographs suffer from poor color saturation.

My biggest disappointment with the book is that it has no bibliography. Most
people, I think, will be impressed with Macdonald's grasp of all forms of literature and research relevant to the red fox, and he discusses a number of vulpine research projects from various parts of the globe in the text. In my opinion, the book would have been more valuable if these sources had been cited in a bibliography. Finally, each reader's level of interest in red foxes will determine how much he or she enjoys the extended case histories of individual foxes that form a large portion of seven of eleven chapters.

Running with the Fox, however, definitely has more strengths than weaknesses. The thirty-two excellent boxes, or sidebars, answer such pertinent questions as: How does radio tracking work? What does the fox's body language mean? Why do foxes live in groups? Can wildlife rabies be controlled? Do foxes limit the number of their prey? Do people limit the number of foxes? Macdonald is at his best in these concise, sharp, reliable sidebars. The answers are not always simple, but Macdonald carries the reader as far as he feels he can go on each of the chosen topics.

In light of my own field research on Vulpes vulpes in a Canadian national park, I was particularly interested in the results of a study of foxes living in environments that had been greatly altered by human activity. The picture that emerges from my research in a near-wilderness environment is that of the red fox as a specialized predator of small prey (insects, songbirds, small rodents, rabbits), with highly evolved and intriguing adaptations for this type of hunting (a lithe build and disproportionately long hind legs and the evolution of many catlike behavioral and physical features). The red foxes of Macdonald's book are opportunistic and highly adaptable creatures (hunters of earthworms on lawns and in horse pastures and scavengers of afterbirths from domestic sheep during the spring lambing time). Both pictures are valid.

Macdonald states that "the red fox has the most expansive geographical range of any living carnivore." It is this magical combination of adaptability and specialization that has made Vulpes vulpes such a wildlife success story. Both dimensions must be understood if the evolutionary life strategy of the red fox is to be fully appreciated.

J. David Henry is an associate professor at the Saskatchewan Indian Federated College and in the Department of Biology of the University of Regina. He is the author of the recently published Red Fox: The Catlike Canine (Smithsonian Institution Press).
At the American Museum

The Once and Future Korea

In 1912, explorer and naturalist Roy Chapman Andrews documented life in remote villages in the north of Korea. Selections from the American Museum's collection of his photographs will be on display for the first time with other pictures and artifacts from traditional and modern Korea. Images of industrial Korea in the 1980s will be contrasted with rare scenes of rural Korean life in the early 1900s. The exhibition will be in the Akeley Gallery from Thursday, April 7, through Sunday, September 25.

From the Amazon to the Andes

Tribal peoples inhabiting the area from the rain forests of the Amazon Basin to the barren slopes of the Andes Mountains are the focus of a lecture series in the Main Auditorium beginning Thursday, April 14. The series examines the impact on hunter-gatherer societies of long-term interactions with anthropologists and

Marriage in traditional Korea conferred adult status. This picture of an eleven-year-old married "man" and a forty-seven-year-old unmarried "boy" was taken by Roy Chapman Andrews and will be shown in "The Once and Future Korea."
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Other social scientists and the ways in which those societies have been portrayed by ethnographers and museums. The slide-illustrated lectures include "Shamanism in the Upper Amazon," "The Andean Music Tradition," and anthropologist Napoleon A. Chagnon speaking on "The Yanomamo Indians: A Quarter Century of Study." The fee for this series is $30 and includes a special preview of the Hall of South American Peoples. For more information call (212) 769-5310.

Art and Mythology
The world of myth, art, and imagination are explored in a lecture series in the Main Auditorium beginning Monday, April 4. Topics include archeological and literary evidence for the legend of King Arthur, the myths and mountains of western China, and the Miraj Nameh, Mohammad's mystical ascent into Heaven. The fee for this series is $30. For more information call (212) 769-5310.

Ocean Frontiers
The New York Academy of Sciences, the Explorer's Club, and the Museum's Education Department observe National Science and Technology Week '88 by presenting three speakers on ocean research and exploration. Ichthyologist Eugene Clark will discuss reproductive behavior in tropical sandfish and deep-sea sharks. Historian Ed Peary Stafford will speak about the explorations and the Eskimo family of his grandfather Adm. Robert E. Peary. John Musick of the Institute of
Marine Science will discuss the use of satellite observation techniques to track sea turtles. The program, in the Kaufmann Theater at 2:00 p.m. on Saturday, April 30, is free and open to the public. For more information call (212) 769-5305.

In the Realm of the Wild

Animal painting, said the Swedish artist Bruno Liljefors, "requires three things—a love of nature and animals, great powers of observation, and the memory of a horse. A person may sit as a model for a portrait painter. This a fox will not do, but will disappear in a flash under a snow-covered spruce." Considered one of the finest wildlife artists in Sweden, Liljefors (1860–1939) remains little known in the United States. Influenced by Darwin, many of his canvases depict predatory relationships and natural selection at work. An exhibition of forty-five paintings by Liljefors, spanning five decades, will be displayed in the Naturemax Gallery from Friday, April 15, through Sunday, August 7.

Latin American Month

April is Latin American Month at the American Museum's Leonhardt People Center. Each weekend, music, dance, films, and lectures celebrate the cultural traditions of Central and South America. Musical highlights include Afro-Brazilian dances, folkloric music of the Andes, Mexican-influenced jazz, the African-derived and Latin sounds of the Spirit Ensemble, and Mexican and Argentine folk
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**At the American Museum, continued**

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**Members' Programs**

*From the Land of the Totem Poles*

The Jesup North Pacific Expedition of 1897–1902 sought to reveal the relationships between Northeast Asian and Northwest American peoples. Aldona Jonaitis, author of the new book *From the Land of the Totem Poles: Northwest Coast Art at the American Museum of Natural History*, will describe the hardships endured by the members of the expedition, the extraordinary artwork they collected, and the public's reaction to the project. A reception in the Hall of Northwest Coast Indians, which houses many of the artifacts brought back from the Jesup Expedition, will follow. The program, which is free and open only to members, will take place in the Main Auditorium on Tuesday, April 19, at 7:00 p.m.

**Wise Birds**

Live birds will join host Bill Robinson on Sunday, April 10, for a family program on owls. Special guests include a barred owl, a great-horned owl, a barn owl, a pearl-spotted owl, and an eagle. The program, which is open only to members, will be presented in the Kaufmann Theater at 11:00 a.m. and 1:00 and 3:00 p.m. Tickets are $2.50.

**Mosaics of Carthage**

David Soren, guest curator of the current exhibition "Carthage: A Mosaic of Ancient Tunisia," will discuss mosaics from Tunisia's Roman period (the first through the fourth centuries A.D.) on Tuesday, April 26. The lecture, which is open only to members, will be given in the Main Auditorium at 7:30 p.m., and the exhibition, in Gallery 3, will be kept open until 7:15 p.m. Tickets are $3.00.

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Cosmic Meetings

by Thomas D. Nicholson

This month we are treated to two close conjunctions of the moon and Virgo’s bright star Spica. The first takes place at about 2:00 A.M., EST, on April 3d. The second occurs on the 30th at about 9:00 A.M., after both moon and star have set. On both occasions, viewers in the Southern Hemisphere will see something even more dramatic—an occultation, or eclipse, of the star. From that vantage point, the moon will be just far enough north in the sky to cover Spica.

On the evening before each event a gibbous moon rises in the east after dark. Somewhat later, Spica, the only object visible in the moonlight, rises just below the moon. The star and the moon are in similar positions relative to each other both times. The moon will close very slowly with Spica as they climb up the sky, passing the bright star late on the night of the 2d-3d, and after dawn following the night of the 29th-30th.

The two conjunctions will be similar but not identical. The differences tell us something about the earth and the moon and their behavior. On the 2d, the moon and Spica rise earlier than on the 29th. They are barely above the horizon by dark. On the 29th they are well up in the east at dusk, higher than the later sunset on that day can account for. The difference in position illustrates the distance the earth has moved around its orbit by then. By the 29th, we on earth have moved enough to make Spica seem farther west in the sky and higher than where it was two hours earlier on the night of the 2d.

A second difference you should note is in the moon’s phase. The gibbous moon, just past full, on the night of April 2 is fat and bright with a slight darkness on its right side. On April 29 the moon is again gibbous, this time just before full, and the darkness is on the left side. That shows the moon is earlier in phase when it approaches Spica late in the month than when it approached the star earlier in April. The moon, already past full at the first conjunction, is almost two days before full when it returns to the star late in the month.

The motion around the sun explains the game, not of the earth alone, but of the earth–moon system. The second time the moon returns to Spica, the earth and the moon have moved almost one-twelfth of the way around the sun from where they were the first time. But before the moon can be full again, it must move still farther to come in line with the sun once more.

The time it takes the moon to make a complete revolution around the sun is called the lunar orbital period. The average lunar orbital period is twenty-seven days, seven hours, and forty-three minutes. The time it takes the moon to go through a complete cycle of phases, say from new moon to new moon, or from full moon to full moon, is known as the lunar month. The average lunar month is twenty-nine days, twelve hours, and forty-four minutes.

The moon takes about twenty-seven days and seven hours to return to Spica after its April 3 conjunction. After the full moon on April 2, the next full moon occurs on May 1, twenty-nine days, fourteen hours, and twenty minutes later (a little longer than the average).

Events in the calendar below are given in local time unless otherwise indicated.

April 1: The nearly full moon is up at sunset in Virgo.
April 2: Full moon occurs at 4:21 A.M., EST. After moonrise, Virgo’s Spica rises beneath the slightly gibbous moon.
April 3: This morning’s occultation of Spica occurs over the far southern world. Venus, at its greatest easterly elongation (to the sun’s left), is in its best evening show in recent memory. April evening Venusian elongations are always good. Because its celestial path is high up this time, Venus will set as much as four hours later than the sun and continue to dominate the western sky as a brilliant beacon. Also, at 2:00 A.M. on this date, clocks are moved one hour ahead for daylight-saving time.
April 5: The waning gibbous moon moves into Scorpius as it rises at about 10:30 P.M., EST.
April 6: After occulting it early today over the Southern Hemisphere, the moon rises close to Scorpius’s Antares but moves away from it during the night.
April 7-11: Keep your eye on the morning moon as it approaches and passes Saturn and Mars during the next four days. It will help you identify the planets for their summer visits this year.
April 7-8: Moonrise is at about 1:00 A.M., EST. Saturn is to the moon’s left.
April 9: Saturn is above the morning moon and Mars is below and to its left. Last-quarter moon is at 2:21 P.M., EST.
April 10: Mars is left of the moon in the dawn sky. Saturn (beginning its retrograde motion) is above the moon.
April 13: The moon, now a predawn waning crescent, is at perigee (nearest the earth).
April 15: Venus forms a triangle with the Pleiades and Taurus’s Aldebaran.
April 16: New moon, at 7:00 A.M., EST, is at the border between Pisces and Aries.
April 17-20: Watch the new, waxing crescent moon and Venus these nights, visible in the southwest at dusk. The moon is near the Pleiades on the 18th. The view of the crescent moon and bright Venus on
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the 19th is spectacular as the moon appears very close to the planet. That night, the moon passes close enough to cover Venus over arctic regions at about 9:00 p.m., EST.

April 20: Mercury is at superior conjunction (beyond the sun) and enters the evening sky.

April 21–22: The crescent moon is in Gemini, near the constellation's twin stars, Pollux and Castor, on the 22d.

April 23: Now in Cancer, first-quarter moon occurs at 5:22 p.m., EST.

April 25: Apogee moon (farthest from the earth) is in Leo, near the Lion's bright star Regulus.

April 26–29: The waxing gibbous moon is in Leo on the 26th, and moves into Virgo on the 27th, drifting slowly east between Regulus to its right and Spica to its left.

April 30: After occulting Spica over the Indian Ocean in the morning, the moon is to the star's left at night, moving away from it.

The spring Sky Map shows the sky for April, May, and June from 40° north latitude at the hours given below. To use the map, hold it vertically in front of you with south (S) at the bottom and match the lower half with the stars you see when you face south. As you face in other directions, turn the map to bring the corresponding compass direction to the bottom. The stars move continuously westward during the night. By morning (before dawn), those on the western half of the map will have set, those on the eastern half will have moved into the west, and new stars (those of the summer evenings) will have risen in the east. The map represents the sky at about 2:00 a.m. on April 1; 1:00 a.m. on April 15; midnight on April 30; 11:00 p.m. on May 15; 10:00 p.m. on June 30. Add one hour for daylight time. The map can also be used for an hour or more before and after the times given.
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A Matter of Taste

Marketing Nostalgia

On a very small scale, old-fashioned apples are making their way to greenmarkets

by Raymond Sokolov

Breezy Hill Orchard is a working apple farm on a pretty road that runs north from Poughkeepsie in Dutchess County. The farm is neither fancy nor big, just thirty-five acres that slope up sharply. But those thirty-five acres produce thirty-five different varieties of apples, apples that find their way to the 14th Street Greenmarket in Manhattan. The young woman who owns the orchard is one of several small producers in the Hudson Valley who are determined to preserve and restore the diversity of apples common in this country in our grandparents' day.

Elizabeth Seton Ryan is not a radical zealot. She is a pomologist from Cornell University who bought her place three years ago from people who had loved their trees and wouldn't sell to a real estate developer for top dollar. They wanted to retire with an easy conscience. They were looking for serious, competent farmers who would continue bringing apples to the greenmarket. Ryan and her husband, a linguist who has learned to do close-quarter mowing in the orchard, filled the bill. On the strength of her Cornell degree, Ryan was able to get credit from a grudging lender who really didn't think agriculture was a viable activity within two hours of New York City.

The first year, she barely scraped by. "Apple-raspberry juice paid our mortgage," she said during a quiet Sunday in her kitchen toward the end of the apple harvest last fall. Breezy Hill is doing better now. There hasn't been time or money to put in new trees yet, but the ones that came with the place are continuing to produce enough apples to make this comparatively small operation a tidy success, according to its owner.

Ryan did not grow up in farming. She was a suburban child who spent reluctant, bored summers on her grandparents' farm in Iowa. Somehow the experience took and she ended up at Cornell studying fruit production and acquiring a competence in farm ecology and agricultural sociology. She's put all that to use at Breezy Corners. On the one hand, Ryan runs her orchard without herbicides, something she can manage with a husband willing to maneuver a tractor armed with a sickle bar mower in and out of closely planted trees and an orchard small enough for him to cover. On the sociological front, she works during winters on the Hudson Valley Fruit Growers History Project, gathering old photographs and printed material and equipment, videotaping interviews, and working with a photographer to record

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and preserve documents and memories of the local apple industry.

For an outsider, however, the most evocative and potent piece of historical material that Ryan has to show is a renewable resource called the golden russet apple. This is an old-fashioned strain that was formerly produced in sufficient quantities to be listed in U.S. Department of Agriculture apple statistics. But it had several innate problems. Golden russet does not conform to the standards of ap-

Sadakelu Vinjal

(Duck and apple vindaloo, slightly adapted from Totally Hot! by Michael Goodwin, Charles Perry, and Naomi Wise, Dolphin Books)

1 whole plump duck, about 4 pounds (or 8 leg-thigh pieces)
½ cup vinegar (preferably cider or malt)
1 stick of cinnamon
8 whole cloves
2 bay leaves
4 cardamom pods, crushed
2 large onions, thinly sliced (about 3 cups)
4 large garlic cloves, sliced (about 2 heaping tablespoons)
1 teaspoon fresh ginger, finely sliced
¾ teaspoon turmeric
1⅛ teaspoons whole coriander seeds
1⅛ teaspoons whole cumin seeds
1 teaspoon ground black pepper
1 teaspoon garam masala (see recipe below)
4 dried red chilies (for example, hontaka, chile de arbol), minced
1 teaspoon salt, or to taste
1⅛ cups chicken stock

Half a head (5 or 6 ounces) green cabbage, halved, cored, and shredded (about 2 cups loosely packed)
2 medium green apples, peeled, halved, cored, and sliced thin (submerged in cold water with 1 teaspoon of lemon juice until ready to cook)
4 small green chilies, trimmed but not seeded, sliced thin (about ¼ cup)

1. Disjoint the duck into two leg-thigh pieces, two breast pieces, two back pieces, and two wings. Score the skin of each piece at ¼-inch intervals, trying not to pierce the flesh. Place the duck pieces in a cold, heavy 12-inch skillet (or two smaller skillets), skin side down. Brown them about ten minutes, turning once and pouring off excess fat. Reserve the fat.

2. Place the duck pieces in one layer on the rack of a steamer. (If you don’t have a steamer with a rack large enough to hold the duck pieces in one layer, use a deep broiling pan and its rack, and cover it tightly with aluminum foil during the steaming.) Fill the
Pearance that mass marketers have come to demand of apples in recent years: it is not red but yellow and—kiss of death—it's skin is russeted, marked with rough brownish dots. As a late-maturing apple, it once filled a niche in the market succession of different seasonal varieties. Today, this is of no advantage. The economy of large-scale picking makes late varieties unprofitable, while modern storage methods make the golden russet's excellent keeping qualities irrelevant. Today's pop-

pot of the steamer (or the broiling pan) with 2 cups of water, ¼ cup of the vinegar, cinnamon, 4 of the cloves, bay leaves, and 2 of the crushed cardamom pods. Set the rack in the steamer or pan, cover, place over medium-high heat, and steam about twenty-five minutes. Check from time to time and add boiling water if necessary.

3. While the duck steams, return to the skillet 3 tablespoons of the rendered duck fat and heat it until fragrant. Add the onion and fry it over a high heat, stirring, until the edges brown a little (about eight minutes).

4. Add the garlic and ginger, lower the heat and sauté them about two minutes until the garlic softens.

5. Add the turmeric, coriander seeds, and cumin seeds, and stir well over low heat for about one minute. Add the black pepper and garam masala and stir well for another minute. Add the dried red chilies, the 2 remaining cardamom pods, and the 4 remaining cloves, and stir well for about two minutes more to blend flavors.

6. Add the remaining ¼ cup vinegar, salt, and chicken stock. Stir and add the shredded cabbage and half the apple slices. Cover and simmer about twenty minutes until the cabbage is nearly tender.

7. Add the steamed duck pieces, the remaining apple slices, and the sliced green chilies. Cook five minutes more. Serve with rice and/or puri and any other side dish you may fancy.

Yield: Four servings

Garam Masala

2 tablespoons cardamom seeds
2 tablespoons ground cinnamon
2 tablespoons whole cloves
1 tablespoon cumin seeds
1 tablespoon mace
¼ teaspoon ground nutmeg

Place the spice mixture in a skillet and roast it lightly over a high flame until the spices darken. Then grind it in an electric spice mill or a clean coffee grinder (or with a mortar and pestle). Store in an airtight bottle.

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108 Natural History 4/88
growers can buck this trend with modest success because they can market their old-fashioned apples directly to consumers who want them. The smallness of their operations is itself an advantage, allowing them to pick each variety when it's ready, instead of being forced to pick one large tract of, say, McIntoshes too early, because they can see their "Cortlands will be right on top of them."

Ryan also says that her kind of small orchard makes better use of its coolers. There aren't truckloads of apples coming in all day, so the cooler doors are almost always closed and the inside temperature stays at an optimal 35°. Constant traffic at the coolers forces farmers to keep the cooler doors open for extended periods, and temperatures can often rise to 50° on a busy day, she asserts.

Not everyone in the apple business agrees with Ryan. She herself readily concedes that big producers do a remarkable job on a remarkable scale. But she is essentially in a different business from them. One Hudson Valley apple expert told her she's marketing nostalgia, "selling to people who remember having a Baldwin when they were kids." The same man, an apple scientist, dismisses her antique varieties as garbage apples.

This is not so much the voice of a paid tool of the mass apple system, I think, as the sincere opinion of somebody whose taste has been formed by the above-ground, narrow definition of what an apple is. I gave one of Ryan's golden russels to a good friend without making much of it. "It's green," he said, "isn't it?" He couldn't relate the subacidity of the golden russet to anything else in his experience except the few really green apples he'd picked from trees himself.

Corruption of taste, narrowing of thresholds of acceptability—these are the real evils that megamarketing of apples brings us. But there are healthy examples of a countertext even in supermarket bins. The Granny Smith apple came to us from Australia recently and caught on in a big way. It is an interesting apple by anybody's standards. So are the Ida Reds my neighbors produce. These apples arrived from Idaho after the war, and they offer big growers a quality alternative to the Delicious. Ida Reds satisfy all of the mindless requirements for big-time success. They are big and very red, but they also have a noticeable taste. Pass the word. But don't tell anyone about golden russels until I get mine.

Raymond Sokolov is a writer whose special interests are the history and preparation of food.

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Wrongs of Spring

Early birds caught by a late March snowfall, a pair of mute swans tend their nest on Bavaria’s Swan Lake, their five-week incubation period already under way. The male, or cob, patrols, while the female, or pen, remains folded over her eggs. These swans overwinter on a nearby ice-free river. In spring, the cob chooses a lakeside nestsite within neck reach of ample reeds and rushes. If the pen approves, she takes over construction of a mound and nestles in its center. When the water rises, the buoyant nest becomes a raft.

The heaviest of all flying birds, with wingspans of about five feet, mutes are also the most territorial of the swans and can mount a formidable defense of nest and young. When they rout an intruder, a pair congratulate each other in a “triumph display” of neck stretching and rubbing and happy snorting. (While their voices are not strident, the swans are far from mute.)

Most mute swans mate for life and are steadfast not just when hormones surge but throughout the year. Especially affectionate, mutes could have inspired Yeats’s vision of swans that paddle “lover by lover” in “cold/companionable streams . . .” This dogged, dignified pair outlasted the snow and went on to raise a brood of cygnets in the warmth of spring.

J.R.

Photograph by Günter Ziesler
Authors

Sarah Blaffer Hrdy (page 63) is a professor of anthropology at the University of California at Davis. Her work and writings have long touched on how offspring fare in the high-stakes game of reproduction that primate parents play. Her research topics have ranged from infanticide in Hanuman langurs (an Indian species she studied between 1971 and 1979) to last will and testaments in Sacrament County. Hrdy lectured on the topic of sex ratios at the third T. C. Schneir Conference, held in 1985 at the American Museum of Natural History. A common thread in all her work has been her interest in understanding how and why parents may invest more in sons or daughters—at birth and afterward. Currently, Hrdy is writing about such matters on a Guggenheim fellowship. Her previous publications include several books: The Langurs of Abu: Female and Male Strategies of Reproduction (Cambridge: Harvard University Press, 1977); The Woman That Never Evolved (Cambridge: Harvard University Press, 1983); and Infanticide: Comparative and Evolutionary Perspectives, coedited with Glen Hausfater (New York: Aldine Publishing Co., 1984). Scientific papers on sex ratios are too numerous to mention, but for readers wishing to delve more deeply into the topic, Hrdy suggests chapter 11 of Robert Trivers’s book Social Evolution (Menlo Park: The Benjamin-Cummings Publishing Co., 1985). She also recommends the more technical The Theory of Sex Allocation, by Eric L. Charnov (Princeton: Princeton University Press, 1982).

For years, reports in the scientific literature have suggested that among reptiles, gender is determined by incubation temperature. While on a postdoctoral fellowship in genetics at the University of Wisconsin, James J. Bull (page 70) decided to look into the matter. He began by marking turtle nests along the Mississippi River, noting the temperature at each nest, and waiting to see what hatched out. He also conducted parallel studies in the laboratory. His work convinced him that environmental sex determination was indeed going on, and later, at the University of Sussex, he began to write up his thoughts on the subject. The result, in 1983, was a book: The Evolution of Sex Determining Mechanisms (Menlo Park: The Benjamin-Cummings Publishing Co.). Bull, now an associate professor at the University of Texas at Austin, plans to investigate the physiology and molecular biology of sex determination in vertebrates.
Although John H. Werren (page 68) knew as a beginning Ph.D candidate that he wanted to concentrate on theoretical questions pertaining to sex ratios, he "floundered about" for the first three years in search of a good study animal. But as soon as the jewel wasp was brought to his attention, he was off and running. After receiving his degree, however, Werren spent four years in the Army to fulfill an ROTC obligation incurred as an undergraduate. For three of those years, he was in a U.S. Army public health lab in Germany, gaining on-the-job training as a bacteriologist. This training stood him in good stead when he returned to his research, for—as he was to discover—jewel wasps carry many inherited microorganisms, some of which may affect sex ratios and the genetic structure of populations. For more on sex ratio manipulation by wasps and bees, see Werren's article in the July/August 1987 issue of Bioscience. Now an assistant professor of biology at the University of Rochester, Werren also has a long-range interest in the use of some of the world's 100,000 species of parasitic wasps to control insect pests.
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Steven N. Austad (page 74) graduated from college with a degree in English literature. But after three years of training lions, tigers, and other large animals for the movie industry in Hollywood, he returned to school to study science and is now an assistant professor in Harvard's Department of Organismic and Evolutionary Biology. Austad, above, was first forced to pay attention to opossums when they began interfering with coauthor Mel E. Sunquist's efforts to live-trap crab-eating foxes and ocelots in Venezuela. Austad and Sunquist decided to take advantage of the opossums' irritating habit of repeatedly getting caught in the traps and asked how they could make use of these animals. Austad says, "The sex ratio hypothesis jumped right out at us." Austad's current research—on aging, sexual selection, and sociality—involves him with a wide range of creatures: spiders, flour beetles, and tropical weevils, as well as the ever-useful opossum (about which he wrote in the February 1988 issue of Scientific American). Sunquist, below at right, a wildlife ecologist at the University of Florida in Gainesville, is continuing his research on the reproductive strategies of opossums, but he, too, studies a diversity of animals, most of them distinctly more carnivorous than opossums. He has researched ocelots in Venezuela; tigers, leopards, and sloth bears in Nepal; and snow leopards in Pakistan. Sunquist and his wife, Fiona, have a book, Tiger Moon, coming out this spring from the University of Chicago Press.

When Robert R. Warner (page 76), then a Ph.D. candidate at Scripps Institution of Oceanography, heard in 1970 that some fishes could change sex, he was hooked. He chose sex change in fishes as the topic of his thesis, and has been studying this and other aspects of fish biology ever since. Four years ago, he summed up many of his findings on mating behavior and hermaphroditism in coral reef fishes in American Scientist (vol. 72, pp. 128–36). A professor of marine ecology at the University of California at Santa Barbara, Warner is now investigating such questions as why some fishes take care of their young and others do not. Pursuing his research subjects takes him to such enviable places as Saint Croix, Corsica, the Galápagos, and Panama's San Blas Islands. He likes to bring his family along on extended stays in the field for "it's the best way to get to know both the fishes and my sons." In his spare time, Warner enjoys fishing and collecting banana stickers.
At first, red-cockaded woodpeckers were a bit of a digression for Patricia Adair Gowaty (page 80). For the past decade, most of her research attention has been devoted to eastern bluebirds. Studying these "bluebirds of happiness" in South Carolina, Gowaty found striking amounts of fighting going on: males against males; females against females. Much of the aggression seemed to revolve around the species' dependence on cavities for breeding. A female without a cavity to call her own may dump her eggs in a rival's nest (see "Bluebird Belligerence," Natural History, June 1985). At present, Gowaty is investigating the various mechanisms—behavioral and ecological—that may have evolved to thwart attempts at egg dumping. She is also interested in what determines when and why bluebirds leave their territories. In the future, Gowaty, a visiting associate professor of biological sciences at Clemson University, hopes to continue her woodpecker studies, with a view toward learning more about which possible behavioral and demographic factors lead to skewed sex ratios in this species. When not following the affairs of woodpeckers and bluebirds, she pursues a strong interest in politics, especially how it is affected by gender.

Günter Ziesler (page 110) has photographed wildlife in many exotic locales, but he came upon the ethereal scene depicted in "The Natural Moment" on his home ground in the Bavarian Alps, where mute swans are year-round residents. He used a Nikon FE-2 with a 80–100-mm zoom lens to photograph the birds nesting on Schwansee, or Swan Lake, just below the two fabulous mountain castles built by King Ludwig II of Bavaria. As a boy, Ziesler was fascinated by his grandfather's cigarette cards depicting Mount Kilimanjaro and African wildlife. Widely traveled in Europe, South America, India, and parts of Asia, Ziesler realized a lifelong dream when he spent a full year photographing in Kenya in 1981. The results can be seen in his book *Safari* (New York: Facts on File, 1984), with text by Angelika Hofer. His work also illustrates Valnik Thapar's *Tiger: Portrait of a Predator* (New York: Facts on File, 1986).

A third-year student at Cornell University's New York State College of Veterinary Medicine, Steven A. Osofsky (page 50) got his chance to work with the endangered Florida panther last summer, when he served as assistant to Melody Roelke, veterinarian for the Florida Panther Project. His first, "life-changing" experience with field conservation had come the year before when he started vet school, when a Harvard University Travelling Fellowship enabled him to journey to Kenya, Tanzania, and Rwanda to observe wildlife species in their natural habitats and to examine conservation problems from a variety of perspectives. That led to the next summer's work studying heat regulation in elephants in Kenya's Tsavo East National Park and ultimately to his decision to spend at least part of his future career on projects involving the reintroduction of captive-bred animals into the wild, and managed breeding schemes integrating captive and wild stock. When not in the field, the lecture hall, or the clinic, Osofsky—pictured above with a cheetah—enjoys camping, photography, scuba diving, and racquetball. For anyone interested in understanding why we must try to preserve endangered species, he says that *Extinction: The Causes and Consequences of the Disappearance of Species*, by Paul and Anne Ehrlich (New York: Random House, 1981) is mandatory reading.
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Semelparous Folklore

I offer the following as a footnote to the fascinating article on the marsupial Antechinus, by Andrew Cockburn and Anthony K. Lee ("Marsupial Femmes Fatales," March 1988).

The notion that the semel- in semelparity ("single reproduction") has some connection with the Semele of Greek myth looks like a bit of biologists’ folklore. The word semel in Latin means "once, a single time," so that semelparity parallels iteroparity ("repeated reproduction"), with iter- borrowed from Latin iterum, "once more, again."

Another learnedism with semel is semelfactive, a linguistics term referring to classes of verbs in Slavic languages that denote a single, usually abrupt occurrence of an action.

JAMES RADER
Editor (Etymology)
The Random House Dictionary of the English Language
New York, New York

Columbus and Corned Beef

Raymond Sokolow’s piece in Natural History ("A Matter of Taste," February 1988) surprised me with its recollection of our meeting in Paris in 1966. But if I really proposed that intrepid Jews already "en- soonered" in the New World were offering the early explorers “chopped liver” or “corned beef sandwiches,” it was surely a joke.

However, when Vasco da Gama sailed around Africa to become the first European to reach India by boat, he was greeted, according to his Journals, by someone who spoke both Spanish and Portuguese. The man was the grand vizier of Goa. He told Vasco da Gama that he was of Polish Jewish ancestry, had been raised in Alexandria, and had ended up in Goa, where he was running the place. However, he was so impressed by da Gama’s ship, and by what he was told about Europe, that he joined the expedition, changing his name to Caspar da Gama when he converted to Christianity. (Vasco da Gama was his godparent.) Caspar apparently spent the rest of his life sailing as the official translator for the Portuguese voyages of exploration. Amerigo Vespucci reported meeting him in what is now Sierra Leone, and Magellan met him near what is now called the Malay Peninsula.

Luis de Torres, the interpreter on Columbus’s first voyage, was a Jew who converted on the gangplank because Queen Isabella would not allow an unconverted Jew on the voyage. Columbus said he took de Torres as the interpreter because he knew Hebrew and some Arabic, which sheds some light as to where Columbus thought he was going. Luis de Torres became the first European to touch land in the New World. He was sent off to find natives and talk to them. One can only speculate about these conversations.

Without going into detail, we know there were Jews in Cortés’s army, on Ponce de Leon’s expedition, and on Coro- nado’s. There is even some evidence that Pizarro was of Jewish origins.

I know nothing about what these people ate, and whether, if they ate some kind of Jewish cuisine, they offered it to others: the natives or the European Christians. I do think it is of interest that Jews were already spread over the planet and were not just in ghettos in Europe. In their involvement with the voyages of exploration and the colonization of the non-European world, one might have expected that they functioned as bankers and suppliers of the voyages, which they did. But they also were in the forefront of extremely risky ventures, at least in the early days. If there were just a few unusual cases, like Caspar da Gama’s, one might write them off as rare phenomena not worth pondering. But the number of people of Jewish origin who went on the voyages, who explored and established settlements, is surprisingly large for the time. Doubtless some were fleeing the Inquisition, but not doing it the easiest way, that is, moving to Italy, the Ottoman Empire, France, or Holland. But fleeing to what?

In answer to this I offer another theory. Miguel Servetus, the Spanish heretic, later burned at the stake in Geneva, wrote in about 1520 that the New World was the Elysian fields where the oppressed and persecuted could find peace and happiness. America had not yet been opened to immigration, but even this early there was the suggestion of its function as a place of refuge for the outcasts of Christian Europe. In America, Bartolome de Las Casas (of Jewish origins) and Alonso de la Vera Cruz (of Jewish origins) tried to create an idyllic world for the Indians, from which the conquistadors would be barred. Las Casas spoke of the possibility that some of the sacred Elect of God, mentioned by Saint Paul, were among the Indians and had to be saved, protected, until the divine climax of human history, when they would play a crucial role.

The Ten Lost Tribes speculation started early, and still goes on all over the planet. Reports come from America, the Pacific, Asia, and Africa of groups speaking Hebrew who have Jewish practices. There was a desire to find the lost tribes because they were essential to the scenario by which the world would be saved. The lost tribes would lead the Jews back to the Holy Land, and then the Messianic age would begin. Both Jews and Christians kept looking for signs of the lost tribes and were rather credulous about the evidence.

So much importance was given to the search that I think this may have influenced various Jews to undertake it.

RICHARD H. POPKIN
Pacific Palisades, California

Wild Apricots

Raymond Sokolow certainly is correct: there is nothing like the taste of a tree-ripened apricot ("A Matter of Taste," January 1988). But he, and most folks, have tasted only the large, cultivated varieties, picked green and shipped to the local supermarket. Here in Idaho, wild apricots can be found in relative abundance in our deep canyons. These wild trees, growing on semiarid canyon walls, are progeny of orchard trees. While the fruit is small—about one inch in diameter—the flavor is fantastic. These deep canyons act as heat sinks, and the naturalized apricots often bloom in March. Steep slopes provide rapid air drainage and thus, in most years, adequate protection from the late frosts that plague apricots on flat terrain.

FRED JOHNSON
Moscow, Idaho
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The Secret Swarm

In the predawn mass mating of sand-burrowing mayflies, timing is everything

by William L. Peters and Janice G. Peters

Our first reaction to the bizarre sand-dwelling creature was, "Can this be a mayfly nymph?" We were new to Florida, just starting to collect aquatic insects in the state, and unfamiliar with the sand rivers where we would spend much of the next twenty years. After taking a harder look, we detected a similarity to published drawings of the nymph, or immature stage, of the American sand-burrowing mayfly, Dolania americana, known then from just a half dozen nymphal specimens in the Western Hemisphere, and not known at all in the adult stage.

Perhaps the unusual nymph had gone largely unnoticed because sand was thought to be an inhospitable habitat. But nymphs hiding in sand could not explain the even more puzzling absence of adult sand-burrowing mayflies. Although we, too, searched, we failed to find living adults. We did, however, find adult remains in spider webs, and for a time we had to be content with robbing webs for dead mayflies, a poor substitute for observing the living animal.

Early one morning a colleague, Jerome Jones, went insect collecting and saw Dolania male and female adults mating, and dying, before sunrise. Synchronized, very rapid, mass mating in the dawn hours would explain why adults had never been collected. Our determination to observe a Dolania swarm marked the beginning of our research on the maturation and mating of this mayfly. We found that of the two-year Dolania life cycle—one year spent as an egg and most of the second year as a nymph—the adult stage accounts for less than two hours or one ten-thousandth of a mayfly's life span, equivalent in human terms to two days in forty-eight years.

A larval life spent tunneling open-eyed through coarse sand requires some modifications and specializations, and these account for the nymph's unmayflylike appearance. Protective hair patches on large outgrowths on its head give Dolania prominent "eyebrows." The middle legs are paddlelike for burrowing, but the front legs are reduced to structures resembling an extra pair of mouthparts, probably to assist this aggressive carnivore in catching sand midge larvae and other prey.

Dolania is not rare, but its distribution is spotty and its habitat is limited. Although its range covers the coastal plain from Louisiana to Virginia, this mayfly's nymphs live only in clean areas of undisturbed, shifting sand bottoms of larger streams and rivers that have never suffered serious ecological disruption.

During our first few years of research, our attempts to observe adults (in the three weeks a year they are likely to hatch) were largely hit and miss. On one beautiful morning we would see nothing; then the next morning a huge swarm would appear. In 1973, we organized friends, family, students, visiting professors, and co-workers for shifts of what turned out to be a thirty-five-day Dolania watch. Through the cooperation of Florida's Game and Fresh Water Fish Commission and Division of Forestry, we had the use of a field station and study site on the protected Blackwater River.

A participant in a Dolania watch gets up at three in the morning to be on the river with equipment by four. The sun rises around six, but the mayflies may begin to emerge up to one and three-quarter hours earlier. The hatch begins when male nymphs swim to the river surface, shed their nymphal skins, and fly to vegetation or sand banks to complete the next stage of life. Mayflies undergo a preliminary winged stage, the subimago, or subadult, before achieving full, winged maturity. In the case of Dolania (and a few other mayflies), the female has dispensed with the final molt and is fully mature as a subimago.

Thus, males have one more life history stage than do females, but to mate, males and females have to be together at the same time and place. To accomplish this meeting, males hatch earlier and rush through the subimago as quickly as air temperatures allow, from twenty-three minutes at 50°F to five minutes at 73°F. Males hasten the process further by breaking off their middle and hind legs and taking to the air as soon as their wings are free of the old skin. Without functional legs, males spend the rest of their lives in flight. They patrol aerially about three feet over the river searching for emerging females. Even an hour before sunrise, females coming out of their old skins are visible to males—and streamside naturalists—because of their large wings, which are a consistently bright, reflective white. Pairs form as soon as the females emerge. Often, males fly above emerging females until the females take wing, then mate.

American sand-burrowing mayfly

Janice G. Peters
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immediately. If a male is present when a female emerges, she may not spend more than a few minutes in flight in her entire life. The male approaches from behind and underneath the female, copulates for two to five seconds, then disengages and goes on to search for other females. If no males are present, females fly slowly in an undulating pattern, displaying their wings. We presume this display is intended to catch the attention of any available males; at least, the strategy has that result.

We have found no evidence that females choose their mates; females most likely never even see their mates. And while, theoretically, males should favor females with the largest, most eye-catching wings (everything being equal, the large females carry the most eggs), our records show that males chase the nearest available female. When several males pursue a single female, the male that copulates first is the victor. As soon as the mating pair engages, other males turn away. Thus, in competition among Dolania males, the race is to the swift. We speculate that by breaking off the “walking legs” during the subimaginal molt, the male not only hurries the completion of that stage but streamlines his body for faster flight as an imago.

A female begins laying eggs almost immediately after copulation, touching the water with her abdomen and dispersing a few large eggs one at a time, then flying to another spot (sometimes mating a second or third time on the way) to repeat the process. In a short time, she tires, falls into the water, and in death is swept away by the current, releasing any eggs left in her body. Even if they are too weak to fly, as long as females are active and flapping their wings, males will follow them. The eggs fall to the bottom of the river and stick tightly to sand grains.

The swarming orgy lasts for about fifteen minutes as more females emerge, mate, begin egg laying, and are carried away downstream. Then, in fishermen’s terms, the hatch is over. Fewer and fewer female bodies are seen drifting downstream, while males continue to fly patrol until they too die, usually around sunrise.

Of our thirty-five days in the field in 1973, many mornings were not fit for man or insect: a few mornings brought just a few mayflies; some brought small hatches; and for a couple of mornings the river rose in a swirl of white wings. Over the years, these data have held: at any particular site, about two-thirds of the Dolania that emerge will do so in one morning, but usually in two or three, and there will be a few mornings of smaller hatches. Five mornings a year with hatches large enough for quantification—collection and counting of floating skins and dead mayflies—is the norm.

We were amazed that most males and females emerged, mated, laid eggs, and died within the same few minutes of the same day (or two or three days) each year. Precise timing was critical. We wanted to understand emergence timing, because environmental and man-made effects on hatches or emergence are impossible to assess when we don’t know when or how emergence occurs in the first place. With its highly synchronous swarm, Dolania became the perfect experimental animal, and the realization that being able to predict emergence would allow us to sleep late some mornings provided extra incentive.

Seasonal temperature and rainfall data enabled us to estimate late April or early May maturation dates. We discovered that an essential factor for emergence is a daily low water temperature of at least 64°F and that this “threshold” temperature must be in effect the day before, rather than the day of, emergence. On mornings with air temperatures somewhat below 50°F, most molting males died trying to achieve the subimaginal molt. Unmated females flew for a while, wings waving, until they also died. Clearly, these mayflies could not predict the weather on the day of emergence; the process was seemingly cued by previous events and, once under way, could not be stopped.

When and how was emergence predetermined? Temperature records showed that emergence correlated perfectly with a strong positive increase in water temperatures the previous morning (compared with two days earlier). Weak water temperature changes over the preceding days gave ambiguous results—sometimes no hatch but often a small hatch—and no mayflies emerged when water temperature fell. Afternoon water temperatures played no role in emergence, but whether the cue for a given day was the temperature at time of emergence or the daily low was unclear, since both occurred between dawn and sunrise at our site on the river.

Events in the life of insects often cue to points in the daily fluctuations of light (photoperiod) or temperature (thermoperiod). For Dolania, the temperature cues for emergence and the daily timing of emergence might depend on the coldest time of day or on the dawn light. On one date, the first male, followed by a cluster of other males, usually emerged about one and a half hours before sunrise. On another date, males would begin to hatch out some twenty-five minutes later, when dawn light had visibly increased. Female emergence times also varied but not as dramatically. For the early grouping, males appeared before or at the time of astronomical twilight, the “crack of dawn.” We once thought Dolania were somehow sensitive to this first streak of light, although we could detect no change in the sky overhead. But the theory seemed increasingly improbable considering that these insects were buried in sand at the bottom of a river and that emergence occurred equally under clear or cloudy skies. Nor could we find any relationship between the water temperature and the time of hatch.

We then postulated the existence of an internal biological clock. To test this idea we experimentally manipulated light, temperature, or both to test effects on emergence and were able to reach some
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conclusions. When natural temperature cycles were eliminated, Dolania nymphs hatched on increasing light, and when light conditions were constant, they hatched at cold temperatures. If temperature and light were both manipulated so that nymphs received no natural indication of daylength, emergence occurred a little later each day. However, experiments were only successful when nymphs had been exposed to the new thermal period or photoperiod about a week before emergence. Presumably, timing cues were being set then, because any attempt to manipulate cues in those last few days led to incomplete emergence attempts and death. One factor that directly influenced Dolania’s response to experimental water temperature and light fluctuation was the critical 64°F threshold temperature. When light cycles and temperature cycles were experimentally separated (making midafternoon the coldest time of day, for example), nymphs emerged at the time of the coldest temperature when the low water temperature had been below threshold, but they emerged at dawn when low temperatures had remained above threshold. There was an exception: certain nymphs emerged at dawn, no matter under what temperature regime they were reared. These nymphs all came from a different Dolania population collected far upstream, where the water was narrow and canopied by trees. There, the daily low water temperature came later in the morning and was not associated with dawn light.

Dolania’s differing responses can be loosely compared to our experiences with alarm clocks. Critical water temperature acts somewhat like an alarm that rings at the same time each day. Assuming it rings at sunrise, it can reinforce other perceptions of dawn and allow us to anticipate its ring. When the alarm is turned off, an internal rhythm, already established by the alarm, continues for several days, with individual variations. Then, dawn illumination itself becomes a cue. With no alarm and no light, less efficient cues are available, such as the time of coolest temperatures. Finally, in the absence of any cues, another internal biological rhythm is established: in our experiments, Dolania emerged a little later each day. Our experimental results helped us understand early emergences in the river following periods of below-threshold water temperatures and later hatches that occurred after five or more warm days with low temperatures above 66°F.

But what happens if low water temperatures have been above threshold but no light has penetrated to the river bottom? Based on experimental results, we assumed that the mayflies would wait until some light eventually penetrated, until they perceived an increase in water temperatures, or until they could wait no longer (internal clock). In 1985, road construction caused heavy red clay to wash into the river after storms, turning the normally clear waters muddy and blocking the light from reaching more than a few inches into the water. Emergence times shifted to past sunrise, and mating and oviposition occurred in full daylight when the mayflies are especially vulnerable to predators.

Such combinations of field and experimental data contributed to our understanding of how man-made perturbations can hurt insect reproduction in a river. Since aquatic insects depend on temperature and light to set emergence time, such changes as a drawdown of a dam in days prior to emergence might cause abortive emergence attempts and death, while a factor such as heavy siltation might shift the hatch to inappropriate times.

More questions remain. Dolania females, but not males, vary in color, with the lightest color forms being the most common and the intermediate forms the rarest. The annual representation of dark forms has varied from 2 percent to 35 percent of the female population. We used a variety of methods to attract and count mayflies and to obtain results that could be analyzed statistically. We know that while dark and light females emerge at the same time, the dark forms, or morphs, are nearly absent from drift nets, are likely to fly farther from the river, and will continue to fly at the site of emergence only if males are absent.

All information is consistent with the hypothesis that the dark females disperse, that is, fly away from their place of emergence, to lay eggs elsewhere. Unlike light morphs, which lay eggs immediately after mating, the dark morphs appear to mate and fly away. From what is known about the behavior of other mayflies, we might expect them to disperse upstream. Sometimes we are rewarded by the sight of the dark morphs floating downstream well after sunrise, but we don’t know that these are from the same population. If they are, they have made a one and a half mile round trip. They might also represent another population flying five miles or more from any other direction.

Late arriving dark morphs actively bounce along the water surface with wings raised, in contrast to the light morphs, which flounder shortly after they fall into the water. Still hardy after nearly two hours of adult life, dark morphs long outlive light morphs, which rarely survive more than fifteen minutes unless males are absent. Dark females are not present after every hatch, and large numbers of them are rare. We can only speculate on what is happening. Reproduction is essential, but dispersal is optional and more hazardous where predators abound. We should not expect to see survivors often.

Our Florida data confirm that emergence early in the day furthers mayfly survival by allowing them to mate and lay eggs before most common predators are active. Also, while birds, bats, and dragonflies prey on mayflies on warm mornings, none appear to be very active on cold mornings. Fish, the principal aquatic predators near our study site on the Blackwater River, are not influenced by air temperatures and usually feed whenever Dolania swarm. Bernard Sweeney and Robin Vannote of the Stroud Water Re-
search Institute showed that mass hatches served to overwhelm predators (principal- 
ly beetles in their study stream in South Carolina) with huge numbers of 
prey; the beetles could not possibly consume enough swarming mayflies to hurt 
the overall population.

Since the debut of mayflies some 350 to 
400 million years ago, their evolution and survival have involved the movement of 
immature stages into sheltered, specialized aquatic habitats and a reduction in 
the length of the adult stage. According to 
George F. Edmunds, Jr., of the University 
of Utah, and Patrick McCafferty, of 
Purdue University, the subimagos, one of many intermediate stages known from fos-
sil mayflies, has probably persevered as the transitional stage to get insects from 
the water to the air.

The brief adult life and apparent move 
toward reproduction in younger stages, 
called neoteny, is evolving in various ways 
in all species of mayflies. All adults lack the 
motoral mouthparts that are found in 
their fossil ancestors, and the adult di-
gestive system has been totally lost. Re-
production by subimagos occurs in 
females of several families, and while there 
are no records of mating in nymphs, there 
is at least one good record of nymphs 
forming pairs before emergence.

The neotenic trend in mayfly evolution is 
apparent in Dolania, where the less time 
spent out of the sand, the better. While 
long-lived dark female morphs may re-
main in the population as dispersers, evo-
lution favors (at least numerically) the 
short-lived lighter forms. Even the short, 
fast mass swarms and precise timing that 
bring adults together inevitably sacrifice 
part of the population to predators. While 
our immediate research concerns environ-
mental pressures, we can hypothesize that 
evolutionary pressures also are at work to 
move Dolania from spectacular adult 
swarms toward reproduction as nymphs in 
the relative security of the sand.

William L. Peters is a professor of ento-
ology and Janice G. Peters is a research 
assistant in the Department of Entomol-
ogy and Structural Pest Control at Flor-
ida A&M University in Tallahassee.
A Tale of Three Pictures

Drawings offer insights into modes of thinking that words often mask or ignore

by Stephen Jay Gould

Goethe, who coined the word morphology and therefore ought to know, once proclaimed that "we should talk less and draw more. I personally would like to renounce speech altogether and, like organic nature, communicate everything I have to say in sketches." As a card-carrying member of the guild of essayists, I should resist this heresy tooth and nail. I might also argue that the world is a better place because Goethe did not take his own advice. We would all be a little poorer without Faust, while Goethe's sketches, although no disgrace, are not depriving us of quintessential insight by their general oblivion.

Primates are visual animals. No other group of mammals relies so strongly on sight. Our attraction to images as a source of understanding is both primal and pervasive. Writing, with its linear sequencing of ideas, is a historical afterthought in the history of human cognition.

Yet traditional scholarship has lost this root to our past. Most research is reported by text alone, particularly in the humanities and social sciences. Pictures are poorly reproduced, gathered in a center section divorced from relevant text, and treated as little more than decoration. (Natural scientists, although not noted for insights about communication, have better intuitions on this subject. Most scientific papers are illustrated, and slide projectors are automatically provided for scientific talks throughout the world. By contrast, I have, three or four times, suffered the acute embarrassment of arriving before a large audience in the humanities or social sciences, slides in hand, to deliver a talk that would be utterly senseless without its pictures. No slide projector, no screen, not even a way to darken the room. My fault. I had forgotten to request the projector because, in my own scientific culture, slides are as automatic as words.

And so, all you budding scientists who may read these essays, if I have taught you nothing in nearly fifteen years of columns, at least remember this and thank me some day for a small boon of advice: if you are ever asked to talk before a department in the humanities, remember that you have to request the slide projector. Call this Gould's law and let it be my immortality—long after everyone has forgotten those upside-down flamingos and pandas' thumbs.

Pictures are not peripheral or decorative; iconography offers precious insight into modes of thinking that words often mask or ignore—precisely because we tailor our words so carefully but reveal our secrets unconsciously in those "mere" illustrations. (My thanks to M. J. S. Rudwick, great historian of geology, who first taught me this lesson and who supplied the initial quote from Goethe.)

Pictures are revealing enough when they simply claim to represent an object "as it is." Shading, emphasis, context, and surroundings all provide an artistic leeway that expresses modes of thought. Have you ever seen a dodo pictured as anything other than alone and forelorn?—although they once abounded on Mauritius. The classic dodo reconstruction shows a single bird dominating the foreground of a desolate terrain. For the dodo is both a large flightless pigeon and our conventional metaphor for extinction.

Iconography becomes even more revealing when processes or concepts, rather than objects, must be depicted—for the constraint of a definite "thing" cedes directly to the imagination. How can we draw "evolution" or "social organization," not to mention the more mundane "digestion" or "self interest," without portraying more of a mental structure than a physical reality? If we wish to trace the history of ideas, iconography becomes a candid camera trained upon the creator's mind.

This essay is a tale of three pictures. It tries to illustrate something crucial in the history of evolutionary thought by discussing three sequential snapshots of "relationships among animals." This sequence presents two favorable features that may promote its narrative from anecdote to illumination. First, all three pictures tell the changing story of the same animal, thereby imparting coherence to a sequence that would otherwise have no anchor. Second, the pictures embody, in a visual epitome that I (at least) found stunning, what may be the most important general issue in our struggle to understand the distinctive character and history of scientific thought.

These pictures were all presented as simple sketches of "objective" relationships among animals; they are also (and primarily, I would argue) iconographies of three strikingly different and incomparable world views. They were drawn by the three men discussed in last month's column: by Louis Agassiz in the 1830's, by William Patten early in our century, and by Erik Andersson Stensiö in 1927. They all include, as a prominent feature, an attempt to fix the biological position of Cephalaspis, the prototype of jawless fishes that gave rise to all later vertebrates, ourselves included of course.

To summarize briefly the sequence of opinions about Cephalaspis: Agassiz discovered that Cephalaspis was a fish, not a trilobite (the bony head shield looks like the external armor of an arthropod, but Agassiz found headed attached to indubitably fishy bodies). Agassiz denied evolution altogether, but Patten tried to interpret Cephalaspis as an intermediary form between arthropods and vertebrates, a key way station on "the Great Highway of Animal Evolution." Stensiö proved, by meticulous dissection of exceptionally
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preserved fossils from Spitsbergen, that *Cephalaspis* was "all fish," without a whiff of arthropod. He also demonstrated that modern lampreys and hagfishes are close relatives of the great primordial group of jawless fishes represented by *Cephalaspis* (class Agnatha, meaning, quite appropriately, "jawless").

Last month's essay also set the story of *Cephalaspis* in the context of an old debate about progress in the history of scientific thought. I argued that this subject is often obscured by a false dichotomy drawn between equally untenable extremes: realists, who argue that science, with its timeless and universal methods, learns progressively more and more about an objective external reality; and relativists, who hold that the history of theories approximates the vagaries of fashion, a series of equally workable solutions altered by whim or social circumstances.

I think that each side of this controversy possesses a central insight, and that their marriage provides a workable solution sensitive to the fundamental concept of each camp. Notwithstanding a long history of arguments, ranging from the playful to the tendentious to the sophist, there is a world out there full of stars, amoebas, and quartz crystals. (We must, in any case, behave as if this claim were true in order to negotiate life's numerous difficulties with any success—and this behavior has brought consistent results, at least in the form of technological achievement.) Science does construct better and better maps of this outer reality, so we must assume that change in the history of scientific theories often records more adequate knowledge of the external world and may therefore be called progress.

On the other hand, we must also admit that the history of scientific theories on any subject is no simple tale of good information driving out bad. Successive theories often display the interesting property of incommensurability. They do not speak the same language; they do not parse the world into the same categories; they embody fundamentally different views about the nature of causality. The new is not simply more and better information heaped upon the explanatory structure of the old. In this sense, the history of theories is a successive replacement of mutually incompatible world views, not a stroll up the pathway of objective knowledge.

The three pictures of relationships among early vertebrates demonstrate, with bold literalty, this principle of scientific change as a series of incommensurable world views, each replacing rather than just building upon the last. Yet the sequence is bound to increasing objective knowledge about *Cephalaspis*; it is not a passive mirror of social change.

Louis Agassiz (1807–73), the great Swiss zoologist who became America's premier naturalist, was the last great scientific creationist (I am writing this essay in the museum and laboratory that he opened in 1859). He built his career upon two fundamental achievements: the development of the theory of ice ages, and a monumental work on the classification and relationships of all fossil fishes. Agassiz summarized his fifteen-year project on fossil fishes with the first major example of an iconography that paleontologists have since adopted as canonical—the so-called spindle diagram. In these geological charts of relationships among organisms, the vertical axis represents time, as though the diagram portrayed a sequence of strata in the field. Each group of organisms is drawn as a spindle, with varying widths through time representing a history of fluctuating diversity, and the ends of the spindle marking origin and extinc-
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tion. The ordering of spindles records degree of relationship, with physical closeness representing biological affinity. We have all seen so many of these diagrams that we read them automatically, rarely stopping to acknowledge that all these features are iconicographic conventions, not necessary realities.

These conventions leave great latitude for portraying a theoretical world view in the guise of objective knowledge—and Agassiz's famous chart is a striking example of concept as iconography. Note two features of Agassiz's fishes (page 16). First, of the various geometries that might be used to portray relationships among organisms—circles, chains, ladders, parallel lines like teeth on a comb—he chooses a topology of branching from a central stem in each of his four groups. This iconography embodies his biological theory of life's history as a tale of differentiation through time from simple and highly generalized archetypes. Life diversifies on an embryological model. Just as all mammalian fetuses begin with a simple and similar form and differentiate later to bat, whale, and camel, so too does the geological history of a group generate more diverse and specialized creatures through time.

This view sounds so evolutionary that we wonder why Agassiz continued his lone holdout against Darwin to the death. But such a feeling only represents the chauvinism of later knowledge imposed upon a fundamentally different world view. Differentiation from a common archetype need not imply a physical, evolutionary connection among successive forms. Suppose that differentiation is God's grand design for all developmental processes in nature. Embryology may proceed in physical continuity, but geological succession portrays a series of independently fashioned forms, linked together as incarnations of an ordered pattern of thought in their creator's mind.

Agassiz depicted his creationist interpretation in the second striking feature of his iconography. The separate spindles in each of his four groups may converge lovingly toward each other, and toward the central or archetypal line, but they never join! And Agassiz knew exactly what he was doing, and why:

Nevertheless, I have not joined the lateral branches to the central trunks because I am convinced that they do not descend, one from the other, by pathways of direct procreation or successive transformation, but that they are materially independent, although forming in their ensemble... a systematic whole, whose connections must be sought in the creative intelligence of its author.

Agassiz placed Cephalaspis as the first side branch from his central stock of the most "primitive" group—the ganoids (sharks and their relatives). He had not been able to excavate the mouth and did not recognize the jawless character of Cephalaspis and its relatives. For Agassiz, Cephalaspis was both primitive and peculiar—a short-lived side branch of God's earlier efforts.

Eighty years later, William Patten gave Cephalaspis a more central role in the order of life's history. Patten recognized Cephalaspis as more than a curiosity, and classified this genus as the prototype of a group—the ostracodermis of his terminology—ancestral to all later vertebrates. But Patten, firmly committed both to a general theory about life's progressive advance and to a specific claim that vertebrates had descended from arthropods, misinterpreted the structure of Cephalaspis. The fishlike body he could not and did not deny, but he also thought (quite incorrectly) that he had found jaws of arthropod design—and he therefore interpreted the ostracodermis as chimeras of arthropod and vertebrate characters and as intermediary forms in an evolutionary sequence from horseshoe crab to fish.

This convenient casting of Cephalaspis allowed Patten to fulfill his dream of mapping evolution upon his hopes for morality and good conduct. Patten yearned to find one true path through the labyrinthine
branching of phylogeny. That path must, of course, ascend to Homo sapiens, thereby making our distinctive features the goal of life’s entire history. This dream would have died if Patten had not been able to link arthropods with vertebrates—for arthropods (mostly insects) represent some 80 percent of all animal species, and their exclusion from our lineage would have converted Patten’s Great Highway of Animal Evolution into a dinky little road less traveled.

Patten’s iconography portrays this claim for linear progress as a single grand highway. This figure is unconventional in its dubious attempt to compress three dimensions into two. The vertical axis represents “progress in organization, brain size, parental care, and adaptability,” rather than the usual geological time. Instead, time runs along the horizontal axis, symmetrically in both directions, from the origin of life at the center, to younger and younger strata both right and left. But time correlates with progress (the chart would be unintelligible otherwise)—so farther from the beginning point (bottom, center) means younger and better. Thus, Patten draws four bubbles, outlined in black and shaped like light bulbs, centered on the starting point. Each bubble adds geologically younger and biologically more advanced forms. The four bubbles represent, in order, Precambrian, Paleozoic, Mesozoic, and Cenozoic eras. The third dimension of organic form can’t be plotted into this scheme, but Patten fudges and simply draws the conventional spindle for each group, radiating from the interior of a bubble toward its edge.

Note the major feature of this iconography—and the obvious rationale behind Patten’s chosen form: the Great Highway of Animal Evolution ascends right

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through all the bubbles in the center of the chart. It rises from arthropods in the first bubble; to ostracoderms (the crucial link, including *Cephalaspis*), fishes, and amphibians in the second; to dinosaurs and early mammals in the third bubble; and finally to man, flanked by primates and hoofed mammals, in the fourth bubble. The great highway does become dangerously constricted now and then, but it always perseveres, and always moves like the motto of New York State and the skyscrapers of its metropolis—Excelsior, "ever upward."

How shall we compare Patten’s iconography with Agassiz’s earlier chart? Is it truer? Better? Does it represent a simple accretion of knowledge—scientific progress—in the intervening eighty years? I suppose so, in some sense. Patten does connect the spindles to acknowledge the discovery of evolution. He also recognizes the coherence of ostracoderms as an ancestral group of vertebrates, whereas Agassiz had regarded *Cephalaspis* alone as a confusing oddity. Yet in other ways, Patten’s chart has lost accuracy. Agassiz correctly classified *Cephalaspis* as a fish, whereas Patten, impelled by his theory of necessary progress, managed to reconstruct the ostracoderms as part arthropod.

But more fundamental than these backings-and-forthings must be the basic incommensurability of these two charts. They are not linearly related by progress or regress in knowledge. In fact, you cannot transform one into the other. They represent two incompatible world views, not a filling-in of new facts on the objective background of history. Each phylogeny is a personal theory, not a hatrack stamped out of universal logic. And the main difference isn’t even the watershed that we usually identify as the chief contrast between Agassiz’s and Patten’s worlds—the intervening discovery of evolution. Agassiz’s topology is easily converted to an evolutionary scheme by connecting the spindles. But Agassiz’s theory cannot be transformed into Patten’s world view, for Agassiz based his vision on differentiation (radiation of numerous lineages from common points of origin), while Patten embraced linear progress. You can’t turn a hand into an upraised forearm.

When Stensiö resolved the debate about *Cephalaspis* by proving both its jawlessness and its relationship to modern lampreys and hagfishes, he summarized his discoveries in a third iconography. This more modest chart does not show all life (like Patten’s) or even all fishes (like Agassiz’s); it portrays jawless fishes only—both the ostracoderms and their modern descendants. It argues that a root stock of ostracoderms split into two basic groups: the first containing two groups of fossils (including *Cephalaspis* among the Osteostraci) and the modern lampreys (*Petromyzontia*); the second with two other fossil groups and the modern hagfishes (*Myxinidea*).

Again, Stensiö’s iconography is no accretion of information onto Patten’s version. It represents yet another world view, incommensurate with Patten’s and therefore not derivable by any transformation from Patten’s grand highway. Stensiö’s organizing scheme is diversification, not progress. His iconography is closer to Agassiz’s preevolutionary version than to Patten’s supposed improvement. Connect Agassiz’s spindles and you obtain something more like Stensiö’s evolutionary iconography than Patten’s linear progress.

But Stensiö is not simply Agassiz after a game of connect the dots. We still note a basic incommensurability. On Agassiz’s chart, all subsidiary groups radiate from a central axis within each of the four divisions. No geologically younger group splits from a previous side branch; all point toward the central stem. This iconography is a consequence of Agassiz’s belief that creation occurs on an embryological plan. Mammals did not evolve directly from reptiles (themselves a side
branch of the vertebrate trunk). Mammals were created after the death of ruling reptiles—as a more highly differentiated incarnation of the vertebrate ideal. The central stem of each group is, for Agassiz, the archetype that must serve as a model for each new and independent side branch of created complexity. But Stensiö's iconography is fully evolutionary. Diversification is hierarchical. Stems produce side branches, and side branches then bud off other side branches. Agassiz's iconography is like a human hand; on Stensiö's chart, fingers generate fingerlets, which generate fingerletchens, which generate . . .

These three successive iconographies lead me to conclude that scientific change cannot, in this case at least, be viewed as a simple accumulation of knowledge within the unchanging framework of a universal, objective method. We did learn more and more about Cephalaspis in particular and about the evolution of vertebrates in general. But the theories of Agassiz, Patten, and Stensiö are three incompatible world views—three visions imposed upon our greatly imperfect knowledge—not a progressive fleshing out of nature's bare bones. And ironically, for those wedded to linear progress in ideas (if not in life's history), Stensiö's "final" version shares more of its iconography with Agassiz's creationist vision of differentiation than with Patten's evolutionary dream of linear advance.

Nature does not tolerate chimeras among its more complex animals. You cannot put a man's head and chest upon a horse's torso, and you certainly can't meld an arthropod's head with a vertebrate's trunk (as Patten proposed in arguing that Cephalaspis had the jaw of a sea scorpion). Organic designs have integrity as working wholes constructed from coherent patterns of development. Nature is not an interior decorator or a postmodern builder recycling the entire history of architecture in an eclectic display of façades.

I believe that ideas have a similar integrity. Great thinkers build their edifices with subtle consistency. We do our intellectual forebears an enormous disservice when we dismember their visions and scan their systems in order to extract a few disembodied "gems"—thoughts or claims still accepted as true. These disarticulated pieces then become the entire legacy of our ancestors, and we lose the beauty and coherence of older systems that might enlighten us by their unfamiliarity in our fallible, modern world.

This integrity of systems also precludes smooth transitions in intellectual life. Some systems will not transform smoothly into others, and discontinuous change must occur from time to time in the history of ideas, of human social institutions, and in the form of organisms. D'Arcy Thompson, great morphologist and admirer of Goethe, made his lone argument for rapid transitions in his classic treatise On Growth and Form (1917). He probably exaggerated the case for organisms with his geometric analogy, but I recommend his words as a stimulating, if overstated, model for the history of great ideas:

An algebraic curve has its fundamental formula, which defines the family to which it belongs . . . . We never think of "transforming" a helicoid into an ellipsoid, or a circle into a frequency-curve. So it is with the forms of animals. We cannot transform an invertebrate into a vertebrate, nor a coelenterate into a worm, by any simple and legitimate deformation. . . . Nature proceeds from one type to another . . . and these types vary according to their own parameters, and are defined by physico-mathematical conditions of possibility. . . . To seek for stepping-stones across the gaps between is to seek in vain, forever.

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.


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San Francisco Peaks, Arizona
by Robert H. Mohlenbrock

Ten miles north of Flagstaff, Arizona, in the Coconino National Forest, a massive volcanic mountain rises nearly 6,000 feet above the Colorado Plateau. Culminating in Humphreys Peak (12,643 feet above sea level) and several lesser peaks (notably Agassiz and Fremont), the mountain is called the San Francisco Peaks. Here, a century ago, ecologist Clinton Hart Merriam observed the way the vegetation changed with increasing altitude, primarily in response to the lowered temperature and increased humidity. A similar pattern, he later noted, was evident as one traveled northward on the continent.

On the basis of these observations, Merriam defined a series of biological "life zones," which with some modification remain useful categories today.

The vegetational changes Merriam described are evident on the trip from Flagstaff to the San Francisco Peaks. Around Flagstaff, a desertlike community of grasses and shrubs abounds below 6,000 feet. This is replaced between 6,000 and 7,000 feet by a dry woodland habitat of widely spaced piñon pines and western junipers. Ponderosa pine dominates still higher terrain, characterizing most of the area from Flagstaff to the Snow Bowl, the winter resort area of the San Francisco Peaks. Merriam called these habitats the Sonoran, Piñon, and Pine life zones; today the terms Lower Sonoran, Upper Sonoran, and Transitional are preferred.

From the Snow Bowl, hiking trails take the visitor through the remainder of Merriam's life zones. Corkbark fir and a sprinkling of Engelmann spruce trees populate the Canadian Life Zone, from about 8,500 to 10,000 feet, with the Engelmann spruce taking over in the Hudsonian Life Zone, 10,000 feet up to timberline. The timberline is marked by the appearance of gnarled, stunted bristlecone pines that rise only a few feet above sprawling shrubs of...
San Francisco Peaks

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circling junipers and gooseberry cur-
rants. Merriam termed the timberline a
different life zone, but nowadays it is sim-
ple considered part of the Hudsonian.

Finally, a bleak habitat known as tund-
ra characterizes the Alpine Life Zone,
above timberline. The tundra occupies
only two square miles, on Humphreys
Peak and Agassiz Peak, but it is notable
for its isolation from similar habitats. The
nearest tundra vegetation grows on the
San Juan Mountains, 250 miles away in
southwestern Colorado.

The slopes above timberline are largely
covered by angular boulders and an as-
sortment of rocks, pebbles, and cinders.
Wind, frost action, and erosion retard
the formation and accumulation of soils. As a
result, most of the tundra plant life con-
sists of lichens and mosses that have man-
aged to etch a foothold onto the rocks.
Occasional tufts of grasses, sedges, and
rushes, with their narrow leaves and in-
nconspicuous green flowers, grow in pock-
etsof soil that have filled crevices.

On east-facing slopes protected from
bitter westerly winds, broad-leaved plants
such as mountain avens, a member of the
rose family, have been able to establish
themselves. Once a seed of mountain avens
lodges between rocks and germinates,
it sends out creeping stems that form com-
 pact mats. As the older parts of the plant
die, they become part of a gradually build-
ing soil layer. The soil, in turn, provides a
nichewhere other flowering plants, such as
Sibbald’s cinquefoil, mossy campion,
and Parry’s lousewort, become anchored.

The broad-leaved flowering plants are
adapted to a short growing season that
lasts from 101 to 113 days. All of them
delay growth until June. In three weeks,
mountain avens, Jacob’s ladder, and
mountain cress are in bloom, but most
species don’t flower until July or August.
Two dwarf gentians and a dwarf golden-
rod wait until September, when snow is
imminent, before they produce flowers.

Rock slides on the steepest terrain cre-
ate talus slopes, where some of the most
interesting alpine wildflowers live. Parry’s
primrose grows tufted among the rocks; in
July its leafless stalks bear a cluster of
inch-wide pink flowers. The rock sand-
wort’s compact, gray-haired leaves blend
in so well with its stony surroundings that
it is often difficult to spot without its white
flowers. Most unusual is the San Fran-
cisco Peaks groundsel, whose small, yel-
low, daisylike flowering heads stand above
a cluster of deeply cleft leaves. Discovered
by botanist Edward L. Greene in 1884
and found nowhere else in the world, it is
listed as a threatened species by the U. S.
Fish and Wildlife Service.

Half of the flowering plants that grow
above timberline on the San Francisco
Peaks occur in similar habitats in the
Rocky Mountains north of Arizona. An-
other 31 percent are circumpolar, that is,
they are found north of the Arctic Circle
in North America, Europe, and Asia,
while 10 percent are confined to North
American arctic regions from Greenland
to Alaska. Only 8 percent of the plants are
known from areas south of the San Fran-
cisco Peaks. Questions of interest to sci-
cists are how these primarily northern
plants got to the San Francisco Peaks, and
how long they have been isolated from the
nearest tundra zones, 250 miles away.

Geologist Henry Hollister Robinson es-
 timated that the San Francisco Peaks be-
gan to form nearly sixty million years ago,
when a volcano built up about 8,800 feet
of lava. Subsequent uplifts that created
the Colorado Plateau raised the elevation
to nearly 16,000 feet. After the volcano
became extinct, about two million years
ago, erosion reduced the mountain more
than 3,000 feet to its present height.

Fifty-five to sixty-five thousand years
ago, when a much cooler climate pre-
vailed, an advancing glacier moved into
the area. Geologist R. P. Sharp believes
the climate was cool enough at this time
for tundra plants from the north to spread
to the San Francisco Peaks. For nearly
fifty thousand years, the climate was such
that the vegetation zones from Colorado
to New Mexico and Arizona were shifted
4,000 feet lower than they are today. But
as the climate began to moderate, about
twenty-four thousand years ago, the life
zones were raised and the highest peaks
became isolated “islands in the sky.”

Because of the southern latitude, the
climate on the summits of the San Fran-
cisco Peaks has become too dry and too
warm for most tundra species to survive
and thrive. The amount and diversity of
life on the San Francisco Peaks is less than
on peaks of similar elevation in the Rocky
Mountains. Botanist Thomas Moore pre-
dicts that the plants will become sparser
and less vigorous if the present climatic
trends continue.

“This Land” highlights the biological
phenomena of the 154 U.S. national for-
est.s. Robert H. Mohlenbrock is Distin-
guished Professor of Botany at Southern
Illinois University at Carbondale.

Above: San Francisco Peaks groundsel.
Opposite: Buckwheat dots the cinder
slopes to the west of the peaks.
Vietnamese immigrants in the United States are intensely curious about almost all movies or television shows, aptly referring to themselves as "movie addicts." The TV set and videocassette recorder have become common features of their homes and are the focus of much conversation concerning what it means to be an American and what it means to be Vietnamese in the United States.

American television and movies worry many Vietnamese, especially parents and elders, who see them as glorifying the individual and his or her war with the family, social institutions, the community, and even the state. Reflecting the individualism of American culture, conflict resolution typically occurs at the expense of the family or community (except in situation comedies usually panned as being "saccharine" or "unrealistic" by television critics). American movies and television, many Vietnamese assert, are most effective in imagining worlds of mistrust, promoting self-righteous rebellion, and legitimizing the desires of the individual.

The anti-authoritarianism of much of American television and movies disturbs Vietnamese, but there are also offerings they commend, such as "The Cosby Show," which explores and promotes values they themselves prize: familial loyalty, togetherness, and a resolution of conflicts within the established social structures. Such shows, I've been told, remind the Vietnamese of their Confucian education and heritage.

Because the language of the immigrant community is still primarily Vietnamese, movies on videotapes imported from Taiwan and Hong Kong and dubbed in Vietnamese form a significant portion of the entertainment diet. The movies most favored are long, multitapec epics that run from five to more than twenty hours. These include contemporary crime stories, soap operas, and romantic comedies, but the clear favorites are the medieval-military-romance cum kung fu extravaganzas.

There is a steady stream of customers at the various local shops that rent imported videotapes. Neighbors, friends, and relatives compare notes on favorite films and stars. Posters and pocket photos of heroes and heroines are eagerly bought. Entire families will sit through the night eating up the latest kung fu romance, their reddened eyes a testament of devotion to the genre and quality of the film.

Atop nearly every TV set in the community rests a tape. While babysitting, grandmothers and aunts will place toddlers in front of the tube and play a Chinese film. (Depending on the time of day, little boys will cut in to watch "The Transformers," "Thundercats," or "G.I. Joe.") Young women confess that they would like to visit Hong Kong, where their favorite movies are made and their favorite stars live. Young men with a definite tendency to hesitancy and the doldrums are not so much reacting to a harsh social and familial atmosphere as modeling their behavior on the beloved melancholic hero of the Chinese movie. Older, more mature men are not immune to the wiles of the films either. I have observed formerly impassive faces creased with emotion and dampened by tears during the viewing of a particularly sad movie, the dialogue of which is punctuated by sniffing sounds and a periodic blowing of noses.

The plots of these films are complicated...
and try the patience of outside audiences to whom I have introduced these films. Their broad outline can best be described as a series of concentric circles of conflict. At the outer edge, there is a general global conflict, such as a war between the Chinese and the Mongols (the latter sure to bring heated boos from the audience). Moving toward the center, the scope of the conflict—but not its intensity—narrows to two families or two different kung fu schools. Judging either side is a difficult endeavor; the conflict is not merely a matter of an obvious good versus an obvious evil, as in American movies. Conflict is inherent in the human desire to form groups, whether the group is a family unit or a kung fu school. And beneath this umbrella of intergroup conflict, there is intragroup conflict. This kind of conflict is generally romantically induced when someone falls in love with a member of an opposing family or school.

While Western media are filled with conflict, they have nothing over the conflict-fraught Chinese film. Take, for example, The Mighty Sword (Than Chau Kiem Khach), Bac Phi, the hero, is a promising kung fu artist, whose master has high hopes of elevating him to take his own place upon retirement. To belong to a kung fu school is to belong to a family, with all that that entails in Oriental culture. The master is the father, and the other members are brothers and sisters. The school's members generally marry members of other schools to form alliances. As in any real family, there is considerable conflict and dissent, but the deal of remaining faithful and obedient to the master is stressed.

Bac Phi's troubles begin when he helps his family during a conflict between two families. Bac Phi's troubles escalate when he is accused of stealing a sword from a wealthy family. Bac Phi must then decide whether to confess or deny the accusation. His choice will determine the outcome of the conflict and the future of his family.

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a damsel, Lady Tuyet, who is being besieged by ruffians. She herself is an incredibly gifted kung fu fighter and, as fate would have it, perhaps the most beautiful woman in the world. They immediately fall in love—love at first sight being the rule in the world of Chinese film.

In the film one gets a feel for the Chinese and, by derivation, the Vietnamese way of romance. The hero and heroine do not touch; most certainly, they do not fondle or kiss. With a particularly sad melody in the background, they look into each other’s eyes. The viewers all sigh and point; they know that the two are in love by “reading their eyes.” Traditionally in Vietnam, lovers communicated with their eyes. Folklore, proverbs, and songs all depict a romance of the eyes: “Like a knife cutting the yellow betel leaf:/His eyes glance, her eyes dart back and forth.” The stage is set for what appears to be a romance made in Heaven. Our two lovers vow to marry and to love each other forever.

After this moment, the meaning of the sad melody becomes apparent. The hero and heroine have pledged their love in ignorance of certain facts ruling the social reality around them. The lovers learn that their two schools are mortal enemies. Bac Phi’s school and master are held to be responsible for the murder of Tuyet’s father, and neither Bac Phi’s master nor Tuyet’s mother will countenance the marriage. The intragroup relationships of both lovers are strained. Tuyet and her mother are at odds and come to blows. Bac Phi’s relationship with his best friend is strained, and he learns that his master is planning to have him marry another girl.

At this point in American television and movies, we would expect an easy solution to the problem. (To the dismay of the audience, I counseled “Elope!”) The Chinese and Vietnamese solution is much more complicated. To decide between Tuyet and his school is not a simple matter, and characteristically for the Chinese hero, Bac Phi is paralyzed by the situation, torn between his lover and his quasi family, his desire and his duty. He becomes lovesick and pines away for Tuyet but never decides once and for all to choose her over his school.

To make matters worse, there are forces behind the scenes manipulating all involved as if they were puppets. Unseen powers are seeking to deepen the rift between Bac Phi’s school and that of Tuyet. These powers attempt to undermine Bac Phi’s love and trust in Tuyet by posing one of their own as Tuyet and having him/her murder one of Bac Phi’s schoolmates. An already impossible situation is raised
to the nth degree. Bac Phi, because of his position in his school, must now avenge the death.

The conflict and its resolution are characteristic of the Vietnamese community. When I asked why the couple simply didn't run away and elope, the Vietnamese audience laughed. “That is the American way,” I was told. “But we have a Confucian tradition.” The Vietnamese were trained in Confucian values at school and at home. Confucianism, in a Vietnamese context, is a tradition of loyalty to one’s family, superiors, and prior obligations. “We were always taught to love our parents more than life itself,” one woman observed. “Parents were more important than the man or woman you loved.”

The conflict would not actually be resolved by Bac Phi and Tuyet eloping and abandoning the social units to which they belong. As the Vietnamese themselves ask, “Could Tuyet trust Bac Phi if he were to fudge on his obligations to his school?” If Bac Phi will sever the bonds of previously established relationships, such as those with friends and superiors, what guarantee does Tuyet have that, when she has lost her figure and taken on wrinkles, he won’t abandon her and chase after a younger, more nubile woman? There is a logic of trust in the films and the community that forbids them to take advantage of a simplistic formula, namely, “If you want it, go for it.” The Vietnamese, ever moralistic, will ask, “Is it right for you to want it?”

The conflict, in the case of The Mighty Sword, is eventually resolved by the defeat of the powers behind the scenes, by a change of heart and character on the part of Tuyet’s mother and Bac Phi’s master, and by the two lovers working to break the endless cycle of revenge and misunderstanding. The conflict is resolved within the social structures, not by their destruction. Despite the mazelike layers of deceit, fear, and manipulation, the movie ends affirming the ultimate worthwhileness of living in society, of being a social animal and not merely a lover.

Unlike most American television shows and movies, the Chinese hero does not always get the girl. A happy ending cannot be predicted. Although most Vietnamese I have talked to prefer a happy ending to their Chinese films, they appreciate and approve of the ethical message of a melancholic ending. “Love doesn’t conquer all,” one viewer told me, tears in his eyes. “Sometimes we have to pay for our mistakes. Sometimes we don’t get what we want just because we want it.” One woman recommended a particularly touching Chinese soap opera to me. “It has a very sad ending. It is very beautiful. It is very Confucian.” She explained that the movie, which I later watched with a lump in my jaded throat, tried to teach that romance must be accompanied by ethics. One cannot simply be a lover. One also has to be a good son or daughter and citizen.

In America, where films and television shows tend to glorify the individual and romance, the Chinese films the Vietnamese adore reaffirm traditional values and help educate their children in the art of being Confucian. Traditional Vietnamese Confucianism has sneaked in through the back door, so to speak, through the VCR. American pluralism and technology have made this possible. They also may have let in a Trojan horse that promises to offer a venerable critique of certain American values. The Vietnamese may do American culture a favor by offering a countervision of what it means to be a social animal, and not merely an animal.

Jesse W. Nash is an assistant professor of religious studies at Loyola University, New Orleans.

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From the Land of the Totem

by Aldona Jonaitis

Less than a century ago, the Indian tribes living along the Northwest Coast of North America were under great pressure to forsake their cultural heritage. At stake were their religious practices, their mythology and customs, and their ancient way of life.

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Poles

by rare archival photographs, many never previously published, of life among the Northwest Coast Indians as seen through the eyes of the nineteenth-century expeditioners. The rich and complex story of the expeditions, the art, and the Indians themselves is deftly woven by Dr. Aldona Jonaitis, one of the world's foremost authorities on Northwest Coast Indian art.

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Cold Matter Is a Hot Topic

A cosmic theory that may explain the formation of quasars and galaxies comes under question

by Stephen P. Maran

Recent discoveries of very distant quasars, and what may be even more distant galaxies, are casting doubt on a cosmological hypothesis called the cold dark matter theory. Usually referred to by its initials as the CDM theory, the hypothesis is itself a logical, although not necessarily mandatory, consequence of yet another concept, the inflationary theory. If doubts about these theories are strengthened by further observations, the CDM theory will be rejected and the inflationary theory will lose much of its credibility.

Galaxies, of course, are those beautiful pinwheel- or egg-shaped systems of hundreds of billions of stars, like the great spiral galaxy in Andromeda and our own Milky Way. According to the CDM theory, galaxies were formed in the early universe by the clumping of gas, which was induced by concentrations of material in a vast sea of cold dark matter that pervaded all space. The dark matter presumably still exists and may constitute the greatest part of all the mass in the universe, although it has not been detected in the environment or in laboratory experiments. It is supposedly composed of one or more kinds of subatomic particles. These CDM particles, according to physicists, may be the hypothesized axions, photons, gravitons, and (I'm not making this name up) higgsinos. According to their calculated properties, these particles don't glow (hence the appellation "dark matter") and they don't travel at the immense speeds of other particles such as the observed neutrinos. The average velocity of particles or atoms in a gas is a measure of its temperature, and since the axions and other putative CDM particles would not be very speedy by the standards of physicists, even if they did exist, they are regarded as "cold." They are, however, taken seriously by leading cosmologists, and cold dark matter has, in fact, become one of the hottest topics in astrophysics.

The universe is generally believed to be expanding. This concept comes from the observation that as we look out into space, galaxies are found to be rushing away from us as well as from one another. The farther away the galaxy, the faster it is receding. That perception is based on the measurement of the red shift in the spectra of galaxies. As a galaxy or other luminous object recedes from an observer, the light in its spectrum shifts to longer wavelengths—toward the red part of its spectrum—as a consequence of the Doppler effect (which states that the frequency of sound waves and light waves appears to change as the source moves with respect to the observer). The greater the speed of recession, the larger the red shift. Galaxies that have larger red shifts than other galaxies are therefore farther away from the earth.

The expansion of the universe that is deduced from the red shifts of galaxies is attributed to the hypothesized big bang at the inception of time, perhaps as much as 20 billion years ago. According to the inflationary theory, however, the big bang occurred no more than about 13 billion years ago, and was followed almost instantaneously by a condition in which the universe expanded at an incredibly great rate for just a brief moment—an eye blink. During that split second, known as the inflationary phase, the nature of physical forces and of space itself are presumed to have changed forever, taking on their present conditions. Then the modest and currently still observed expansion of the universe resumed.

The inflationary theory accounts for the uniformity of the cosmic microwave background radiation (composed of short-wavelength radio waves, like those in a microwave oven) that pervades all space. That's a big point in favor of the inflationary theory, since other cosmological theories are inconsistent with detailed observations of this radiation. The inflationary theory, however, predicts conditions in the
early universe that would have prevented the formation of galaxies and clusters of galaxies as we know them unless space in the newborn universe was filled with cold dark matter. The CDM theory was formulated in order to validate the inflationary theory.

Although the purported constituent particles of CDM are uncertain and undetected, the theory does have a direct consequence that can be tested by observation. It predicts that galaxies did not form until the universe had reached at least 7 percent of its present age. As a result, there shouldn’t be any galaxies with red shifts of more than 5—a very high red shift. A red shift that great means that the light from such galaxies has been lengthened by an amount equal to more than five times its original wavelength. Since the greater the red shift, the greater the distance, if light from a galaxy has that large a red shift, it must have left the galaxy longer ago than the time of galaxy formation specified by the CDM theory. If galaxies formed before then, the dark matter theory is wrong.

Attempts to test the CDM theory, therefore, consist of searching for galaxies with large red shifts. The red shifts of investigated galaxies are measured by photographing the spectra of the galaxies with large, ground-based telescopes. The spectra contain features, known as spectral lines, that occur in recognizable patterns in many galaxies. The red shifts of galaxies are measured by studying these patterns.

The goal of astronomers testing the CDM theory is therefore clear: they look for a galaxy with a red shift greater than 5. In fact, the discovery of many galaxies with red shifts larger than 4 might even be a challenge to the theory. Lest that observational test seem easy, however, I should mention that until very recently no galaxy with a red shift greater than 2 had ever been found. The reason is that galax...
ies with such large red shifts are far away and very faint. It is true that in January a new record for galaxy red shift was announced by Harding Smith, an astronomer at the University of California at San Diego, who discovered a galaxy at red shift 2.3. That finding, although a considerable achievement, is of no use in testing the CDM theory, which is perfectly consistent with the existence of galaxies with red shifts of about 2. Since astronomers believed until very recently that galaxies far enough away to have red shifts of even as much as 2, let alone 4 or 5, could not be found, investigators have concentrated on searching for quasars with large red shifts. Because quasars, construed as powerful eruptions concentrated in the centers of galaxies, are so bright, we can readily photograph them from distances at which the galaxies themselves are invisible from the earth. Most astronomers believe that, like the smoke that reveals a hidden fire, where there’s a quasar, there’s a galaxy—even if we can’t see it.

Although photographing a very distant quasar is easier than photographing a similarly distant galaxy, identifying the far-off quasars remains a difficult task. It is so hard that at one time astronomers suspected that there might not be any quasars with red shifts much above 3. Then in 1973, a quasar with a red shift of 3.5 was discovered and acclaimed as the most distant object ever found. It held that record for nine years despite exhaustive searches. When a more distant quasar, with a red shift of 3.8, was found in 1982, it too held the record for several years. Some astronomers thought there might be a limit to detectable quasars near red shift 4, just as many track fans once thought that no one could run a four-minute mile.

In the past year, however, the search for distant objects has struck pay dirt. The red shift 4 “limit” was breached in 1987 and, parallelly the breaking of the four-minute mile, one far-distant quasar after another has since been found. Patrick Osmer, a veteran quasar hunter at the National Optical Astronomy Observatories in Tucson, Arizona, says that as of last January, seven quasars with red shifts of 4 or greater have been located. Among them is the new record holder, Q0051-279, with a red shift of 4.43. This quasar and a few of the other distant quasars were discovered by a team, of which Osmer is a member, led by the young British astronomer Stephen Warren of the Institute of Astronomy at Cambridge University.

The Warren-Osmer team adopted an ingenious and laborious search technique that makes use of advanced photographic-analysis technology. The group photographs the sky with the United Kingdom Schmidt Telescope, a wide-angle telescopic camera, in Australia, observing each area of thirty square degrees separately through five different colored filters. After development, the photographic plates are scanned with a laser beam by a computer-controlled measuring machine. The machine determines the relative brightnesses of celestial objects recorded on the plates, and catalogs them, so that the relative intensities in the different colors of light of each cataloged object can be determined. The myriad foreground stars, dotted all over the photographs, are of no interest in the search for distant quasars and can be recognized by their characteristic colors and thus eliminated from the search, while distant quasars, whose light has been highly red shifted, stand out. Osmer told a recent press conference of the American Astronomical Society in Austin, Texas, that “we look at hundreds of thousands of stars and galaxies to find one of these objects.” Once objects are identified by their colors, they are studied with a spectrograph on a larger telescope, to see if they are true

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quasars and to measure their red shifts. Progress is also being made in other deep-space hunting. One of the most impressive examples was reported earlier this year by two graduate students, Mark Dickinson and Patrick J. McCarthy, at the University of California at Berkeley, who were studying a small galaxy, near the large radio galaxy 3C441, with the 120-inch telescope at the Lick Observatory near San Jose, California. The region of the sky under investigation was recorded in a single exposure. It was defined by a small mechanical aperture placed at the focus of the telescope to isolate the light from the small galaxy for spectroscopic analysis. This field of view was fully 1.6 million times smaller than the wide-angle view of the telescopic camera used by Warren and Osmer. And yet, when the results of the observation were examined, the students found that a second object, which turned out to be a quasar, was present in the tiny field of view. In a stroke of seemingly blind luck, Dickinson and McCarthy won the astronomical equivalent of an Olympic silver medal: their quasar, dubbed Q2035+29, has a red shift of 4.39—the second largest red shift ever measured.

As mentioned above, if enough quasars are found with red shifts of more than 4, then the credibility of the CDM theory would be threatened. But the fatal blow would come if astronomers discovered galaxies or quasars with red shifts greater than 5. The latest word is that this may have already happened. And surprisingly, it is supposedly two galaxies—not quasars—that have been found with estimated, but not yet measured, red shifts of more than 6. This remarkable discovery came as the first result of a new survey made at wavelengths that are a few times longer than those of visible red light. This research was done by another graduate student, Richard Elston, working with a noted wife-and-husband team of infrared astronomers, Marcia and George Rieke of the University of Arizona, in Tucson. Elston used a new infrared camera designed by Marcia Rieke with a sixty-one-inch telescope on Mount Lemmon, near Tucson, to photograph the sky with unprecedented sensitivity. The camera revealed objects so faint that they may be 10,000 times dimmer than the background glow of the night sky.

In photographs of the first two sky areas that they studied, Elston and the Riekes discovered two objects, L1a-4b and SA572-3b, that they classified as very distant galaxies undergoing rapid bursts of star formation. According to this interpretation, the infrared light was actually produced in the ultraviolet region of the spectrum, at wavelengths too short to be seen with the human eye, and then red shifted due to the immense velocity of recession of the two putative galaxies-in-formation. The red shifts, of more than 6 but less than 25 (that’s the best estimate given the limited data now at hand), stretched the light waves so much that, as received on the earth, they are too long to be seen by the eye.

If the objects Elston found are truly galaxies with red shifts greater than 6, then the cold dark matter theory will certainly be rejected and advocates of the inflationary theory will be seriously deflated. Until Elston’s observations are confirmed, cosmologists may continue to speculate. But if his interpretation is correct, they will have to go back to the beginning of the universe and develop new ideas.

Stephen P. Maran is a senior staff scientist in the Laboratory for Astronomy and Solar Physics at NASA’s Goddard Space Flight Center in Greenbelt, Maryland. The opinions expressed here are his own.
King of the Stream

When it comes to protecting their turf, both male and female kingfishers play rough

by William James Davis

In June of 1977, I set up a simple field test along the banks of the Great Miami River in Ohio to see if belted kingfishers defend their territories. Near what looked like a good riverbank nesting spot, I placed a stuffed museum skin of a kingfisher in a tree and set up a speaker to play kingfisher calls. If the birds were territorial, I reasoned, they would approach and investigate the model. After taking care to position the stuffed bird as realistically as possible and to conceal the speaker, I retreated toward my observation blind. Before I had taken five steps, a male kingfisher hit the model with great force, decapitating it. Even though I'd promised to take good care of the museum skin, I was pleased with the rapid, emphatic result of my test.

Belted kingfishers breed along freshwater streams, rivers, and lakes from northern Mexico to central Alaska and northern Quebec. Historically, the breeding habitat of belted kingfishers was limited to waterways that provided both food and nesting banks; the birds are fish eaters and excavate their nests in earthen embankments common along rivers and streams. Robert Brooks and I investigated the habitat preferences of breeding kingfishers in Ohio and Pennsylvania. We found that the birds require banks that are sandy, for ease of digging, and that generally rise more than four feet above water, so nests will be safe from predators and flooding for the twenty-three days of incubation and the additional twenty-three days of nestling occupation. More recently, road cuts and gravel pits have exposed sandy banks that offer kingfishers good nesting. In Minnesota, for example, man-made embankments provide previously unavailable sites in a landscape dotted with ideal fishing lakes.

Kingfisher breeding times vary by locality. In Ohio, pairs stake out breeding territories from March through May, while in Texas breeding may begin as early as January. I soon learned, after a few more trials with the stuffed model, that both male and female kingfishers are territorial. Female territoriality is found in other birds as well, but typically, males undertake territorial defense. In the breeding season a mated pair of kingfishers defend one territory, but during the winter the sexes guard separate and smaller feeding areas. Why and how such territoriality has evolved in the belted kingfisher became the focus of my research. I discovered that in both Ohio and Texas, females were even more territorial than males, while males contributed more time and energy to raising young. I believe both traits have evolved independently in response to the sometimes harsh and unpredictable conditions that exist along most rivers and streams where kingfishers breed. Seasonal changes are great: drought and heavy rains may bring famine, and floods can destroy nests.

Among biologists, the topic of territoriality has generated a lot of debate, particularly over what determines territory size. For example, if food is abundant and a few birds are competing for it, birds may not defend territories at all. But when many hungry birds vie for patchily distributed food, possessing a territory has its advantages. In theory, the size of a territory defended by a bird varies according to the abundance of food within the territory's bounds. This helps explain some kingfisher behavior. I found, for example, that along sections of streams where fish were concentrated, winter feeding territories were smaller than along sections where fish were scarcer.

To determine the size of kingfishers' linear territories, I walked along rivers and streams, flushing birds from their perches. By repeated flushing, I could push a kingfisher to the very edge of its domain, at which point it became agitated, refused to go any farther, and doubled back down the stream. By nudging a bird both upstream and down, I could easily delineate its territory. I also caught, counted, and measured prey fish species. Fish caught to feed nestlings varied between two and a half and five inches in length. In Ohio one minnow species, the stoneroller, accounted for about 40 percent of the total diet. All other fish species combined made up 49 percent, and crayfish formed the remaining portion of the nestlings' diet. Adults consume the same kinds of prey they feed to their young. I found that fish
A belted kingfisher perches after a successful dive. With their broad, brownish red band, females are more brightly plumaged than males of the species.

Bob and Clara Calhoun; Bruce Coleman, Inc.
Prey fish favored by kingfishers frequently concentrate in patches of shallow, purling river water called riffles. The birds spot a fish from a vantage point, fine-tune their flight path, and plummet for the catch, using their long beaks as pincers. After a strike, a kingfisher carries the fish to a convenient perch and pounds it against a branch before devouring it head first.

Both photographs by Rich Drains.

Eaten by kingfishers were concentrated in areas of shallow, flowing water, or riffles. For a kingfisher, a section of stream with well-stocked riffles is prime real estate. Riffles alone were a good predictor of territory size; the smallest territories encompassed stream sections full of riffles.

The relationship between riffles and territory size let me assess the potential for a given stream to support a population of kingfishers, and I used this information with moderate success to help evaluate new study sites. Kingfishers may use the same technique to assess possible homesteads. Specific environmental cues such as foliage height, which can influence habitat selection in other species of birds, are always associated with vital facets of the animal's life, such as the presence of food and good nesting sites. Theoretically, kingfishers may well take into account the number of food-rich riffles in a territory before they expend energy in its defense.

Kingfishers scrutinize clear, shallow riffles and pools—where fish can be seen near the surface—from a vantage point, usually either perching on a tree limb or hovering above the water. Hovering is the default mode of foraging along sections of a stream where perches are unavailable. With a steady wind, kingfishers can stay suspended in the air with a minimum amount of flapping. Birds fishing along the coast face into the wind and repeatedly hover between unsuccessful dives without returning to a perch to rest. On calm, windless days, however, hovering is undoubtedly an exhausting way to catch fish.

Once a fish is in sight, kingfishers often make fine aerial adjustments in their dive trajectories before they plunge. In shallow water, kingfishers rarely submerge completely after hitting the surface. With their eyes closed, they grab their prey with a pincerlike action of the bill; to catch a meal their aim must be perfect. If successful, a bird transports its catch to a nearby perch and beats it repeatedly against a branch before swallowing it head first. Fishing success at different spots depends mainly on the concentration of fish and water depth; the success rate at exceptionally good fishing spots may be as great as 44 percent. Ownership of good fishing holes, however, does not guarantee an easy life. Even a rich territory may provide few fish when the river becomes laden with silt and debris after a heavy rain. During rainy periods, kingfishers survive exclusively on crayfish, a less nutritious prey found along the water's edge, or they may even temporarily abandon their territories to search for food elsewhere.

During the breeding season, if weather conditions remain favorable, the average territory provides enough food to sustain the two adults and their relatively large brood of six to eight young. Having hand reared several kingfishers and counted the fish brought to the nest, I estimate that an adult-size bird consumes ten fish, each about four inches long, per day. At this rate, a pair of kingfishers with nearly grown young would have to catch about ninety fish per day to feed their offspring and themselves. During inclement weather, however, the number of fish caught is drastically reduced, and nestlings often starve to death waiting for
the parents to bring home food. Moderate rains reduce the visibility required to catch fish; heavy rains may also reduce the number of fish available.

Even when food is plentiful, breeding may be limited if nest sites are scarce. My own and other studies conducted in Ohio, Texas, Pennsylvania, and Minnesota all indicate that suitable kingfisher nesting banks, close to streams and safe from floods, are in short supply. I believe this premium on good nest sites has helped shape kingfisher behavior.

During cold Ohio winters, for example, many kingfishers are forced to migrate south to find ice-free water. I found that most males, however, were reluctant to leave the nesting area, and during mild winters in Ohio, many males remained in their breeding territories. Furthermore, during a visit to south Florida, I counted twice as many female belted kingfishers as males. Females are more likely to travel south and tend to go greater distances than do males, which are consistently the first to arrive in spring. Of these males, the ones returning earliest have the best chance of finding and defending a territory with a prime nest bank. This evidence is corroborated by my observations in Texas, where I found that males stayed close to nesting banks throughout the winter and often bred again on the same territory. Females may also return to the same male and the same nesting site from year to year.

Competition for good breeding sites arises between females as well as males. Early one April, I discovered two females competing for one of the few available banks along a stream in southwestern Ohio. At this particular site, the younger of the two females had arrived several weeks earlier, mated with the resident male, and laid a full clutch of seven eggs. Given the high stakes, I expected the younger female to defend her territory successfully from the hostile newcomer. (In most animal societies, territory owners win conflicts.) For two days the females clashed repeatedly, while the male played only a passive role, following the females during their struggle. On the third day, the younger bird disappeared, in effect
giving up her home to her adversary. The victor promptly dumped her rival's eggs and within a week had laid her first egg in an adjoining nest chamber. Presumably, the male had no difficulty in accepting the newcomer as a mate.

At the time, I was surprised by both the intensity of the fighting and its outcome, but since then I have found overt female aggression to be common. Female kingfishers—more brightly colored than the males, which lack the broad rufous band—will readily attack male and female models introduced into their territories, and they defend larger winter feeding territories than do males. Furthermore, females spend less time excavating the nest chamber, incubating eggs, and feeding the young than do their mates. Why have belted kingfishers switched roles?

Sex-role reversal is rare in vertebrates in general. In most species, the number of a female's offspring is limited by the number of eggs she can produce, while a male, readily producing innumerable sperm, is limited only by the number of females that are willing to mate with him. Furthermore, sperm production takes less of an energy toll than does egg production. So males commonly are polygynous; they
Kingfishers prefer to nest several feet above water level in soft, sandy riverbanks. While both parents tend nestlings after the twenty-three-day incubation period, the father does most of the caretaking, including feeding, left. After another twenty-three days—if the nest and its inhabitants escape flooding and predators—six to eight robust fledglings, like the one below, are ready to try their wings.

James D. Young

have more mates and care less for their offspring than do females. But this pattern does not hold for all species, and we now know that ecological conditions play an important role in the evolution of mating patterns. For example, 91 percent of the 8,600 species of birds are considered to be monogamous. In these species, biparental care may be needed to protect and keep eggs warm and to protect and feed nestlings, and if so, a parent would not be likely to desert its brood to seek another mate. But polygamy has evolved in some birds, such as red-winged blackbirds, in which males mate with several females, and in phalaropes, in which the female leaves the eggs in the father's care and goes on to mate with different males. These species live under conditions that permit one parent to raise the young alone. Apparently, in phalaropes, role reversal has evolved to a greater degree than in belted kingfishers. But my investigation into kingfisher ecology has provided answers to why sex-role reversal is taking place in this still-monogamous species.

I believe that, like the male phalarope, male belted kingfishers have taken on extra parental duties so that their mates have a chance to recoup energy lost during egg laying. Kingfisher females typically lay a large clutch of seven eggs. From the male's perspective, a healthy female is one that is capable of laying a second clutch if the first is destroyed. Increased paternal care and the ability of females to lay second clutches work to the advantage of both sexes. Male and female are maximizing the number of young they, as individuals, can produce. Taken to its extreme, the replacement-clutch hypothesis may lead to the complete role reversal found in phalaropes.

The hypothesis assumes specific ecological and life history traits of the species in question. First, the possibility that a given nest will be destroyed should be high; second, the physiological stress of egg laying should be substantial; third, during a typical breeding season there should be little time to waste before a second clutch is laid; and last, the chance of the male acquiring a second mate if he deserts the female should be low. These conditions are met in both phalaropes and belted kingfishers. During each of four breeding seasons in Ohio, I recorded nest failures for belted kingfishers, and in two of those years all nests on several streams were flooded out. And as mentioned above, nest banks are scarce. To desert one's mate after the nest is destroyed in hopes of finding a single bird of the opposite sex that has a good breeding territory is chancy. Under these conditions, a male that strives to maximize the number of offspring he has sired should do more than just cooperate with the female; he should increase his share of caring for the young to keep his mate healthy.

The female's perspective differs from the male's in that she produces the eggs,
When threatened, kingfishers scream and spread their wings and, like the startled male below, may raise their white eyespots. Right: A vigilant female surveys her territory.

William James Davis

and if he is unwilling to cooperate, she has a lot to lose. A male may indicate his willingness to provide parental care by the amount of courtship feeding of the female he undertakes before the eggs are laid. I have observed courtship feeding in four species of New World kingfishers, including the Amazon, green, ringed, and belted kingfishers. Courtship feeding may be part of the ritual of courtship from which the name is derived or it may serve an entirely different purpose. In kingfishers, it occurs most frequently after the pair bond has already formed and several days before the eggs are laid. The timing of courtship feedings suggest that they are important in egg production and can potentially be used by the female to regulate when and how many eggs she will lay. Such a hypothetical regulatory process would most likely be based on physiology rather than a conscious decision made by the female. Support for such a mechanism comes from earlier investigations of courtship feeding in the common tern, another fish-eating bird.

One difference between phalaropes and kingfishers, which may explain why polyandry has evolved in one but not the other, is that phalaropes have precocial young. Phalarope chicks hatch with downy feathers and are capable of walking and feeding themselves. Biparental care is not needed to show a clutch of chicks where to peck for food. So the female phalarope may seek other mates for her second clutch. In contrast, kingfishers produce helpless, naked young that require feeding by an adult. Biparental care is apparently essential during most years because the availability of food may fluctuate as water levels rise and fall.

I believe the kingfishers' riparian life style has contributed to the evolution of territorial behavior in both sexes, and furthermore, that becoming a diligent father is to the male's advantage. Nevertheless, many questions remain. Why, for example, are females more brightly colored and aggressive than males? Has natural selection not so much increased aggression in females, as reduced aggression in males? Would a less aggressive male be a better provider? To further test my ideas, I am conducting a study of the Amazon and ringed kingfishers of Latin America, close relatives of the belted kingfisher. Soon I will be able to make comparisons across the board to determine if similar ecologies, the conditions that occur along streams, result in similar evolutionary solutions in each species of kingfisher.
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The Other World of

The creator of fantasy stories for children was also a keen observer of the natural world

by Joyce Irene Whalley

Beatrix Potter offers us the unusual example of an artist in the English watercolor tradition who never exhibited her paintings and never sold a picture, as such, except to raise money for the purchase of Lake District land in northwestern England. She also had little formal training in her art. Yet today, her name is known worldwide, and on the rare occasions when an example of her work comes on the market, it commands a high price. Children's book illustration is undoubtedly the most familiar aspect of Beatrix Potter's art and there must be many people who would be surprised to learn that she produced anything else, so much has the attraction of the Peter Rabbit books overshadowed everything.

For the most part Potter was self-taught. From a very early age she had copied illustrations from books, and this exercise had trained her in the disciplines of drawing and observation. As soon as she was old enough, she became a regular gallery visitor. The Potter family moved in a circle that was aware of contemporary art styles, and discussions on art must have been commonplace among them. Beatrix Potter herself studied the paintings at the exhibitions she visited with great care, making detailed notes about the various works in her journal. This gallery visiting was probably one of

Study of a weasel
Courtesy of the Linder Collection

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the most formative influences on her as a young artist. Almost as important was the family link with the painter John Everett Millais, a close friend of her father’s, which made her familiar with the concerns and problems of an artist.

Meanwhile Potter was developing her own style. Once she had decided to try and earn some money by designing greeting cards, she consciously imitated the style of card that the printing processes of the period produced. She developed her own dry-brush technique and, with a meticulous attention to detail, painted the creatures she chose as her subjects in almost miniature fashion. Her subject matter was strictly limited right from the first—she rarely attempted anything that she thought she could not draw well. There were no scenes with children on her cards and, in fact, few “scenes” at all. As a young child she had copied exotic pictures of leopards and other jungle creatures, but now she chose to concentrate on those animals that she and her brother had kept as pets or had studied at close hand—mice and rabbits, hedgehogs and squirrels. She had the confidence of knowing that she could paint these well because she had practiced drawing such creatures in every

detail, covering sheets of paper with claws and paws, heads and tails.

She could see, and make us see, beauty in the simplest things. Her microscopic paintings are not only scientifically accurate, but they can convince us that even unattractive creatures—or bits of creatures—have an intrinsic beauty. The same can be said of her fungi or of her archeological paintings. Although these are specialist subjects, the sheer painterly skill that Potter brings to her work makes us look at them in a new light.

Potter's painting later became much freer in style, and the meticulousness of the work she had produced for the chromolithographed greeting cards gave place to general studies using a more fluid line, frequently combining the use of watercolor with sepia ink outlines. The paintings of this period have great charm and for the most part are devoted to natural history subjects and sketches of places she had visited. In the 1890s she began to write the picture letters that were to play so important a part in the books later on. In these she made use of line drawing, filling pages with lively and entertaining sketches.

Beatrix Potter's first illustrated book was privately published in 1901. She had discovered her ability to compose and write simple, attractive stories, and her solitary reading and regular journal entries had given her a command of good English and a lucid style. Potter usually reworked her earlier sketches for publication, but sometimes she found she could not recapture the first flush of originality, and then an older painting was used.

After her marriage in 1913, Potter turned her attention to farming in the Lake District. She had little inclination to continue with book illustration, and her eyesight was no longer good enough for detailed work. But she still sketched for pleasure, and her work became much more impressionistic.

The wide range of Beatrix Potter's interests has resulted in her work being regarded in many different ways. To some she is a writer or an artist or a lively diarist of the late nineteenth century. To others she is the great benefactor of the National Trust or a sheep farmer or a mycologist. For many people she will always be one of the finest writers and illustrators of children's books. But there is also a great deal to interest those who have never seen anything more than the book pictures. Indeed, just looking at the detailed study and preliminary sketching that went into the creation of the familiar books may, in itself, say more about the art of Beatrix Potter than any amount of writing on the subject.

Joyce Irene Whalley is past curator of the Leslie Linder Collection, the largest single collection of Beatrix Potter's work, which is housed at the National Art Library of the Victoria and Albert Museum, London.
Beatrix Potter: Artist and Storyteller, the first comprehensive exhibition devoted to this noted author-illustrator, will open at the Pierpont Morgan Library in New York City on May 12. The exhibition will include watercolors, manuscripts, letters, photographs, and other memorabilia and will remain on view through August 21.
Set to intercept salmon on their journey upstream to spawn, a gill net stretches into Dry Bay, the mouth of the Alsek River. The net owner's permit number for commercial fishing is marked on the buoy staked to the shore.

George Gratch
Two Rivers, Two Cultures

Native Tlingit and non-Indian fishermen compete for Alaska’s bountiful salmon

by George Gmelch

At Yakutat, 350 miles southeast of Anchorage, Eli Hanlon and Sammy Johnson load their sixteen-foot wooden skiff with three gill nets, a lantern, a Coleman stove, fuel, food, and water. They also pack two .44 Magnum pistols for protection from bears and, possibly, hostile fishermen. At six in the morning they rendezvous with two other boats of Tlingit Indian fishermen, to make the fifty-mile ocean journey to the mouth of the mighty Alsek River. They have a reason for leaving so early. As in many rivers, a submerged bar of sand and silt creates breakers at the mouth of the Alsek. If the water is too rough to cross into the river, the men must have time to get back home before the afternoon wind kicks up the sea. As they leave Yakutat Bay, they can see the edge of Malaspina Glacier, which covers an area the size of Rhode Island. Out of sight, far up the bay, are the Valerie and Hubbard glaciers (in 1986, these glaciers gained international press coverage when they created an ice dam that trapped dolphins, seals, and other marine life).

Three hours into the journey the strain of the noise of the twin 50-HP Mercury engines and the vibration of the boat shows in the men’s faces. They are anxious for the trip to end. Nearing Dry Bay, as the mouth of the Alsek River is known, they enter a dense fog bank, caused by the clash of the cold river water with the warm ocean air. The surface is turbulent where the river rushes out to meet the sea, and for up to a mile the ocean is discolored by the mud and silt carried in the plume of fresh water. On a clear day they would be able to see the snowy peak of 15,300-foot Mount Fairweather, forty-five miles to the southeast. The Tlingit people used to call it “paddlers’ mountain,” because if it was visible, it meant it was safe to travel by canoe on the unsheltered sea.

The men maneuver their skiffs near the breaking surf, searching for a safe place to cross the river bar. The year before they were twice forced to turn back to Yakutat. As the ocean swells reach the bar, the waves become steeper, crest, and tumble over themselves. The men watch very carefully, assessing the best way in, then throttle the engines. A large swell lifts Eli
and Sammy’s boat and propels it forward, but the pleasure of the sensation is diminished by the knowledge that, when taken in the wrong direction, such waves can capsize a boat. Indeed, two Yakutat natives drowned near this spot when their boat was swamped.

Safely inside the bar, they travel along the eastern shore of the wide mouth of the Alsek. The air, chilled by the river, is much cooler than it was on the ocean. They beach the skiffs and make camp, pitching their tents near those of other Tlingit fishermen who have arrived before them. On the windward side of each tent the men erect a palisade of drift logs. A few years before, the windscreens also protected them from shots fired by several non-Indian fishermen who wished to scare them off. A Tlingit village once stood nearby, on the bank of Cannery Creek, but in 1908 its 150 inhabitants moved up the coast to the larger native community in Yakutat. Eli’s clan was one of those that came from Dry Bay, and he recalls his grandparents’ tales of living here before the white men came.

There are thirteen salmon-producing streams along the 200-mile stretch of coast that the Yakutat Tlingit fish. Two of them, the Alsek River and, a few miles away, the East Alsek River (commonly known as the East River), are as different as rivers can be. The Alsek drains a large area of northern British Columbia, the Yukon Territory, and southeastern Alaska and is the only river in more than 500 miles of coastline to have muscled through the high Alaskan coastal ranges. It is 200 miles long and flows through some of the most remote lands in North America. As it nears the ocean, its immense volume, second only to the Columbia among Pacific Coast rivers, fans out into a large mouth. The East River, in contrast, springs from an artesian source and runs just seven miles to the sea.

The current of the Alsek is swift, averaging six knots; the current of the East River is a gentle two knots. The Alsek is extremely cold (38 to 42 degrees) since most of its volume is meltwater from glaciers. The East River is shallower and nonglacial and therefore unusually warm (55 to 65 degrees). The water of the Alsek is turbid; from the air, its milky gray color gives it the appearance of watery cement. The East River, in contrast, is crystal clear.

Both rivers have large salmon runs, and together they spawn all five species of Pacific salmon: red (sockeye), king (Chinook), coho (silver), pink, and chum. But the Alsek has no pink salmon; the East has no kings. Even the same species of salmon appears quite different in the two rivers. Alsek salmon, which must travel several weeks in swift and frigid waters to reach their spawning grounds 120 miles upriver, are torpedo shaped, better muscled, and have a higher fat content than their species mates in the East River. And because they have much farther to travel to reach their birthplace, they arrive from the ocean earlier. Sockeye salmon in the Alsek, for example, begin arriving from the sea in late June, a full five weeks earlier than sockeye in the East River.

Although both rivers rank among the top salmon producers in southeast Alaska, the tiny East River outperforms its Goliath neighbor. One reason, according to fisheries biologist Alex Brogle, is that the East River’s artesian flow prevents the river from freezing, resulting in a high survival rate for the salmon eggs. In addition, its profusion of underwater vegetation shelters the young fry from predators and pumps oxygen into the water, helping to create an ideal growing environment.

In both rivers salmon are caught with gill nets, which are four feet deep. Specific regulations govern the number and length of nets: on the East River, for example, a commercial fisherman is permitted only one 20-fathom net during the first part of
Salmon, like the sockeye below, have been a major resource of the northwest Pacific Coast since prehistoric times. Today, some 800,000 fish are harvested annually from the Yakutat area alone. Right: A river threads its way through the temperate rain forests of the Dry Bay region.

Both photographs by George Gmelch

the season. The nets are suspended at the water's surface by a cork line that runs along the top; a lead line weights down the bottom edge. Fishermen stake one end of their nets to the riverbank, then stretch them into the river by boat, where they anchor and buoy the other end.

Salmon migrating upstream to spawn hit the nets and become entangled, usually caught around the gills. The trapped fish are then “picked” from the nets by the fishermen, who pull themselves back and forth in boats while the nets are still in place. For each species of salmon a different size mesh is used. As each species arrives from the Pacific to spawn, the fishermen remove the old webbing and hang on the new, proper size.

Once or twice a day the fishermen take their catch to a small fish processor on the bank of the Alsek River. Depending upon the intervening terrain and river conditions, the catch is transported either by boat or by off-the-road vehicle with a trailer. At the processor the catch is weighed and then gutted, with the roe being packed separately for export to Japan as caviar. The fish are put on ice until they can be flown out to Yakutat for further processing and distribution to West Coast markets.

Because the East River is clear, salmon are able to see the gill nets. For this reason, fishing on the East River used to be done primarily at night. Only the less wary chum salmon could be caught in quantity during the day. In the mid-1970s, when nylon nets replaced the bulky and more visible cotton webbing, fishing during daylight hours became worthwhile on the East River. The extreme turbidity of the Alsek River, in contrast, means that time of day has little effect on fishing success.

One benefit of clear water, however, is that fishermen on the East River can see the fish, so they know exactly where to set their nets. In choosing a “set,” they look for a pool or eddy (a circular current in which the water reverses itself), where the salmon are resting from the current on their journey upstream. Finding fish in the murky Alsek River is more difficult; as in divining for underground water on land, intuition and years of experience help.

Because fishermen on the East River can see their prey, they can increase their catch by chasing fish into their nets. They do this by driving their boats back and forth across the pools or holes where the fish are resting, pushing them toward the nets. As the chasing takes place, many fish hit the nets at once, their silver bodies flashing as they struggle to get free.

If fishermen did not regularly remove the trapped fish, the fish following behind would see the commotion and go around the nets. Similarly, fishermen must keep their nets free of debris, and here again the two rivers pose very different problems. In the East River, underwater vegetation (“moss”) carried downstream by the current clogs the nets; to get rid of moss, fishermen must regularly shake the nets a small section at a time. This is exhausting work and means that fishermen on the East River must spend more time at their nets than those on the Alsek or other area rivers. On the outgoing tide, which increases the current, there can be so much moss that fishermen must remove their nets from the water or risk having them sink to the bottom from the added weight.

The Alsek does not have moss, but it does have drifting logs, as well as ice from the calving Alsek Glacier upstream.
Small logs and chunks of ice merely foul the nets and must be removed; large logs and icebergs can destroy them. I once watched a fisherman lose two nets to an iceberg the size of a car. Also, the Alsek Glacier occasionally surges forward, displacing a huge amount of water and making the river an unfishable torrent.

Harbor seals preying on the salmon trapped in the nets are also a headache for fishermen on the Alsek. An estimated 5 percent of all the salmon netted there are lost to seals. Seals, say the fishermen, are clever and understand how gill nets work. In 1981 a severe storm caused fishermen working in the surf outside the river mouth to abandon their nets. When a fisheries biologist went to remove the nets after the storm abated, he found a seal behind three of them, driving fish into the nets and then eating them.

Seals are uncommon in the East River because there is less food for them in warm-water streams. The main items in the seals' diet (when they are not poaching salmon) are flounder and shrimp, which are more abundant in and around the colder waters of the Alsek. Seals have also had a more difficult time surviving the assaults of fishermen in the clear water of the narrow East River, where they are easily seen and shot at or else chased with skiffs until they drown.

A second animal predator that competes with the fishermen is the brown bear, abundant near both rivers but more common along the Alsek. The coastal variety of the Alaskan brown bear reaches nine feet in length and averages 1,200 pounds, considerably larger than the interior Alaskan grizzlies. The area near Dry Bay has an unusually dense bear population, attributable to a steady supply of high-protein fish offal dumped by the local fish processor. "Their rich diet," explains game biologist Ron Ball, "means the Dry Bay brown bears are especially fit when they go into hibernation. In the spring, we see more Dry Bay bears with three cubs than is true in other areas." The bears are also attracted to the fish caught in the fishermen's nets, and will wade into the water or haul the nets onto the bank to get at them. Either way, fish are lost and the webbing is damaged as the powerful animals tear at the nets to remove the fish.

Fishermen on both rivers typically pack guns. There is much local lore about encounters with bears, and the behavior and movements of individual bears are a frequent topic of conversation among fishermen. To protect their nets and their own safety, fishermen have adopted a number of strategies to keep bears away. One Alsek fisherman spreads his dirty laundry on the bushes near his set to give the area a strong human scent; another uses a noise-making cannon, like those used to scare crows from cornfields. When fishing at night, some men keep a lantern or fire burning on the riverbank. Since the chance of being attacked is greatest when a bear, particularly a sow with cubs, is surprised, some fishermen wear bells when walking in the woods or brush to let bears know they are in the area. And a few fishermen, particularly non-Indians, shoot them. In Alaska, shooting a bear without a permit is illegal, except in defense of life or property. Nonetheless, one Alsek fisherman told me that he had killed more than twenty bears in two decades.

I first came to the Dry Bay area in 1982 as an anthropologist contracted by the National Park Service to study the harvesting of the fish, plants, and animals by the residents of the area. Two years before, the Dry Bay region had been designated a National Preserve under terms of the Alaska National Interest Lands Conservation Act (ANILCA). It was added to Glacier Bay National Park with the provision that all harvesting activity that existed before the creation of the preserve had to be protected. Park planners anticipated only problems in trying to oversee
the activities of trappers, big game hunters, and commercial fishermen, particularly given the tensions that existed between the Tlingit and non-Indians. For me, however, it was a welcome opportunity to see how different groups of people exploited the same resources and how they accommodated to each other.

The Tlingit have traditionally been a maritime people, living by fishing and hunting sea mammals, as well as forest game. Before the Russians first made contact with them in 1741, the Tlingit had already evolved one of the most complex non-agricultural societies in the world. To the outside world, the Tlingit people are best known for their potlatches and for their elaborately carved wooden house and funerary poles. Today they live in twenty-five villages and towns scattered 400 miles along the Alaskan coast from Yakutat to Ketchikan. Most still fish and hunt for subsistence, and many, like Eli Hanlon and Sammy Johnson, are commercial fishermen as well. Others hold wage jobs, often in logging operations and fish canneries. And some are college-educated professionals.

Tlingit fishermen move from one river to another to take advantage of the arrival of different runs of salmon, usually working four different rivers during the five-month-long salmon season. They fish both inside the rivers and outside the river mouths. In the latter case, the nets are anchored to the beach or allowed to drift free, attached to a buoy at either end. This “surf,” or “breaker,” fishing is a highly uncertain activity, with the ever-present danger of being capsized by an unexpected wave. Because of the risk, surf fishing is done with two men in a boat—one to work the nets and the other to watch for approaching swells—and with two or more boats working together, so that help will be nearby in case of trouble. Unlike the peripatetic Tlingit, non-Indian fishermen remain in one place throughout the fishing season. Most live in the score of fish camps upriver from the Tlingit people on both the Alsek and the East rivers. Those who have fished and lived in the area longest are descendants of Norwegian and Finnish immigrants who arrived between 1910 and 1912 to work in a newly built cannery at Dry Bay. The cannery closed suddenly in 1912, just three years after it opened, when the company’s 106-foot vessel, the Oakland, sank crossing the bar at the mouth of the Alsek.
The trim palisade of a permanent fish camp, left, contrasts with the makeshift windscreen of temporary installations, below. Non-Indian fishermen stay in their encampments throughout the season, usually setting their nets nearby. Tlingit are more likely to seek salmon at several different rivers.

Clarence Summers

losing the entire season's catch of 14,000 cases of salmon. A half-dozen Scandinavian workers returned on their own the following season to fish, building small cabins along the Alsek. Other non-Indian fishermen arrived after World War II, particularly in the 1960s and 1970s, mostly from the lower 48 (the Tlingit refer to them as the "Washington fishermen," for the state from which most originate and to which they return each fall after the last run of coho salmon).

While the Tlingit live clustered together in tents on the sand near the river mouths, the non-Indians live in individual fish camps, usually consisting of a small cabin, an outhouse, a storage shed, a net-drying rack, and a smokehouse. By using salvage from a lumber barge that sank off the coast, several have expanded their primitive camps into comfortable homes, with generator sheds, saunas, and in one case, quarters for guests. The region's fish camps are strung out along the banks of the Alsek and East rivers, spaced far enough apart so that no one is in sight of his neighbor. Except for the occasional trapper, no one lives in Dry Bay during the winter, when fierce, icy winds sweep down the Alsek gorge from the Yukon.

All fishing is done by permit, a requirement instituted in 1974 to protect salmon from overfishing. While permits for subsistence fishing are easy to obtain, only 160 permits have been issued for commercial fishing in the Yakutat region. A permit covers just the boat and nets for one fisherman, but one additional person is allowed to assist the permit holder. Sometimes, two fishermen with permits will choose to share a boat.

The average annual income for the commercial fishermen is about $33,000, although some earn two or three times that figure. About seventy of the permits are now owned by non-Indians. Like a car or house, the commercial permits may be individually bought and sold. During crises or at other times of financial need, some Tlingit have sold their permits to non-Indians, often at less than their real value, and then later have been unable to afford another permit. With the demand for the limited number of permits greater than the supply, their value has risen to more than $40,000, a figure well out of reach of young Indians. Denied the opportunity to fish for a living like their fathers and grandfathers, young Tlingit often resent those outsiders whose money has enabled them to buy into the fishery.

Before European contact, the Yakutat Tlingit were adapted primarily to the demands of their physical environment. Their nearest Native American neighbors—the Tutchone Athabaskans of the interior—were separated from them by the massive mountain wall of the coastal ranges. Other than occasional trading, there wasn't much contact or competition between the groups. But with Russian and then American settlement in Alaska, the Tlingit have had to adapt to other groups who want a share of the resources. And since Alaskan statehood in 1957, they have had to adjust to the increasing requirements of bureaucracies (the Alaska Department of Fish and Game, the U.S. Fish and Wildlife Service, the National Park Service, the U.S. Forest Service) that regulate the physical environment.

Relations between Tlingit and non-Indian fishermen are strained, at best. From 1977 to 1981 there were thirteen incidents
In which Tlingit fishermen were fired at in an attempt to drive them away. Tlingit fish camps have also been set afire, and in 1978 the helicopter used to carry the Tlingit catch to the fish processor in Yakutat was shot at and disabled.

The cause of the conflict is competition for salmon, precipitated by the return of Tlingit fishermen to Dry Bay after a twenty-year absence. Most Tlingit had left the area in the aftermath of the 1958 earthquake, whose epicenter was not far from Dry Bay. The earthquake, measuring 8.2 on the Richter scale, fissured the earth and caused the alluvial deposits of the region to undulate like waves on water, knocking people off their feet. Fifty miles down the coast at Lituya Bay, the earthquake set off a landslide so massive that the resultant splash and wave denuded the forest to a height of 1,720 feet above the level of the bay. This was the largest wave ever recorded.

In the Dry Bay area, one side of the Doame River was thrust forty-five feet upward (the largest vertical uplift ever recorded), blocking the river’s outlet to the sea and forcing it to flow into the East River. The salmon migration was severely disrupted because the mixing of the rivers changed their “smell” enough so that the spawning salmon arriving from the sea did not recognize them as home. In the years following, the Tlingit avoided the Dry Bay area, fishing instead the bountiful salmon runs in the rivers nearer to Yakutat.

The salmon runs in the Alsek and East rivers eventually reestablished themselves, however, and in 1977, after hearing rumors of enormous catches and huge profits on the East River (indeed, one Washington family had earned $250,000 the previous year), the Tlingit returned. One from Yakutat, Larry Bemus, flew over the East River and observed a gigantic run of sockeye salmon. He and a few other Tlingit then traveled down by boat to set their nets. They did well. In Yakutat the news of large salmon catches spread fast, like talk of gold in the Klondike, and more fishermen joined them.

Threats and attacks on Tlingit by non-native fishermen followed, and additional Tlingit came primarily to offer their support. Sheldon James, whose family’s clan hails from Dry Bay, recalls: “When my brother was shot at, I said to myself that I had to go down there and help out. I was not going to let those Washington fishermen run us out.” By late July 1978, there
were forty fishermen from Yakutat on the East River, double the number of the non-Indian fishermen.

In river fishing there are a limited number of good places to fish, and they are generally known to most fishermen. The difference between a good and a poor set can mean a lot of money to a fisherman. Consequently, a system regulating choice and access to sets is necessary. Here again, different conditions on the Alsek and East rivers have led the fishermen to adopt different customs.

The Alsek River, until it fans out into Dry Bay, flows through rock, and therefore the contours of the river and the locations of good sets are fairly constant from year to year. Here sets are tied to fish camps, and the person who "owns" the camp fishes the set nearest it. These sites thus belong to particular families, all of whom happen to be non-Indian. In effect, the river has been divided into distinct fishing territories whose integrity is observed by all local fishermen.

The waters of the East River and most of Dry Bay, in contrast, flow through sandy alluvial deposits that are constantly eroding and shifting: the bends, eddies, and sand bars change and there is much flux in the location of good sets. In these waters, fishermen claim sets on a first-come, first-served basis. Each fisherman claims a set by placing a buoy on the river bank with his name and permit number on it. No other fisherman can then set his nets within 100 yards (the distance between nets is determined annually by the Alaska Department of Fish and Game). This system works fine as long as there are enough good sets to go around. But that has not been the case since the 1977 return of Tlingit fishermen to the area.

Non-Indian fishermen, few in a vast area, never developed a mechanism for dealing with a shortage of sites. Being the first to arrive on the rivers each summer, they simply refused to consider any counterclaim to their sites. In contrast, the Tlingit solve the problem by openly competing for good sites in a "race-off," in which fishermen wanting the same set for a given run of salmon race their skiffs toward the center of the river while feeding their nets over the stern. The first to get all of the net and the end anchor in the water is the winner. The loser must then pick up and move to another site.

Non-Indian fishermen on the East River have generally refused to race for sets. Reflecting the sentiments of many, one explained:

I fish the East River all season long, and that should give me the right to keep this set for as long as I want it. Now, if I move up or down river, then someone can take it away. But as long as I stay here it should be mine. When I came here twenty years ago, the Indians weren't even here. They were up there fishing on the Situk and Icy Bay and them other places. We were here first.

Some of their opposition to race-offs may also be due to the realization that they have little chance of beating the Tlingit, who are more experienced with boats and with this type of competition.

From the Tlingit perspective, "challenges," as race-offs are also known, are not only fair but have a long tradition on all the rivers in the region. They believe that no individual has the right to monopolize a site for an entire season when other sites are not performing well. The varying attitudes held by the two groups no doubt
also reflect important cultural differences: the Western emphasis on individual or private ownership of land and resources versus the Tlingit's more communal sense of ownership.

Aside from refusing open competition for sets, the non-Indian fishermen also object to the Tlingit setting nets outside the mouths of the Alsek and East rivers. They believe that surf fishing reduces the size of their own catches by intercepting the salmon before they enter the river. In 1981, complaints about surf fishing led the Alaska Department of Fish and Game to ban the practice around the Alsek and East rivers. The ban did not apply to the other eleven salmon rivers, where surf fishing occurred but did not affect non-Indians. In response, twelve Tlingit fishermen sued the Department of Fish and Game, charging racial discrimination.

In 1982, the Alaska Human Rights Commission ruled in favor of the Tlingit but, uncharacteristically, made no recommendation. Subsequently, only part of the surf was reopened to fishing, and the fishermen were not compensated for income lost during the previous years. Not until 1987, when the case reached the Alaska Superior Court, did the plaintiffs finally win. At the trial, in a reversal of roles, I was in the witness stand giving “expert” testimony on the history of the Tlingit fishery, while in the gallery were the Tlingit fishermen who had been among my teachers. (I should note that, although I appeared on behalf of the plaintiffs, during my fieldwork, I actually lived, and did most of my research, among non-Indians.)

The trial went well, for the state had little credible evidence to offer in defense of the Fish and Game Department’s action. The settlement, to be announced this spring, is expected to fully compensate the fishermen for their lost income. The larger problem remains, however—how to mediate the competition between the Tlingit and non-Indians on the Alsek and East rivers. What principles should govern the allocation of fishing sites and, perhaps thorniest of all, what should be done about the high cost of commercial permits, which now effectively denies many Tlingit the opportunity to fish for a living?
A group of Tlingit men with a subsistence permit pull their net out into a bay north of Sitka, a town about 200 miles south of Yakutat. Unlike the salmon caught by commercial fishermen, which will be factory processed for shipment to fresh fish markets, most of the fish this group hauls in will be frozen or smoked.

George Gmelich
Dearth of the Blues

Butterflies that have thrived since the Ice Age are now endangered by suburban sprawl

by Margaret M. Stewart and Claudia Ricci

The breathtaking beauty of the Albany Pine Bush is due to its diverse habitats: swamps, deep woods, and sedge-covered sand dunes up to a hundred feet high. Most spectacular of all is the spring bloom of wild lupine that spreads like an azure blanket over the gently rolling dunes. Blue butterflies, sometimes in groups of a hundred or more, flit among the lupine and alight on picnickers and hikers, attracted to their perspiration in the dry, plain-like climate.

Sadly such diversity is easily destroyed. Several years ago we saw bulldozers and chainsaws arrive to clear the way for the construction of a shopping mall. Within a few weeks, nearly 300 of the 3,000 acres of Pine Bush were wiped away in a whirl of sand, dust, and woodchips. Within the sea of asphalt, the developers spared a single field of lupine flowers: an eleven-acre island of sand dunes surrounded by a white slat fence where now lives one of the largest-known colonies of Karner blue butterflies. It is a colony that, like the Albany Pine Bush itself, faces an uncertain future.

These are tough times for the Albany Pine Bush, a diverse inland sand dune ecosystem that lies only minutes from the hectic downtown areas of Albany and Schenectady, New York. Bordering and sliced by several major highways, this rare pine barrens, which once stretched for forty square miles, is rapidly being ruined by modern suburban sprawl. To developers, the Pine Bush represents prime urban real estate, ripe for housing, office buildings, and shopping malls. But development interferes with the natural fires that are essential to the survival of a pine barrens community. Without fire (which occurs naturally about once every ten years), competing species invade the pitch pine and scrub oak; aspen, maple, white pine, and black locust crowd out the lupines, which grow best on open sand.

The sand dunes of the Albany Pine Bush were born out of sand deposits left behind by postglacial Lake Albany, a mammoth body of water that filled the Hudson Valley some 12,000 years ago. The remnant sand of the glacio-Mohawk delta was wind swept into dunes and then stabilized by scrub oaks, huckleberries,
A female Karner blue butterfly (her sex identified by the large, orange spots on the upper surface of the hind wings) basks in the sun in the Albany Pine Bush. The upper surface of the butterfly's wings, which appears blue to the human eye, flashes a brilliant signal to potential mates.

R. Carr; Bruce Coleman, Inc.
Dune fires renew the Pine Bush habitat by keeping competing species from crowding out the fire-resistant pitch pine and scrub oak. Fires once burned over miles of these dunes but are now controlled by fire companies or limited by highways that cross the pine barrens. Prevailing winds from the northwest (upper left in the infrared aerial photograph, right) shaped the dunes, some of which are a hundred feet high. The area in the upper right with no vegetation is where sand-mining operations cut away the dune.

John F. Cryan
blueberries, and a scattering of gnarled pitch pines. The sandy barrens also supported wild lupine, which tolerates long periods of drought. The lupine's clusters of blue, pea-shaped flowers, tapering to a point of young buds, attracted an associate of similar color, the Karner blue butterfly, whose larvae feed exclusively on that plant. When the lupines disappear or are too few or too far apart, they can no longer support colonies of Karner blues.

The Karner blue, with a wingspan of only about an inch, has taken on a significance far disproportionate to its size in the battle over the Pine Bush. The first insect to be listed on the New York State Endangered Species list in 1977, the butterfly nearly stopped the construction of the shopping mall. In 1980, eight months of heated public hearings pivoted on testimony regarding the fate of the Karner blue. The evidence suggested that the mall would endanger not only the Karner blue but also a second rare and interesting lepidopteran, the buck moth, as well as amphibians and reptiles—among them the spadefoot toad, Fowler's toad, the worm snake, the hognose snake, the box turtle, and the spotted turtle. In the end, the New York State Department of Environmental Conservation required that the Pyramid Corporation, the company that developed and owns the Crossgates shopping mall, set aside acreage in the mall. But isolated on the shopping center grounds, the butterfly colony, with its limited gene pool, may not be longlived. Without fire to suppress the invading aspen, the lupines will not thrive. And one extremely harsh winter could doom the isolated Karner blue population.

With lupine colonies gone from several sites where they once thrived, Karner blues are at an all-time low in the Pine Bush. They have disappeared from their former ranges in Pennsylvania and New England, except for a colony near Concord, New Hampshire.

The very existence of Karner blues in one area or another often appears to be by chance: adults can fly only short distances during their ephemeral lives, but they sometimes fly high enough to make it across highways to form a new colony. Some areas where lupines grow, such as the Rome sand plains in central New York, have no Karner blues. The reason may be that the distances from major populations are too great.

Blue butterflies are a confusing bunch. There are some thirty species of small blue butterflies in North America and they have traditionally been included in the family Lycaenidae. But when isolated
Stands of lupine, below, grow among the scrub oak and reach their full bloom in late May, just before the Karner blues are most numerous. Karner blue caterpillars need lupine leaves to survive. Also called sundial plant because its leaves track the sun’s movements, wild lupine is a prairie plant that needs a sandy, low-acid soil.

Frank Knight

from other colonies they may evolve into different forms and eventually become new species, lending much confusion to their classification. The Albany form of the butterfly was first mentioned in the literature in 1862, but lepidopteran specialists still disagree about details of taxonomy and name changes are frequent.

In the 1940s, the blue butterflies caught the attention of novelist-lepidopterist Vladimir Nabokov, who used to visit the Pine Bush on his way from Cornell University, in Ithaca, where he wrote and taught, to Harvard University, in Cambridge, where he studied butterflies. In 1943, he published a paper in which he named the famous blue butterflies Lycaeides melissa samuelis, to honor Harvard entomologist Samuel Scudder (scudder had already been used as the name for another blue). Nabokov designated the butterfly’s type locality (the place where the first described specimen was found) as Albany, specifically, Karner, New York, once a tiny whistle stop in the Pine Bush on the New York Central railroad.

Will the blue butterflies disappear altogether from the place where they were first named? The answer to that question is entwined with the fate of the Pine Bush itself. Although the area is full of rare creatures, the terrain is rough, stark, and often mistaken for wasteland. “Pine barrens areas such as the Pine Bush have always been held in low esteem,” wrote entomologists Robert Dirig and John Cryan. “The scrubby growth covering a bleak landscape, the searing heat in summer and bitter cold in winter, the frequent fires that leave smoldering blackness in their wake, the lack of visible animal activity, and the utter uselessness of areas such as the Pine Bush to man have been frequent causes of their destruction.” But for many species, the warm, sandy scrublands are their only refuge. A survey in the Pine Bush by Margaret Stewart and her student John Rossi in the 1970s found twenty-nine species of amphibians and reptiles. Five of these—the eastern spadefoot toad, Fowler’s toad, box turtle, worm snake, and eastern hognose snake—are not found in the surrounding county outside the Pine Bush. While the turtles can use the upland and dry woods for breeding and feeding, the toads and snakes only survive the heat of the Pine Bush by burrowing into the dunes or seeking shade beneath discarded trash. (Efforts to clean up trash now destroy a great deal of remaining habitat.)

These species also depend on temporary ponds. Amphibians, especially, need these ponds of lupine, with bluish purple, sweet-pea-like blossoms and pretty parasol-like leaves, is a spectacular wildflower of the Pine Bush. It probably arrived at the Pine Bush from western North America during the hypsithermal interval, a relatively arid period, several thousand years ago. With it, or soon after, came the Karner blue, an insect that thrived in hot, dry places, fed as larvae only on wild lupine, and was able to survive where brush fires were frequent. As a postglacial survivor, the Karner blue is one of the most habitat-dependent species in the Northeast, always found in dry “islands” like the Pine Bush.

Adult Karner blues are on the wing twice yearly, in late May and early June, and again in late July and early August. Spring brood females glue tiny, greenish white, turban-shaped eggs singly to lupine leaves. The eggs hatch in about a week. The caterpillar, or larva, is green, exactly the color of lupine leaves. Thus camouflaged, it feeds and grows for about three weeks. When mature, it is three-quarters of an inch long, has a dark green stripe along its back, paler stripes along the sides, and is covered with fine velvet hairs. Karner blue caterpillars have a distinctive feeding habit: they eat away all but the upper layer of the lupine leaflet, leaving translucent spots, or “windows,” and are easily found in the wild by this sign. At maturity the larva moves off the lupine plant and prepares to pupate on a grass blade or elsewhere in the surrounding duff. It spins a silken pad, to which it attaches its anl prolegs, and also fastens a silk belt around the middle of its body. In a day or two, a green chrysalis forms. A week later, the developing butterfly can be glimpsed through the pupal shell a few hours before emerging and expanding its wings. Then a new Karner blue darts away, a resplendent azure jewel flashing in the summer sun.

Adults of the midsummer brood mate, usually in early afternoon, and the females again lay eggs. But in the meantime, the lupine has set seed and died down, leaving only a few old leaves and occasional new sprouts. This time the butterflies place their eggs on the seed pods and dried stalks of lupines or on adjacent grasses. These eggs may or may not hatch in late summer; overwintering as an unhatched egg is probably more likely than as a
young larva, although the buck moth, another rare Pine Bush insect, hibernates as both an egg ring and an unhatched pupa. However it is accomplished, new Karner blue larvae can be found leaving their window signatures on tender lupine leaves the following May.

Karner blues, like all butterflies, are coldblooded and frequently bask with widespread wings to absorb the sun's rays. When warmed for flight, they drink nectar at a large variety of Pine Bush flowers, including several rare plants that still survive in the Pine Bush. Adults also drink at puddles, at times in huge companies; up to 200 have been reported together. Butterflies also feed at bird and mammal droppings, and will occasionally land on humans (and perhaps other mammals) to lap up perspiration. All available fluids must be exploited in such an arid place. Karner blues are so closely associated with lupine that they can be found roosting together on or near the plants during rainstorms and at night.

The association of ants with caterpillars is well known in several species of blue butterflies. The caterpillars produce a nectarlike fluid that ants eat, while the ants may deter predators and parasites. Last summer Dolores Savignano of the University of Texas at Austin studied Karner blue larval–ant interactions. She found nine species of ants attending Karner blue caterpillars in two small colonies of the butterfly. She also discovered that wasp and fly parasitoids still attacked Karner blue caterpillars, indicating that ant “protection” is not perfect.

In the 1940s, Nabokov published a taxonomic revision of the genus Lycaeides, which includes the Karner blue. In his paper he renamed the northeastern entity (which floated like “blue snowflakes” in his novel Pnin) Lycaeides melissa samuelis, considering it a subspecies of a western North American blue. Thirty years later, Nabokov was sure that he had erred and that the Karner blue was a full species. But he did not live to do the taxonomic work necessary to prove this, and the question remains.

The butterfly’s alarming decline is probably the result of habitat reduction and fire suppression. Without fire, the lupines are shaded out. As lupine abundance and location change within the Pine Bush in response to fires, the Karner blue must be able to follow. While well adapted for these local movements, this butterfly is unable to colonize lupine stations that may be tens or hundreds of miles away. Thus when habitats disappear, local populations are lost forever.

Butterfly weed, below, thrives in the Pine Bush and tolerates more disturbance to its environment than the lupine.

Novelist-lepidopterist Vladimir Nabokov
Pine Bush sand was used to make the forms for the cast-iron façades that adorn many of Albany’s buildings and—because of its low acidity and even texture—was ideal for the manufacture of concrete. By the time sand mining was outlawed in 1975, many dunes had been stripped away. When a dune is gone, the pitch pine, scrub oak, and lupine that once grew on its surface can take decades to return.

Right: An adult male Karner blue rests on a lupine flower in the early evening. The average life span of the adult is three to five days.

Both photographs by John F. Cryan

the cool, moist ravines and bogs of the Pine Bush.

These species exist in the island of sand now so far from others of their species that little immigration occurs to replace lost individuals. Today there is usually a large gap between Pine Bush populations and populations to the south. Tiger salamanders, once found in Albany, are now never found anywhere north of Long Island, New York. Many insects can only live in the sand barrens habitat.

The mixture of species found in the Albany Pine Bush differs from that in the New Jersey Pine Barrens or the Long Island barrens. But like them, the sands of the Pine Bush are underlain by an extensive aquifer that provides abundant clean water. Consequently, the Pine Bush has been exploited throughout history. Native Americans burned the bush in an effort to improve the habitat for turkey, deer, and berries, and their fires helped maintain the characteristic scrub vegetation. Early Dutch colonists cut the then towering pines for homes, stockades, and masts. The dunes were gougied out around the turn of the century to make molding sands for foundries. In 1850, Albany tapped the Pine Bush’s water by damming Patroon Creek to form Rensselaer Lake. The city relied on this water supply until 1875.

In the nineteenth century, farmers attempted to raise crops in the pinelands but gradually deserted, sold, or swapped the unproductive land. The dunes later became the dumping ground for all sorts of garbage, including rusted cars, refrigerators, and furniture. Hunters poached the plentiful deer. Teen-agers held drinking parties in the Pine Bush and littered the landscape with beer cans. The city of Albany located its landfills there.

Intense development began in the early 1950s as Albany, hemmed in by the Hudson River to the east and by other communities to the north and south, pushed westward. The easily moved sand was a builder’s dream. Scores of houses, office buildings, and warehouses now stand on what were once rolling dunes. Precious parcels of pine barrens were transformed into backyard gardens, driveways, and parking lots. But the Pine Bush is not conducive to suburban living. Lawns must be sprinkled to survive summer droughts. Termites thrive. Summers are beastly hot, and winters are cold with little to slow the cold winds sweeping down the Hudson Valley. Streets flood in early spring rains. Yet the builders continue to build. Besides the Crossgates shopping center, there is also the State University of New York’s Albany campus and a sprawling state office complex covering what used to be open Pine Bush terrain.

For now, development in the Pine Bush has been halted—temporarily at least—by recent court rulings. Most important was New York’s Supreme Court Appellate Division decision last July that an environmental impact study failed to determine the minimum acreage necessary to protect the Pine Bush ecosystem. The question for both the court and scientists was, Can the species that live here be protected in small tracts or must large continuous preserves be set up? In another ruling the State Supreme Court voided a plan to build 200 homes on an eighty-acre site estimated to contain one-quarter of the Pine Bush’s Karner blue butterflies. The state, the city, and the Nature Conservancy now plan to set aside about 2,000 acres of the rapidly dwindling pine barrens community and preserve it through controlled burning.

Today, Kings Road cuts right through the middle of the Pine Bush. During Colonial days it was known as the Kings Highway, a major thoroughfare connecting Albany and Schenectady and hence, the Hudson and Mohawk valleys.

In early June 1987, a group of twenty scientists visiting Albany for a conference ventured out of their cars to spend the afternoon exploring a tract that was swept by an April fire. Green leaves were already sprouting from the charred black branches and trunks of the scrub oak and pitch pine. Lady bird beetle larvae, black with bright yellow spots, were feeding on the tender young shoots. Yellow foxweed was blooming at the edge of the trail. Chumps of New Jersey tea were festooned by white flower clusters, and bracken ferns had unfurled new fronds. We could smell the sweetfern fragrance as we brushed against the resin-dotted leaves. Towhees and prairie warblers called from the brush. Now and then we came across the orange-red flowers of wild wood lilies. Lupine bloomed along the edge of the trails. And although the plant wasn’t nearly as plentiful as it once was we were heartened to find the characteristic clear windows in the leaves, evidence of feeding Karner blue caterpillars.

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The Devil Fish and the Tiger

Roy Chapman Andrews emerged from his Korean expedition with animal specimens, photographs, and—not incidentally—tales to spin

by Laurel Kendall

“I am averse to writing about adventures,” claimed explorer-naturalist Roy Chapman Andrews (1884–1960), prefacing one of the accounts of his Korean expedition. Adventures, he explained, “are a nuisance. They interfere with work and disrupt carefully laid plans.” But a generation of American schoolchildren remembers Andrews for his popular books, crammed with the unabashed romance of exploration.

Rumors of a “devil fish,” whose description matched that of the allegedly extinct California gray whale, were what brought Andrews to Korea in 1911 on behalf of the American Museum. Establishing himself in a whaling station at Ulsan, forty miles north of Pusan, on Korea’s eastern coast, Andrews soon verified his hunch. By March 1912, he had observed, measured, and photographed his gray whales, taken specimens, and prepared whale skeletons for shipment to the American Museum and to the National Museum of Natural History in Washington, D.C.

His initial mission accomplished, Andrews then secured permission from the Japanese colonial authorities to travel in the far north of Korea. While his stated purpose was to gather bird and mammal specimens from a corner of the world not represented in museum collections, he was also led by the allure of largely uncharted territory: “I made up my mind to be the first to tell the Western world what lay in the solitude of the Korean wilderness.”

Andrews left Seoul with a Japanese interpreter, who had appeared “in a frock coat, much too big, and a badly ruffled silk hat [but nevertheless] proved to be an excellent man,” and a doughty Korean cook, who spoke some English and enjoyed discoursing upon “the early history
of his country in which he was well versed.” Andrews and his party sailed from Pusan to the northeastern port of Ch’ongjin, then continued their journey by hand-operated push railway to Mürung-dong and by breaking oxcart to the old walled town of Musan, near the Tumen River. In Musan, Andrews hired six pack horses, five drivers, and a renowned tiger hunter, Paik Son-dai, who served as gun-bearer as well as occasional guide.

After an easy trek to the village of Nongssi-dong, the little party entered the wilderness, progressing with difficulty up steep plateaus covered with larch forest “so thick that at times we had to cut our way through the tangled branches .... The Korean horsemen and in fact all the party came under the influence of the gloom and silence and it was difficult to force them to proceed.” They were revived by their first sight of the towering peak of Paektu-san, “like a great white cloud that had settled to earth for a moment’s rest.” The mountain slopes proved even less hospitable: “The snow had become so deep that it was difficult to proceed, and we made our last camp in a driving storm of sleet and rain which kept us in tents for two days.”

Andrews abandoned his intention of reaching the summit and turned west, traveling through “dense forests, swamps, and drizzling rain” to the three lakes of Samjyŏn. At the time he thought he had discovered the lakes, but he later located them on a military map from the Russo-Japanese War. From the lakes, the party proceeded toward the Yalu River, slowly traversing swamps where it became necessary to lay logs end to end and drive the horses over. Fallen horses were but slowly extricated from the mud.

At Shin’galp’ajin, a raft was secured for

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travel down the Yalu River to Antung. Andrews then returned to Seoul by train, checked into the Lontag Hotel “dressed in Korean clothes except for coat and hat,” and read his own obituary. “For nearly five months,” he recounted in 1929, “I had dropped out of the world and the usual reports of death in the Korean wilderness had been cabled far and wide. I have ‘died’ so frequently since, that I am quite accustomed to it.”

In his two memoirs, *Ends of the Earth* (1929) and *Under a Lucky Star: A Lifetime of Adventure* (1943), Andrews embellished the account of his Korean expedition with three good yarns—of a near mutiny, an encounter with bandits, and a tiger hunt. The adventure stories he dissembled allowed him to present Andrews as Andrews was supposed to be.

In the memoirs, the five drivers plot desertion on the mistaken assumption that Andrews is leading them blindly through the wilderness.

They began to talk furtively among themselves and when we camped were ominously silent if I passed their fire. The interpreter told me that they were planning to desert that night with the ponies and food, leaving us to die or get back as best we could . . . . I could find my way out easily enough but no game meant probable starvation.

Andrews and the interpreter stand watch for two nights threatening to shoot anyone who approaches the horses.

The first sight of the majestic peak of Paektu-san restores the men’s confidence in Andrews and convinces them of the awesome power of his compass. Andrews casts himself as the Connecticut Yankee who travels back in time, bearing the technology of an advanced civilization. (It is unlikely, however, that his drivers had never seen the compasses used by geomancers to establish auspicious grave sites.) Interestingly, when Andrews alluded to this same incident in a 1919 *National Geographic* article, he dated it later, when he turned from Paektu-san to strike out toward the lakes at Samjiyon. Perhaps the men had simply not contracted to go so far.

The mutinous drivers may also have been still smarting from having been forced by the Japanese gendarmes to accompany Andrews into the wilderness in the first place. Coercion, according to Andrews, was a necessary evil. In a 1912 article for the *American Museum Journal* (as *Natural History* was then called), he attributed the drivers’ reluctance to a fear of brigands: “Absurd stories that wandering bands of Chinese robbers ranged along the borders of the forest had been rife since we left the coast.” In his 1929 memoirs, the rumored bandits do appear, but Andrews’s pluck saves the day:

While hunting roe deer, I stumbled into the camp of eight Manchurian bandits; tall, brown, hard-bitten fellows armed with long flintlock rifles. I suspected immediately what they were but they saw me as quickly as I saw them. My rifle did not help any. There was nothing to do but bluff it out. Fortunately I knew a little Chinese. I said I
was a friend, laid down my rifle and advanced. He invites the band home for dinner and, with the help of the cook, wins their friendship: "They told us how to avoid others of the band who might not be as friendly." The incident ends, like a Robin Hood story, in a fellowship of the greenwood.

And then there is the tiger story. In his scientific description of Korean fauna published in 1913, Andrews notes blandly that he spent three weeks hunting two elusive tigers near Musan, without getting so much as a single shot. He opines that the local people "greatly exaggerated the accounts as to the numbers and ferocity of these animals." In the memoirs, however, the tiger has become "The Great Invisible," almost supernaturally sly, and Andrews is called upon to aid the victimized populace. A tiger "was harrying the villages. Already it had killed half a dozen children and hardly a day passed that some tearful peasant did not report a new loss to the gendarmes . . . Would I kill the tiger? I would be a public benefactor!"

He pursues the elusive tiger through the countryside. "A breathless native would arrive at my camp saying that the tiger had been seen at his village . . . A girl had been the victim. We viewed the remains which were not pleasant to look upon." The climax comes when Andrews and the hunter Paik track the tiger to the mouth of a cave. "Paik announced that since the tiger would not come out we would crawl in and kill him where he slept. He had shot two that way with his old muzzle loading gun. Emphatically that method did not appeal to me."

Andrews demurs, but is goaded inside the cave by the resolute Paik. "'If you are afraid, give me your rifle and I'll go in alone,' he said but the look he gave me told just what he thought about white men who pretended they wanted to kill a tiger. That was a bit too much." Suspense builds as the two men track the tiger through the cave, Andrews making every effort to hide his mounting fear from his calm and collected gun bearer. The tiger has escaped through an unknown second entrance to the cave. Disappointed, but secretly relieved, Andrews loudly bemoans the loss of the tiger, and Paik does not suspect "how thoroughly frightened I had been." Andrews casts himself as the great white hunter, but with a twist—he tells a tale as much about the perils of image maintenance as about the perils of the wild.

Laurel Kendall is an assistant curator in the American Museum's Department of Anthropology.

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Venus on the Go

by Thomas D. Nicholson

Thinking about the sky from a geocentric, or earth-centered, rather than a heliocentric, or sun-centered, point of view can have its rewards. It helps, for instance, in understanding Venus' changes in size, shape, and apparent brightness this spring and summer.

Venus revolves around the sun inside the earth's orbit, closest to us when it passes between us and the sun and farthest from us when it is on the other side of the sun. In the latter position, the planet appears at its smallest and dimmest; in the former, at its largest, but interestingly, not its brightest.

The diagram (below) illustrates how Venus' path would look if Venus and the sun revolved around a stationary earth (shown in the center of the illustration). The sun moves to the earth's left in the sky beyond (with its location shown on May 1 and monthly thereafter). The curved line looping around toward the earth represents Venus' apparent path and relative distance from the earth. The dashed blue lines in the diagram show the line of sight between the earth and Venus monthly from April to October. When compared with the sun's position, the lines also show that in April, Venus is far to the sun's left; it is in line with the sun on June 12, and well to the sun's right in October. This left and right distance is a factor that governs

![Diagram of Venus' path around the sun and the earth's orbit.](Dennis Davidson)
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how high Venus appears as an evening star (when left of the sun) or as a morning star (to the sun's right) as seen from the earth. Venus shines by reflected sunlight; its brightness depends not only on its distance from the earth but also on its phase, that is, how much of its sunlit surface is visible from the earth. The effect of phase on brightness is significant for only a few months during Venus' nineteen-month cycle. Most of the time, distance is the principal factor, but soon before and after Venus comes nearest the earth, both distance and phase change rapidly and dramatically.

In the illustration the planet seems about three times larger on June 12 than in November. As it moves in front of the sun, Venus turns its illuminated side rapidly away from the earth before coming in line with the sun; then it rapidly opens up against the sun, going from a gibbous phase to a crescent and back again.

Taken together, the two changes of size and shape explain how Venus changes in brightness. As it moves closer to the earth and gets larger, it brightens, but when its bright side turns away, it gets dimmer. The balance between these opposing trends comes on May 6 when Venus is at greatest brilliancy in the evening sky. The roles of distance and phase reverse after mid-June: increasing distance dims the planet, but the waxing phase brightens it, so it reaches its greatest brilliancy again on July 19 in the morning sky.

With the aid of binoculars, the crescent Venus can be easily seen this month, hovering high in the west early at night. It will become more difficult to see by the last week, when it appears much lower and sets earlier night by night. But in early July, Venus repeats its performance in the morning sky, as bright and prominent as it was during May.

Galileo's discovery of Venus' phases in 1609 helped confirm the Copernican interpretation of the planetary system. While the illustration may clarify how the phases occur, they were a startling demonstration in Galileo's time that the earth (and Venus) did indeed move around the sun.

Events in the calendar below are given in local time unless otherwise indicated.

May 1: Full moon occurs at 6:41 p.m., EST, in Libra. Scorpius, Sagittarius, and bright Saturn rise behind the moon later at night.

May 2: Jupiter, in conjunction with the sun, ends its cycle as an evening star. It will be seen as a morning star by late June.

May 3: Scorpius' reddish star Antares,
near tonight's moon, is occulted over the Southern Hemisphere.

May 4: Morning moonlight spoils the Eta Aquarid meteors, not very prolific (twenty or so meteors per hour at best), but sometimes bright.

May 5: Saturn is above the Teapot's lid in Sagittarius, with the gibbous moon below it.

May 8: Last-quarter moon, at 8:23 p.m., EST, is in Capricornus, rising after midnight.

May 9: The Southern Hemisphere is treated to another occultation when the moon covers Mars at about 1:00 A.M., EST. The moon and planet are close but separate in our morning sky.

May 10: Perigee moon (nearest the earth).

May 13: Our last view of the old crescent moon before it moves between the earth and the sun.

May 15: New moon is at 5:11 p.m., EST.

May 17–18: The very thin, young crescent moon may be far enough north to be visible on the 17th, certainly on the 18th—below Venus on the 17th and above it on the 18th. Mercury, at its greatest elongation to the sun's left on the 18th, is relatively well located to be seen as an evening star. Look diagonally to the right below Venus for about a week before and after the 18th. Mercury is brighter earlier in that period.

May 19: With Venus below it, the crescent moon highlights Pollux and Castor after dark.

May 21: The crescent moon is between Pollux and Castor (below) and Leo's Regulus (above).

May 22-23: Venus begins its retrograde (westerly) motion, taking it rapidly toward the sun as it approaches inferior conjunction in June. The moon, reaching first quarter at 11:49 A.M., EST, on the 23rd and apogee (farthest from the earth) a few hours earlier, brackets Regulus from the 22nd to the 23rd.

May 24–27: After passing Regulus, the waxing gibbous moon chases after Virgo's bright star Spica, closing with it until the 27th, when it passes very near the star and occults it far in the Southern Hemisphere.

May 30: The nearly full moon is close to Scorpius' Antares tonight, with Saturn rising about two hours later below them.

May 31: This month's second full moon occurs at 5:53 A.M., EST, as the moon again occults Antares.

Editor's Note: The Sky Map in the April issue shows the evening constellations and stars for this month and gives the dates and times for use.


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That's a Moray!

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—B.D.S.

Photograph by Nancy Sefton
Born in the U.S.A.

American cuisine arose from the collision of the Old World's ideas with those of the New

by Raymond Sokolov

When I first began thinking about food in public in 1971, I knew of nobody spending serious time on food history. There were collectors of old cookbooks, and there were a few earnest souls reprinting them. Williamsburg had its publication; so did Maryland. But the bulk of the effort of preserving—and serving—traditional American foods was a catch-as-catch-can business, occurring in the odd showplace restaurant or at special holiday celebrations or chamber of commerce events celebrating local history once a year or once every centennial. Most of the so-called traditional restaurants owed almost nothing to the past. But even though they often distorted culinary history, these regional restaurants were frequently the only places where an outsider—or in many cases a local person—could experience even an unreasonable facsimile of regional food.

To give one example. The Olympia oyster is unquestionably the emblematic creature of Puget Sound. The whole region around Olympia, Washington, once based an important part of its economy on the harvest of these minute bivalves. In the San Francisco of the gold rush, rowdy millionaire prospectors and madams from the Tenderloin ate Olys by the hundreds. By the time I arrived in Olympia, there was only one restaurant and one oyster company where you could reliably find the region's characteristic food. The restaurant served them deep-fried in a thick breading that masked any natural oyster taste that cooking had not destroyed. The enterprising person with all morning to spend at it could locate the oyster company on a back road behind piles of thumbnail-size shucked shells. So while it was possible in the mid-seventies to get a taste of Olys, it was much more possible to be served an oyster cocktail of giant and tasteless Pacific oysters and have them passed off as Olympias because they had grown in nearby waters. Not many people seemed to care.

All that has changed. In the fifteen years I've been the food columnist of Natural History, American cuisine has captured the popular imagination. Chefs have built careers with resurrected antique recipes. Suppliers have made young fortunes shipping Michigan morels to Manhattan. And jaded gourmets from Berkeley, California, to Houston, Texas, and points east have learned to love those fanciful adaptations of traditional American dishes that make up the American nouvelle cuisine.

Now that we have a new cuisine, it is high time to ask, What was the old one? What do we mean when we talk about an American cuisine?

You don't have to be French to dismiss the whole notion with your nose in the air. None of the standard theories for explaining the origin of cuisines in other places fits the food of this country, in whole or in part. With the possible exception of Amerindian foods, we in this newfound land have not had time to accrete a coherent body of dishes and food customs that could properly be called a cuisine in the European or Asian sense of the word. We've had no tradition of royal and noble cookery to perfect an haute cuisine. Similarly, we've had no settled peasant population, on the same land, under the same conditions for centuries, evolving their own regional cuisines. In this country we honor century farms—farms worked by the same family for more than a hundred years. What most of us tend to eat is an eclectic mix of foodstuffs and food ideas gathered from a hundred places and never given the undeniably national stamp that a meal in France or in Italy usually has, regardless of region.

It was with thoughts like these in mind that, to my subsequent regret, I mocked James Beard in a review of his magnum opus on American food. Beard claimed that corned beef sandwiches and tacos and roast beef with Yorkshire pudding all belonged together in this country and qualified, collectively, as a cuisine. At the time, I said I was reminded of what the critic John Simon said about C.P. Snow:

Insiders harvesting wild rice in Minnesota

Jim Brandenburg
“He sees two cultures where I see barely one,” Beard saw one cuisine where I saw either none or dozens, depending on how you defined cuisine.

I have come to realize that Beard did not think that johnnycakes and kielbasa fitted into a seamless whole. He meant that they were the survivors in a winnowing process that had left large parts of traditional cuisines behind in their homelands. Here in this unmelting pot, some very disparate things had floated to the top and looked like they were staying there for the duration. He meant that America’s cuisine, like America, was not to be understood by referring to an Old World model. Its coherence was in its incoherence. Diversity made it whole.

If you detect a mystic tone there, you are not mistaken. I only half believe what I just said, except after an exceedingly good nouvelle cuisine meal in a restaurant in a shopping mall south of Los Angeles that serves mayonnaise flavored—highly flavored—by smoked jalapeño peppers. When my head is clearer, as I hope it is now, I tell myself that America’s traditional cuisine, if we have one, is the result of many separate collisions between immigrant groups applying what they knew from the old country to what they found in the new.

Stated in the abstract like that, my definition probably sounds like a simple-minded cliché. So let’s come down to earth a bit. Maybe it will help if I tell you what I think should be excluded from the gastronomic universe I’m defining as specifically American. Obviously, I don’t mean French food or other traditional dishes brought here by skilled native practitioners and reproduced more or less authentically, without the substitution of local ingredients that significantly alter the result to a point where a visitor from the country of origin would be justified in

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disowning what is served. In fact, I want to exclude all ethnic or imported foods that haven’t changed on these shores. Mayonnaise, even Hellman’s, is not American by this definition. Homemade mayonnaise is an import, and so is the bottled kind, invented in England within the past 100 years or so. The only pasta that I’d call American is probably the commercial kind known misleadingly in one version as Franco-American. But that is a trivial exception.

High principles also force me to reject hot dogs and hamburgers and apple pie. All of them came here from other places and didn’t change, except in the way they were appropriated to the American myth and grew popular because they suited local conditions of food service so well.

So what am I willing to call American food? All the plants and animals native to this hemisphere and unknown to the Old World until Columbus opened the way to their discovery and to their spread throughout the world. In this category belong the turkey, the American persimmon, black walnuts, corn, sassafras, chili peppers, blueberries, Olympia oysters, wild rice. Settlers took these new foods and adapted them to European culinary and agricultural methods. There are hundreds of examples of this process. Wild rice is an ideal case. The only native North American grain, it grows in the lakes and rivers of Minnesota, upper Michigan, Wisconsin, and adjoining parts of Canada. Wild rice is an aquatic plant, appropriately labeled *Zizania aquatica* in scientific nomenclature. At least the second half of the scientific name is appropriate. *Zizania* was picked as the genus name for no very obvious reason. It comes from a Greek word for weed, probably the darnel, which grows among wheat. The vernacular name is even more misleading, since wild rice is not an uncultivated type of domesticated rice, *Oryza sativa*, but closer in nature to wheat. The early French explorers added to the confusion. They called it *folle avoine*, “crazy oat.”

The important point here is that when European settlers confronted wild rice, they learned to harvest and process it from Indians. Even today, local enthusiasts preserve the primordial method of reaping wild rice as described, for example, in a memoir written in 1820:

> It is now gathered by two of the women passing around in a canoe, one sitting in the stern and pushing it along, while the other, with two small pointed sticks about three feet long, collects it in by running one of the sticks into the rice, and bending it into the canoe, while with the other she threshes out the grain. This she does on both sides of the canoe alternately, and while it is moving.

Eventually, the canoe filled up with rice and went to shore, where the Ojibwa Indians then cured it to prevent spoilage and to make it possible to remove the hull. Before colonization, Indians dried wild rice in the sun or over smoky fires. Settlers showed them how to toast the grain in calderons, stirring it with canoe paddles. At this point, the process became men’s work. They dug a shallow hole in the ground, lined it with skins, and poured in cured rice. Wearing moccasins and leather gaiters to keep the rice from working its way inside their moccasins, they literally danced on the rice to loosen the hulls, leaning on poles planted outside the hole for balance and leverage while jigging.

I was able to witness Indian wild rice jigging in the late 1970s. It was a staged demonstration in a park, but there were still connoisseurs who would only approve jigged wild rice and turned up their noses at industrially processed grain. Canoe harvesting was also very much a part of the wild rice cuisine for such aficionados. They viewed with alarm and distaste the onset of cultivated wild rice planted in man-made paddies and harvested by special combines. But this was obviously where the future of the grain lay. Today it is the main source of wild rice for nonhobbyists outside Minnesota. Wild rice ceased to be wild and became a cultivated grain when growers developed a strain of the plant with two crucial characteristics: it is the future of the grain. Today it is the main source of wild rice for nonhobbyists outside Minnesota. Wild rice ceased to be wild and became a cultivated grain when growers developed a strain of the plant with two crucial characteristics: it is the main source of wild rice for nonhobbyists outside Minnesota. Wild rice ceased to be wild and became a cultivated grain when growers developed a strain of the plant with two crucial characteristics that allow it to be harvested economically. Its seeds do not shatter at maturity and fall on the ground, and all the seeds mature at the same time. So when the combine passes through a wild rice paddy, trundling along on half tracks, all the grain is still on the plant and stays attached during harvesting; none of the grain is immature. Wild rice shatters—that’s what made the Indian method possible—the threshing stick gives the seeds the last nudge they need and sends them shattering into the canoe. And the Indian method leaves the plants intact so that the immature seeds can continue to ripen for later harvesting.

Does wild wild rice, hand toasted and jigged, taste better or even different from cultivated wild rice processed in a modern factory? I once went to some real effort to find traditionally gathered and processed wild rice, and then did a comparative tasting. Yes, there was a palpable difference. The old-style Indian rice was, paradoxically, much tamer than the store-bought rice. The jigging had taken off nearly all of the hull, leaving a softer, milder grain. Indians and other local enthusiasts considered the more refined rice to be superior. Commercial rice, they said, started out as
harder seeds that had to be cured longer and ended up darker. But this is exactly the "wild" texture and flavor that I associated with wild rice. It was wilder, crunchier, more appealing to someone who was not eating wild rice as his staple grain.

Our mission here, however, is not to decide this aesthetic dispute, but to observe that the post-Columbian history of wild rice is an ideal model for explaining the evolution of American cuisine. Step 1: Settlers discover this native foodstuff and learn the native methods of preparing it. Step 2: They adapt it to their own foodways. First, they add European technology to the processing (caldrons for boiling seeds, machinery for automatic jiggling). Second, they incorporate the new food into the cuisine they brought with them, creating recipes for wild rice muffins and other whole-grain dishes and substituting it for plain rice in European dishes, especially game dishes, on the theory that wild goes well with wild.

There the matter stood for two centuries, until the demand for scarce wild rice—a demand whose growth coincided with the rise of interest in American regional foods—gave economic encouragement to the development of cultivable wild rice that could be produced in large quantities. This process of discovery and adaptation occurred again and again in the history of American cuisine.

---

**Wild Rice**

(Adapted from Nanny's Texas Table, by Larry Ross, Simon and Schuster, Inc.)

\[
\begin{align*}
\frac{1}{2} \text{ cup oil} \\
1 \text{ clove garlic, minced} \\
\frac{1}{2} \text{ cup finely chopped onion} \\
3 \text{ tablespoons chopped fresh parsley} \\
1 \text{ cup raw wild rice} \\
1 \text{ cup boiling water} \\
1 \text{ cup boiling stock} \\
\text{Salt}
\end{align*}
\]

1. Preheat oven to 325°.
2. Heat the oil in a frying pan and sauté the garlic and onion until limp. Add the parsley and wild rice and sauté over medium heat for 4 to 5 minutes, stirring frequently.
3. Remove from heat, put the rice mixture into an ovenproof casserole, pour in the boiling water and stock, and add salt to taste.
4. Cover, place in oven, and bake for 15 minutes, then lower heat to 300° and bake for another 45 minutes or until rice is tender. Serve hot.

Yield: 4 to 6 servings

Raymond Sokolov is a writer whose special interests are the history and preparation of food.
Although he earned his bachelor's degree in civil engineering, William James Davis (page 38) turned to another early interest for his postgraduate work. He received his doctorate in zoology from the University of Texas. Kingfishers became the focus of his research about ten years ago. In addition to his work on belted kingfishers in the United States, Davis has studied the ringed, Amazon, and green kingfishers of Central America. Now a postdoctoral fellow at the Smithsonian Research Institute in Panama, he intends to continue to investigate the behavior and ecology of the New World kingfishers.

As asked by the National Park Service in 1982 to study how residents of the Dry Bay area of southeast Alaska harvested fish, plants, and animals, anthropologist George Gmelch (page 52) arrived to find Indians and non-Indians in the midst of a conflict over fishing rights. Although his first experience of the Dry Bay area was inauspicious—the plane that carried him there dropped him in bear country, miles from the nearest encampment—he eventually lost his greenhorn status and gained the respect of the local inhabitants, not least because of his surprisingly strong showing in a July 4 softball game. (Little did the locals know that the associate professor from Union College, Schenectady, New York, had once played professional baseball in the Detroit Tigers' farm system.) In 1987, Gmelch appeared as an expert witness to substantiate the Indian fishermen's claim to traditional use of the local rivers. Gmelch, who wrote on Britain's Gypsies for Natural History in February 1988 and on Barbadian emigrants in the October 1985 issue, is now finishing a book about West Indians who emigrate to Britain and North America but eventually return to their native islands. For more on Yakutat Tlingit culture, he recommends Frederica de Laguna's definitive study, Under Mount Saint Elias (Washington: Smithsonian Institution Press, 1972).
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Margaret M. Stewart (page 64) has been taking her classes to the Albany Pine Bush ever since she began teaching at the Albany campus of the State University of New York thirty years ago. She has since seen much destruction of the wind-swept, scrub-covered dunes, and has been active in trying to preserve what remains. Her studies (with John Rossi) of the reptiles and amphibians of the Pine Bush established that the area was the northernmost outpost for many species in New York. Stewart (left) is Distinguished Teaching Professor in the university’s biology department and a member of the board of trustees of the New York State Nature Conservancy. Last year, the Albany Foundation presented her with their Citizen Laureate Award for her work in the Pine Bush. Her present research is on the biology and behavior of the Puerto Rican coquí. Coauthor Claudia Ricci (right) is assistant dean of public health at the same branch of the university and is also a free-lance writer. She first learned about the Pine Bush and “the little blue butterfly that nearly halted a shopping mall” while on the staff of the Wall Street Journal. Those interested in learning more about the Albany Pine Bush can find it in Pine Bush: Albany’s Last Frontier, edited by Don Rittner (Albany: Pine Bush Historic Preservation Project, 1976). Robert Dirig is an assistant curator at Cornell University’s vascular plant herbarium in Ithaca, New York. He has studied the blue butterflies and buck moths of the Albany Pine Bush for the last fifteen years. Dirig corresponded with Vladimir Nabokov on the taxonomy of the Karner blue.

Nancy Sefton (page 84) had run off thirty-five shots of the moray when the arrow crab came out of the eel’s lair. She got them both in the last photo on the roll. Sefton and her husband, Ron, live on Little Cayman Island (population: twenty-two people and ten thousand boobies and frigates) in the Grand Caymans, where she has been a photographer and journalist for the last seventeen years. Her fifth book, Caribbean Reef Invertebrates, written with Steven K. Webster, was published last year by Sea Challengers Press of California. The photograph of the eel and crab in this month’s “Natural Moment” was taken with a Nikon F fitted with a 55-mm macro lens.

**Erratum:** A photo caption on page 26 of the January 1988 issue of *Natural History* incorrectly identified two mountain peaks. The mountain on the right is Annapurna I; Annapurna South is at left.
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Cover: A stoat, or short-tailed weasel, on the alert in Alaska's Denali National Park. Photograph by Michael Giannechini; Photo Researchers, Inc. Story on page 54.
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The Halloween Mask Episode

A gull researcher learns the barefaced truth about western gulls

by Larry Spear

On an otherwise ordinary day in the middle of the 1980 breeding season, the western gulls on Southeast Farallon Island suddenly went berserk. Just moments earlier, many of the 25,000 birds in this colony had been calmly incubating their eggs. But the moment I stepped through the doorway of the old Coast Guard house that serves as the living quarters for biologists working on the island, a full third of the gull population rose up and circled around in a panic, giving strident distress calls. It was as if a bomb had exploded, but the sad truth was that I had alarmed the gulls. Normally, incubating Farallon gulls aren’t bothered by people working on the island. Even gulls nesting on the border of much-used trails remain calm as people pass by. The gulls’ extraordinary reaction on this particular day was the culmination of a series of inroads I had made on their security.

Southeast Farallon Island, the largest of five islands thirty miles west of San Francisco, is the breeding site of twelve species of seabirds, including western gulls, common murres, pigeon guillemots, tufted puffins, black oystercatchers, three species of cormorants, two of auks, and two of storm petrels. The Farallon seabird rookery is the largest in the lower forty-eight states, with a breeding population of about a quarter million birds.

During the early nineteenth century, however, the Farallon seabird population was well over a half million, perhaps even a million birds; the most numerous were common murres. This changed with the coming of Europeans, whose depredations on Farallon avifauna peaked in the mid-to-late 1800s, when an estimated 14 million eggs were harvested and sold. As the eggers drove the murres from their nests, predatory western gulls were quick to take advantage of the situation, often eating many murre eggs before the eggers could collect them. To get rid of their avian competitors, eggers began crushing the gull eggs on sight, thereby reducing the gull population.

Disturbance by humans affected other seabirds as well: by the beginning of this century only about 100,000 birds bred on the Farallons. So few murres (60,000) were left that eggigging practices, no longer profitable, were ended. Meanwhile, Southeast Farallon had been manned by lighthouse keepers, whose dogs, cats, and other domestic animals prevented the gulls from breeding anywhere except the most inaccessible places. As a result, the gull population continued to decline; by 1903, only a few thousand were breeding on the island.

In 1972 Farallon birds were given full protection. By 1979, the gull population had risen to 25,000. Now they nest all over the island—in extensive areas once inhabited by fur seals before they were extirpated by Russian and New England sealers in the nineteenth century—and their numbers seem to be slowly rising.

Point Reyes biologists and volunteers have banded 2,000 western gull chicks on the island each year since 1971. Each chick receives a metal U.S. Fish and Wildlife Service band on one leg and one or more colored, plastic bands on the other. A different color or leg combination has been used each year. Western gulls reach adulthood in four years, and immature gulls spend their growing-up years along the coast of the mainland, from Washington to Mexico. The first group of banded birds returned to breed in 1975, and the number of banded birds breeding on the island has been steadily increasing ever since.

I was using this valuable resource—a population of known individuals of known ages—to study whether survivorship and breeding success were age related, how adult gulls became breeders, and where and how their young dispersed. This required surveillance of many of the known-age individuals, a task I accomplished by reading the numbers on their bands with a spotting scope. Since this was my only means of recognizing individual birds, I was alarmed to discover in 1978 that they were losing their aluminum bands at a high rate (later determined to be about 16 percent per year). I therefore began re-banding birds with stainless steel.

Rebanding an adult gull is a much different proposition from banding a flightless, downy chick trying to hide in a rock crevice. To trap each grown bird, I placed a cord noose around the rim of its nest and attached the noose to a monofilament line on a fishing rod and reel that I held while crouched at a distance. When placing the cord around the nest rim I also temporarily removed the gull’s eggs (to prevent their being broken in the ensuing commotion) and replaced them with dummies. When the gull resumed its position on the nest, I pulled the noose tight around its legs and reeled it in. When the noosed bird began struggling, all the gulls nesting in the vicinity reacted by circling overhead, giving continuous piercing cries that have the uncanny effect of driving anyone beneath them into a panic. This is the same type of distress response that gulls exhibit when a mammalian predator, such as a fox or coyote, enters a colony.

Although my activities appeared to be causing a major disturbance in the colony, I was relieved that few gulls used the occasion to steal eggs from the nests of other gulls, as they sometimes do even under
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more usual conditions. Apparently they were concentrating on me as a predator and were too distracted to consider egg stealing. Besides calling and flying about in circles, they swooped closely over my head, sometimes knocking my hat off. Once, presumably through miscalculation, a gull struck the back of my head. In addition, airborne gulls frequently bombarded me with excrement. For these reasons, and to reduce disturbance in the colony, I slipped snared birds into a canvas "gull bag" as quickly as possible. Once the victim was in the bag, the other gulls calmed immediately and landed at their nest sites. After weighing and banding the gull, I took it out of the bag for release; at that instant there was another, less intense distress response from the gulls nesting nearby.

During the rebanding project, I found that the gulls' distress response intensified as the season progressed and more birds were trapped. If I noosed only one or two gulls every few days, usually at different locations on the island, agitation in the colony remained low. In 1980, however, I arrived late in the incubation period and had a very short time in which to reband a number of older, known-age birds of great value to my research. After I had trapped nine birds in two days, the intensity of responses escalated well beyond my expectations: the colony was in an uproar at the sight of me leaving the house.

The immediate problem for my own work was obvious: how could I observe banded birds in their breeding territories if they were all up in the air? But this concern soon paled. As I walked toward the north side of the island, I assumed the birds' reaction would subside, as in the past. Instead it followed me through the colony like a wave. When I reached a pupping area for northern sea lions, the gulls' frenzy set off a sea lion stampede into the water. No pups were crushed, but I had clearly become a threat to the breeding rookery, and the situation was serious. I slunk back to the house and stayed there.

My dilemma naturally became the talk of the household, and in conferring with my co-worker Bob Boekelheide, we came up with a possible remedy. Other humans on the island generated no distress reaction from the gulls. Obviously the birds were recognizing me. Perhaps what I needed was a disguise.

While I outfitted myself, Bob and I pondered the western gull's apparent ability to pick out one "enemy" among several humans, an interesting find in itself. We knew from studies conducted by others that birds can discern species that prey on them, but to my knowledge the capacity to remember individual predators hadn't been demonstrated. In cases where certain individuals of a given species are predators and others are not, this kind of recognition, requiring a well-developed memory, might be a real advantage.

But just how do western gulls recognize different human beings? The conditions I had inadvertently created gave us an unusual chance to investigate. I began by thoroughly concealing my identity. I wore a wide-brimmed straw hat instead of my yellow stocking cap, clothes that didn't fit well and that I had never worn before, and a Halloween mask with a bright green face and orange hair. I left the house in this garb and walked with a pronounced limp down the main path through the gull colony. To my astonishment, absolute calm prevailed. I found myself eye to eye with individual gulls I hadn't seen for quite a while.

Although we had made some progress, we were still asking the same question, that is, which part or parts of my disguise
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prevented the gulls from recognizing me? Besides an exciting opportunity to gain a better understanding of gulls' perceptions of humans, I was soberly asking myself a more mundane, but practical question, "Do I have to wear this costume for the duration of my stay on the island?" I changed into my regular clothes, kept the green-and-orange mask and straw hat, went back outdoors, and walked down the main path without a limp. The gulls remained calm. For the next stage of the experiment, I wore my yellow stocking cap (a different color from the other headgear then being worn on the island) but retained the mask. When I walked through the colony, a mild distress response ensued, so I went back indoors once again and replaced the yellow cap with a gray one. This time the gulls remained calm as I passed by.

At this point, the only part of the original disguise that remained unchanged was the Halloween mask. To test our suspicions that the gulls were basing their recognition on my facial features, I put the poorly fitting clothes back on, along with the straw hat, but I took off the mask. The instant I appeared outside, the gulls flew up in mass distress—an obvious response to my familiar face!

These results seemed amazing at first, but why shouldn't western gulls use the same methods we do to recognize individuals? Biologist Niko Tinbergen has noted that, like humans, gulls have an excellent ability to distinguish among forms. Both species' sensory mechanisms are primarily audio-visual and are similarly keen. Taking this a step further, these powers of recognition work to the advantage of gulls living in large colonies. For example, we know from Tinbergen's work that nesting gulls can recognize their mates in flight at a distance of one hundred feet, and that they also recognize neighbors by sight. Well-developed recognition between mates is important because the pair must prevent other gulls from landing in their territories and stealing eggs or young. Recognition of neighbors is also important because some members of the colony specialize in pirating food or plundering nests. We don't know what cues are used, but as Tinbergen suggested, facial features may well be important—especially since the shape of a gull's head is determined largely by bony structures that vary considerably, whereas body areas are more densely feathered and, at least to the human eye, are less individualized.

So, for the rest of the 1980 season, I always wore the mask and gray cap when outdoors, and the gulls remained calm—except once. A full month after the "recognition experiment," I grabbed the rod and reel and assorted fishing gear for a day on the water. I left the house but didn't get far. As I started down the path, I soon found myself at the center of another distress wave, this time of moderate intensity. I was puzzled (I was wearing the mask), but then it dawned on me that I was carrying the fishing pole, the implement of the dreaded "predator."

All things considered, the Halloween mask episode of 1980 certainly added a new dimension to my respect for these birds. Even at the beginning of the 1981 breeding season, when I appeared on the island barefaced, many gulls flew up and objected to my presence, remembering my face a full year later. My own ability to identify gulls by reading their band numbers seemed crude in comparison.

Larry Spear is a biologist with the Point Reyes Bird Observatory in Stinson Beach, California. He first wrote of his experiences with the western gulls for the observatory's quarterly newsletter.
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Founding Fathers and Mothers

While small, isolated populations are especially influenced by genetic differences, we are all shaped by the "founder effect"

by Jared M. Diamond

Death in infancy has been common throughout human history. Still, to anyone who has watched it happen, it is unspeakably cruel. Baby Pierre (I have altered his name) was born in Canada on March 7, 1964, weighing a healthy six and three-quarter pounds, but from the start he fed poorly. By the time he was hospitalized on September 14, he had gained only half a pound, his ribs were showing, his muscles were weak, his behavior apathetic, and he was vomiting periodically. What was strangest, his urine always smelled of rotten cabbage, and the smell came to permeate his body and clothes. To keep him alive, the doctors had to instill nutrients down a tube through his nose into his stomach. For a time he became more alert and actually gained some weight, but he still refused to feed from a bottle or spoon. Finally, on November 30 his condition suddenly deteriorated, and he vomited blood and died.

In the same year in which Pierre's brief life was completed, Canadian physicians became increasingly aware of other infants dying with symptoms like those just described for Pierre. Most of the babies were from the remote Chicoutimi area of Quebec Province, about 120 miles north of Quebec City. Some parents lost three or four children in this way and also reported similar deaths in previous generations. While the parents themselves were normal, on the average, one-quarter of their children had Pierre's disease, and an equal number of boys and girls were affected. All these facts suggested an inherited condition of the type known as an autosomal recessive disease, in which the victim has two copies of a harmful gene, one inherited from each parent. Yet the parents are symptomless by virtue of having one normal gene along with one defective copy. To use genetic terminology, the victims are homozygotes; their parents heterozygotes.

The particular disease in Pierre's case was hereditary tyrosinemia. The defective gene results in the lack of a liver enzyme that breaks down the amino acid tyrosine, one of the building blocks of proteins. When this enzyme is absent, tyrosine accumulates and damages the liver and kidneys, thereby leading not only to the cabbagelike smell of urine (from excreted amino acids) but also to other, often-lethal side effects. Although hereditary tyrosinemia is extremely rare in most of the world (less than 1 case in 100,000 newborns), in the Chicoutimi area it affects about 1 in every 685 newborns, and an astonishingly high proportion of the population (estimated as 1 in 14) carries the gene as heterozygotes.

Historical and genealogical sleuthing by Canadian geneticist Dr. Claude Leberge uncovered how tyrosinemia became relatively so frequent at Chicoutimi, of all places. The Chicoutimi region was settled in the 1840s by a few dozen families who migrated north from Quebec's Charlevoix County. Because of Chicoutimi's isolation, few other settlers followed, and most people living there today are descendants of those original families. The pedigrees of all of Chicoutimi's tyrosinemia patients could be traced back to just one couple, Louis Gagné and his wife, Marie Michel, who emigrated to Quebec from France in the mid-seventeenth century. Evidently, either Louis or Marie had the gene for tyrosinemia and passed it on to some of their nine children and uncounted grandchildren, at least two of whom moved to Charlevoix. Since only a small number of people from Charlevoix moved in turn to Chicoutimi, today's Chicoutimi population is rather inbred: the parents of the tyrosinemia patients share on the average as many genes as second cousins would.

Hence, not infrequently both a husband and wife are carriers of the Gagné/Michel curse and both pass it to their child, who is homozygous and consequently suffers from tyrosinemia.

Hereditary tyrosinemia at Chicoutimi exemplifies a phenomenon for which the evolutionary biologist Ernst Mayr coined the term "founder effect." This phrase refers to an animal or plant population becoming genetically distinctive as a result of being founded by only a few individuals, whose genes must inevitably be a biased sample of the genes of the ancestral population from which they were drawn. Some of those founding individuals will carry genes that are rare in the ancestral population, while many other genes of the ancestral population (especially, uncommon genes) will not be carried by any of the founders. Thus, the new population becomes instantly different. It already has distinctive gene frequencies at the moment that it is founded, even before natural selection has had time to operate in the new environment and to change gene frequencies further.

The founder effect has widespread importance in evolutionary biology. For many species, new local populations arise frequently, whenever a piece of habitat grows up to a stage appropriate to that species (for example, when an abandoned farm becomes suitable for oak trees and red-eyed vireos). On a larger geographic scale, new populations also appear whenever individuals of a species happen to reach an island or area from which the species was previously absent. New populations generally start off small and gradually become more numerous, implying
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that the population was founded by a few pioneering individuals rather than by a mass immigration. These are exactly the conditions under which the founder effect is expected to operate and to create an instantly distinctive population.

In fact, outlying populations (like the Savannah sparrows breeding on Cape Sable Island off Nova Scotia) often do differ from the central population. However, for animals and plants, actually documenting that a population’s distinctiveness stems from the founder effect is difficult. What bird can point out its siblings or name its grandparents and what they died of? The founder effect might cause a local bird population to be genetically distinctive, but so might natural selection or random genetic drift in small populations.

Thus, the best-documented examples of the founder effect come from human populations. We constantly examine ourselves and each other in minute detail for possible abnormalities. We are all identified individually by name. Most of us can point to our biological mother, siblings, and putative biological father. Many of us can name our ancestors going back for many generations and can say where they came from. Thus, texts of medical genetics are full of accounts of local genetic conditions, like hereditary tyrosinemia in Quebec, that can be confidently attributed to the founder effect.

Why, for example, are there 82 six-fingered dwarfs among the Amish population of Lancaster County, Pennsylvania? Because the few founders of that community included a certain Mr. Samuel King, and either Mr. King or his wife happened to have the gene for six-fingered dwarfism. Why do many South Africans, but few people elsewhere in the world, have a genetic condition called osteodental dysplasia that causes all their teeth to fall out by the age of twenty? Because all those South Africans are descended from a polygamous immigrant named Arnold, who carried the gene and spread it among the 356 traceable descendants he sired by his seven wives. Why is Huntington’s chorea, a fatal neurological disease, disproportionately common in Tasmania and southeast Australia? Because an English widow called Miss Cundick, who emigrated to Australia in 1848 with her thirteen children by two marriages, passed the gene to offspring of both marriages and thereby became the ancestor of at least 432 Australian victims of Huntington’s chorea.

These examples can be multiplied almost indefinitely. Virtually every isolated human population that has been examined turns out to have its own “private”
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genes—ones that are common in that population but rare elsewhere. The founder effect is a plausible explanation even in those cases where the gene's pedigree has not been actually traced.

But the examples I've discussed so far are too esoteric to establish the founder effect as important in human evolution. They involve genetic diseases that are rare by world standards. They also involve human populations that were founded only within the last 500 years, and that are still small and either geographically peripheral or isolated. What about common, important genetic traits of large populations with ancient roots?

Through fossils, the human lineage can be traced back for several million years in Africa, and for hundreds of thousands of years in Europe and Asia. That means thousands of human generations in which to erase accidental genetic legacies of the particular individual cavenmen and cave-women who happened to colonize Europe, Asia, and the parts of Africa beyond the hominid homeland. Can we thus dismiss the importance of the founder effect for most of humanity?

I see two flaws in this reasoning. First, it ignores the other three inhabited continents: North America, South America, and Australia. The Americas were settled by colonists who spread from Asia over the Bering land bridge to Alaska, probably no more than about 15,000 years ago. While archaeologists' scenarios still differ over the exact date of that colonization, all scenarios envision only small bands of hunters crossing into Alaska, and then other small bands passing through or around the Canadian glaciers into the area of the present United States. No archaeologist proposes hordes of Asians pouring through the hostile arctic environments. The descendants of those few bands multiplied, populated an entire hemisphere, and became the ancestors of most North and South American Indians.

In the settling of the Americas, we see the basis for the founder effect operating on a colossal scale. Similarly, about 50,000 years ago, Australia was settled by humans who somehow arrived from the islands of eastern Indonesia across at least sixty miles of ocean. Those first arrivals were probably no more than a raftload of coastal people blown out to sea, but their descendants spread over a continent and founded the modern Australian aboriginal population.

The other flaw in the reasoning that dismisses the importance of the founder effect for human evolution has to do with Africa, Asia, and Europe. While humans have occupied these three continents for
hundreds of thousands of years (or millions, in the case of Africa), the many former populations certainly did not contribute genes equally to the populations of today. Each of these continents has had major population explosions within the last 8,000 years. Because of some advantage in technology or food production, localized groups have expanded over large areas, displacing other peoples and becoming the ancestors of most of today’s population.

Bushmen and Pygmies probably occupied most of subequatorial Africa until about 2,000 years ago, while Bantu-speaking blacks lived in a small area of the Cameroons or Congo. After the Bantu acquired iron, agriculture, and domesticated animals, they drove the Bushmen and Pygmies into a few areas unsuitable for Bantu agriculture. Those Bantu pioneers overran half a continent and multiplied in numbers to become the 60 million Bantu-speaking blacks of modern times. Thus, although Africa has a long history of human occupation, the gene pool of subequatorial Africa was virtually founded anew a mere 2,000 years ago.

Similarly, most of the modern inhabitants of Indonesia, the Philippines, and parts of Southeast Asia—some 170 million people—are descendants of a population expansion that can be traced back to Taiwan about 6,000 years ago. Europe, too, despite its long history of Cro-Magnon, Neanderthal, and pre-Neanderthal occupation, has been genetically reconstituted twice in recent millennia: first, and most thoroughly, by the spread of farmers from the Near East, starting about 8,000 years ago, and then by the explosion of speakers of Indo-European languages out of southern Russia about 6,000 years ago.

Hence the genetic legacies of the founder effect are not necessarily confined to isolated human populations founded within the last few centuries, such as the Amish, French Canadians, or white Australians. Almost any human population might show evidence of the founder effect, because the populations of three of the six inhabited continents were founded de novo 10,000 to 50,000 years ago, and much of the population of the remaining three continents was refounded in the last 2,000 to 8,000 years.

What genetic traits may the founder effect propel to high frequency? In the short run, any gene—good, bad, or neutral—may be overrepresented in a founding population. However, natural selection then starts to eliminate the deleterious genes. Even if one of the few founders of a small population happened to carry a deleterious gene, which thus started off at high frequency, the gene would gradually become rarer as its bearers died or left fewer children than bearers of other genes. Most cases of deleterious traits whose present-day high frequencies can be attributed to the founder effect prove to involve recently founded populations (like the French Canadians at Chicoutimi) and recessive genes (like those for hereditary tyrosinemia and six-fingered dwarfism). Deleterious recessive genes linger for many more generations than deleterious dominant genes, because only homozygotes (who inherit the recessive gene from both parents) suffer the ill consequences; the much more numerous heterozygotes remain healthy and continue to pass on the gene. But the deleterious recessive genes will still eventually become rare.

For genetic legacies of founder effects that were launched thousands of years ago—legacies of the first peopling of the Americas and Australia or of the Bantu and Indo-European expansions—we therefore have to scrutinize neutral or beneficial genes rather than deleterious ones. Here our discussion inevitably becomes speculative because we can’t trace any living American Indians back to one particular hunter who crossed the Bering land bridge 12,000 years ago, in the way that we could trace all victims of hereditary tyrosinemia at Chicoutimi back to

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The other trait I'll mention is the best-studied case of a beneficial gene confined to certain human populations: sickle-cell hemoglobin (Hb S). In much of Africa and some nearby regions the oxygen-carrying protein of our red blood cells, hemoglobin, is partly replaced in many individuals by a genetically determined protein of slightly different structure, hemoglobin S. Sickle-cell hemoglobin has been shown to protect its heterozygous bearers against malaria, which is a serious health problem in those areas of Africa where Hb S is common. But malaria is also a health problem in Southeast Asia, where instead of Hb S one finds a different hemoglobin (hemoglobin E) that is also thought to protect against malaria. And there are other hemoglobins, plus still other genetic traits termed thalassemias and glucose-6-phosphate dehydrogenase deficiencies, that are thought to protect against malaria elsewhere. The simplest, though not the sole, explanation for this plethora of antimalaria genes is that each rose to high frequency in different areas through accidents of founder effects.

What about possible contributions of the founder effect to future human generations? At first, it might seem that the conditions making it so important in our past no longer exist. Isn't it true that every habitable scrap of the earth's surface has by now been occupied by Homo sapiens and that no places remain where new populations starting off with new gene mixtures could be founded? Yes, but .... Think of what lies ahead for humanity, and you'll realize that a dramatic example of the founder effect may be coming in the next few centuries. If we continue our slide toward nuclear war followed by nuclear winter, those scattered fragments of humanity who might survive in certain rural areas of the Southern Hemisphere will carry only a fraction of our present genetic diversity. Perhaps there will be no redheads, no one with an Rh negative blood type; perhaps most of them will be Brazilian Indians or Polynesians. Should they eventually succeed in reoccupying the Northern Hemisphere, those founding fathers and mothers of the new world will have reconstituted humanity in their own genetic image.

Jared M. Diamond teaches biophysics, physiology, and ecology at the School of Medicine of the University of California at Los Angeles.

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A Novel Notion of Neanderthal

"Human unity is no idle political slogan or tenet of mushy romanticism"

by Stephen Jay Gould

I am not insensible to the great American myth of wide-open western spaces (nurtured, in my formative experience, primarily by the closed domains of Hollywood backlots used for sets of B movies). Still, as a New Yorker now resident in New England, I tend to side with Frost on the correlation between good fences and good neighbors. Nonetheless, I must admit that, once in a while, the folks next door can actually outdo a resident on his own turf. I prefer T. H. Huxley or Charles Lyell—strictly as literature—to many Victorian novelists. Conversely, I regard one important area of my own profession as better enlightened by novelists than by scientists.

Science is constrained by its canons of evidence. Pure speculation, however reined by plausibility or pregnant with insight, does not lie within the realm of our game. But novelists are free, like Milton’s "L’Allegro," the embodiment of good cheer:

Come, and trip it as ye go;
On the light fantastic toe;
And, in thy right hand lead with thee
The mountain nymph, sweet Liberty.

(I was as happy as the namesake of this poem when I first read these lines in a dull college course, for they resolved one of those little puzzles that weighs, however lightly, on the intellect. I had never understood how you could “trip the light fantastic on the sidewalks of New York” because, in my streetwise parochialism, I had always pictured a traffic beacon.)

Many crucial events in life’s history have provided no direct data for their resolution. Yet the art of plausible reconstruction has value to science because we must have frameworks to discipline our thoughts. Writers of fiction can enlighten us in this treacherous domain. No event so poor in evidence has so strongly captured our imagination as the meeting of Neanderthal and Cro-Magnon people in Europe some 30,000 years ago. The people of Cro-Magnon carved intricate figures of horses and deer and painted their caves with an esthetic power never exceeded in the history of human art. Some Neanderthals buried their dead with ceremony and may have adorned their bodies with other, but they had no concept (so far as we can tell) of representational art. We feel that something fundamental about our origin, and our “essence,” must lie hidden in the character of this contact between our ancestors and our closest collateral relatives. But we have no data at all beyond the temporal and geographic overlap. We do not know if they murdered each other or met with the equivalent of a Paleolithic handshake, ignored each other or interbred.

This combination of fascination and mystery has spawned a minor industry of novel writing—from William Golding (The Inheritors), who explored another aspect of human nature in Lord of the Flies, to more recent works of the Finnish paleontologist and novelist Bjorn Kurten (Dance of the Tiger) and the saga of Ayla as depicted by Jean Auel (Clan of the Cave Bear and sequels).

Let me cite just one example, at my own expense, of the novelist’s power to enlighten. In the racist tradition, all too common and often unconscious, Cro-Magnons, as modern conquerors, are usually depicted as light-skinned, Neanderthals as dark. In Meet Your Ancestors (1945), for example, Roy Chapman Andrews wrote of the Cro-Magnon people:

They have been called the finest physical types the world has ever produced. Probably their skins were white. In fact, if you saw a Cro-Magnon man on Fifth Avenue dressed in a sack suit and a Homburg you wouldn’t give him a second glance [well, you probably would these days, for his outdated apparel]. Or perhaps you might, if you were a woman, for artists depict him as a debutante’s “dream man.”

I had unconsciously adopted this stereotype in my mental picture of these people, but Bjorn Kurten’s reconstruction explicitly depicts Neanderthal as white, Cro-Magnons as dark. This conjecture surely makes more sense—for Neanderthals were cold-adapted people living near the ice sheet of glacial Europe, while Cro-Magnons may have had a more tropical origin. Since we possess no direct data, a scientific treatise would have no basis for discussing the skin colors of these people. But a novelist is free, and Kurten’s well-conceived conjecture taught me something about prejudice and the hold of tradition.

For all their breadth and variation, however, one unchallenged assumption pervades the Neanderthal novels. The modes and reasons differ, but Cro-Magnons are superior, and they quickly prevail in all accounts. This contact of ca. 30,000 years ago is portrayed as the “first meeting” of primitive and advanced—and the Neanderthals rapidly succumb. Neanderthals are dazzled by the technological superiority of Cro-Magnons. Golding’s primitives are awe-struck by a Cro-Magnon boat with sails, because they have never thought beyond a floating log when they needed to cross a river. Kurten’s watch dumbfoundedly as a Cro-Magnon artist carves the likeness of an animal in wood. The brains of Auel’s Neanderthals are so stuffed with memory that they cannot initiate anything new. Of the Cro-Magnon heroine Ayla, Auel writes, “In nature’s way, her kind was destined to supplant the ancient, dying race.”

This notion of temporal succession—
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THE GLENLIVET: JUST SLIGHTLY OUT OF REACH.
superior supplanting primitive—is common to both major theories about the biological relationship of Cro-Magnon to Neanderthal. In one view, Neanderthals represent an ancestral stage in a progressive sequence of general advance toward modern humans. (The next step to Cro-Magnon then occurs outside Europe. Neanderthals become primitive survivors in a European backwater, and the emigrating Cro-Magnons wipe them out.) In the second view, Neanderthals are a side branch, not an ancestral stock. Yet their early division from an advancing central stock guarantees their backwardness and rapid defeat. Thus, even the novelists, with their maximal range of reasonable conjecture, have never challenged the cardinal premise of conventional wisdom—that modern people arrived in Eurasia far later than primitive Neanderthals, contacted them once, and quickly prevailed.

In this context, a report by H. Valladas and five colleagues generated astonishment in press accounts throughout the world (“Thermoluminescence Dating of Mousterian ‘Proto-Cro-Magnon’ Remains From Israel and the Origin of Modern Man,” Nature, February 18, 1988, pp. 614–16). Neanderthals are a Eurasian group dating from about 125,000 to 150,000 years ago, for their first known occurrence, to about 30,000 years ago, for their supposedly singular replacement by modern Cro-Magnons. Anthropologists have puzzled for a long time over a few Eurasian sites that yield anatomically modern human remains but seem to be substantially older than the canonical 30,000-year date for contact and conquest. For example, the Qafzeh caves of Israel contain anatomically modern humans in association with species of rodents usually considered to have been victims of extinction during the early days of Neanderthal in Eurasia. Nonetheless, the presumption of nonoverlap between moderns and Neanderthals (until the crucial and momentary 30,000-year replacement) has been so strong that these sites have remained in limbo, usually rationalized in the literature as “probably” 40,000 years old or less.

Valladas and colleagues have confronted this tradition by reporting a date of 90,000 years for the anatomically modern humans of Qafzeh. You might cling to the old view by arguing that the Levant is not Europe and lies close to the favored African source for modern human origins. Perhaps the Levant was a long staging ground for a western European invasion 60,000 years later. But this resolution will not work, because Israel and the Near East also house abundant and well-documented remains of classical Neanderthals clearly younger than the Qafzeh moderns. Thus, the geographic potential for contact between moderns and Neanderthals must have existed for nearly 60,000 years before the novelists’ western European apocalyptic. Yet moderns did not supplant Neanderthals.

I must admit that I am not fully confident about the 90,000-year date for Qafzeh because the technique of thermoluminescence dating (called TL in the trade), although applied in the most modern and meticulous way by Valladas and colleagues, includes some intrinsic, theoretical uncertainty. (Press accounts, in their lamentable tradition of reporting only claims, and omitting any critical discussion of procedure and methodology, have bypassed this issue entirely—and simply reported the 90,000-year date as though it possessed the factuality of a new fossil bone. I do so wish that this tradition could be broken. Science is a methodology for the testing of claims, not a list of oracular pronouncements about the nature of nature.)

As natural materials are exposed to ionizing radiation, both from the external environment and from the breakdown of isotopes in their own composition, they accumulate energy in the form of electrons trapped at defects in the crystal lattices of their constituent minerals. When the materials are heated, these electrons are driven off, often producing a visible "puff" of light, called thermoluminescence and first reported by Robert Boyle in October 1663 after he took a diamond to bed and warmed it against his naked body. (I shall refrain from the obvious vulgarities, but must report that Boyle considered his diamond as especially sensitive because he viewed his own constitution as "not of the hottest.") TL is not the ordinary red-hot glow of conventional heating, but a distinct emission of light at lower temperature caused by release of these trapped electrons. In any case, the intensity of the TL peak might measure the age of a sample since these electrons accumulate through time.

But how could we use TL to date ancient humans? Clays and flints record their own age, not the moment of human use. Unless, of course, human use has heated the materials and released their TL, thus setting the TL clock back to zero. The subsequent accumulation of new TL will then record the time since human heating. Unsurprisingly, this method was first developed for dating pottery, since clays are fired at temperatures sufficiently high to release TL and reset the clock to zero. The method has been quite successful, but its application is neither straightforward nor unambiguous. In particular, no lawlike, universal rate governs the accumulation of TL; one has to measure the local influx of ionizing radiation from surrounding materials. This requires a firm knowledge of the postburial history of an artifact. In practice, gauges are usually buried for a year at sites where artifacts were found. The excess of an artifact’s TL over this yearly dose should, in principle, determine its age.

But Neanderthals and early moderns didn’t make pottery. However, they did occasionally drop flint tools and flakes into their fires. Thus, the reported TL dates at Qafzeh and other early sites are based on burned flints—and I am not entirely confident that human campfires invariably burned long enough or hot enough to reset the TL clocks to zero. However, I think that Valladas and colleagues have presented the best possible case, given intrinsic uncertainties of the method. They dated twenty flints from Qafzeh, and all fell in the narrow range of 82,400 to 109,900 years. Moreover, the associated mammalian fauna of Qafzeh, as previously mentioned, has been hinting for years that these anatomically modern humans predated the later Neanderthals of the Levant. (See M. J. Aitken, Thermoluminescence Dating, Academic Press, 1983. I also thank Tim White of Berkeley and John Shea of Harvard for their generous help in discussion and supplying references for several topics discussed in this essay.)

For the past thirty years or so, the main excitement in studies of human evolution has centered on discoveries about our early history—from the dawn of the first known australopithecine more than 3 million years ago, to the later transition to our own genus Homo, to the evolution and spread of Homo erectus from Africa throughout the Old World. The fascination of the opposite end—the much more recent origin of our own species, Homo sapiens—has received relatively little attention because no real breakthroughs have been made. This situation has changed dramatically in the last few years because two independent sources of data seem to be converging upon a firm, exciting conclusion that has been intensely surprising (but shouldn’t be) to most people—Homo sapiens is the product of a relatively recent, discrete event of branching speciation in Africa, not the result of a continuous process of worldwide advance. The redating of Qafzeh provides a confirming link in this story—hence its status as the central item in this essay.

Genetics and paleontology are the part-
For spelling "Valley," less. I River (They suspect bear half essentially ancestor, age from est-known suggest Only in lective brutish, 200,000-year-old origin humans only can evolution are Africa Levant an plus an, 200,000-year-old humans, more recently.

Humans,“ review ners 1263-68.) Happily, the the from 1987, the genealogical tree of modern humans, as reconstructed from the evolution of mitochondrial DNA, contains two major branches: one with only Africans; the other with additional Africans, plus everybody else. This topology implies an African source for the most recent common ancestor. (Although origin in the Levant with multiple migrations back to Africa is not excluded, no data support this more complex reconstruction.) If we are willing to accept a constant rate for the evolution of mitochondrial DNA (unproved, but supported by data now available from other groups), then all non-African racial diversity in Homo sapiens is only 90,000 to 180,000 years old, while the common ancestral stock of all modern humans probably lived no more than 250,000 years ago, and perhaps a good deal more recently.

Genetic data cannot tell us what these ancestral people looked like or date their origin with certainty. Perhaps this ca. 200,000-year-old common ancestor was a brutish, small-brained fellow—and the selective blessings of mentality then promoted the evolution of modern characters in both great branches of our family tree. Only the direct evidence of paleontology can resolve this issue.

Happily, fossil data are beginning to suggest an interesting conclusion. The oldest-known anatomically modern humans are probably the South African remains from the Klasies River caves, dated at some 80,000 to 130,000 years old. The redate of Qafzeh indicates about the same age for anatomically modern humans in the Levant. We still do not know the form of the ca. 200,000-year-old common ancestor, but if Klasies and Qafzeh are essentially us, then at least we can say that half the history of our species involves little change of anatomy. Mired in my own biases of punctuated equilibrium, I rather suspect that the 200,000-year-old forebear won’t look much different from us either.

Where does this reinterpretation leave Neanderthal, who looks quite a bit different from us—not the Alley Oop caveman primitive of legend, but different nonetheless. Neanderthals have been controversial ever since their first discovery in 1856. (They were found in a valley of the Düssel River named for the minor poet Neander. Valley, in German is Tal or, in an older spelling often used in the nineteenth cen-

ners of this reinterpretation. (For a good review of this important subject, see C. B. Stringer and P. Andrews, “Genetic and Fossil Evidence for the Origin of Modern Humans,” Science, March 11, 1988, pp. 1263–68.) As discussed in my essay of June 1987, the geographical tree of modern humans, as reconstructed from the evolution of mitochondrial DNA, contains two major branches: one with only Africans; the other with additional Africans, plus everybody else. This topology implies an African source for the most recent common ancestor. (Although origin in the Levant with multiple migrations back to Africa is not excluded, no data support this more complex reconstruction.) If we are willing to accept a constant rate for the evolution of mitochondrial DNA (unproved, but supported by data now available from other groups), then all non-African racial diversity in Homo sapiens is only 90,000 to 180,000 years old, while the common ancestral stock of all modern humans probably lived no more than 250,000 years ago, and perhaps a good deal more recently.

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The Northwest Coast Indian Art Collection at the American Museum of Natural History
by Aldona Jonaitis

Less than a century ago, the Indian tribes living along the Northwest Coast of North America were under great pressure to forsake their cultural heritage. At stake were their religious practices, their customs, and their ancient way of life.

Franz Boas, a young curator at the American Museum of Natural History, later to become known as the "Father of American Anthropology," determined that this culture must survive, if not in daily practice, then within the protective walls of a great museum. In 1897, he launched what is still the biggest, most important expedition in the history of American anthropology and gave impetus to the creation of the greatest collection of Northwest Coast art in the world.

For the first time, this extraordinary collection and the adventures behind its formation are available to you in a stunningly illustrated hardcover book, From the Land of the Totem Poles. Many of the hundred color photographs are of objects of great magic and meaning—stunning works of art never before seen by the public. This outstanding book is enriched by rare archival photographs of life among the Northwest Coast Indians. The rich and complex story of the expeditions, the art, and the Indians is deftly woven by Dr. Aldona Jonaitis, one of the world's foremost authorities on Northwest Coast Indian art.

This lavish book, one of the most important publishing efforts of the Museum in a decade, is available for only $28, 20% less than its bookstore price of $35.
Neanderthal may be a separate branch of the human bush, not a more primitive ancestor. We are used to conceptualizing evolution as a tale of transformation within a continuous lineage—think of the museum parade of horses, from cohippus (fox-terrier sized, of course) to Seabiscuit, or the line of human ascent from Australopithecines, naked in the African bush, to John Q. Businesssuit. Mired in this prejudice, for example, the Auckland Sun (February 19, 1988) reported the Qafzeh redating with this lurid leading paragraph (well, they do walk upside down out there in New Zealand, so maybe we shouldn’t be surprised): “Evolutionary theories were turned back to front this week when scientists claimed modern humans existed before Neanderthal Stone Age caven.”

We shall be truly wiser when we understand that the Qafzeh redate did not turn evolutionary theory upside down. Rather, the separation and prolonged simultaneous existence of Neanderthals and moderns as distinct species fits beautifully with a proper understanding of evolution. The only casualty of Qafzeh is a cultural prejudice for gradual, continuous advance as the canonical style of evolutionary change.

Evolution, at geological scales, is fundamentally about bushes and branching. Modern Homo sapiens and the extinct Neanderthals are two distinct branches, two contemporaneous species for most of their existence, if the data and arguments of this essay hold up to future scrutiny. Evolutionary trends usually work this way. The transition from reptiles to mammals, for example, is not the slow movement of a large population in lockstep from cold to warm blood, and from jaws to carbones. Trends arise within a forest of distinct branches. Most of these branches die; a few are successful and produce more branches like themselves to fuel the transition. Trends are propagated by the differential birth and death of distinct branches, not the wholesale, gradual transformation of a single great entity. Mammals arose because the most mammal-like species within a particular group of reptiles tended to live longer or branch off more daughter species. The robust australopithecines died; Homo habilis lived. Neanderthals became extinct; Homo sapiens survived.

Scientists are subject to the same biases of thinking; the press and general public hold no monopoly upon bloody-mindedness. Professional understanding of human evolution has long been hampered by a preference for viewing trends as the gradual transformation of “whole things,” rather than the differential success of some kinds of little branches versus others. Stringer and Andrews, in the article cited previously, distinguished two basic views of human evolution. The “multi-regional model” embodies the older view of trends as gradual transformation. It holds that Homo sapiens evolved over a large part of the Old World in a coordinated transition from African and Eurasian Homo erectus. Contact and gene flow was sufficient, according to this view, to forge Homo erectus from Nairobi to Beijing to Jakarta into a functioning whole, then gradually transformed by natural selection into modern humanity.

The second view, often called Noah’s Ark among anthropologists, holds that most ancestral lines died, and that modern humans descend from a local group that eventually spread throughout the world. Everything discussed in this article—from the redating of Qafzeh to the status of Neanderthal to genetic and paleontological evidence for a common, temporarily shallow root of all humanity in Africa—stands as a ringing confirmation of this second theory.

Yet as I advocate this second view with such delight (for it fits so well with my own preferences for punctuated equilibrium), I strongly reject its designation as Noah’s Ark. I have no objection to flippancy or to biblical metaphor, but only to the inappropriate implications of this name. The Deluge was a disaster outside the ordinary course of nature. If all modern humans stem from the fortunate survivors of a debacle, then our evolution seems unusual among the trends of life’s history. But nothing could be more ordinary than the derivation of a successful stock from a single event of branching. Evolution works this way nearly all the time.

Human unity is no idle political slogan or tenet of mushy romanticism (I speak of the biological meaning, not the ethical concept that science cannot touch). All modern humans form an entity united by physical bonds of descent from a recent African root; we are not merely the current state of a tendency, as the multi-regional model suggests. Our unities are genealogical; we are an object of history. This insight is evolution’s finest contribution to our greatest quest—the injunction inscribed as one of two cardinal precepts upon the Delphic oracle (according to Plutarch), and later invoked by Linnaeus as the very definition of the name he gave us, Homo sapiens: Know thyself.

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.
The Moon Dallies with Spica

by Thomas D. Nicholson

We have reported monthly lunar occultations of Spica since February 1987 (and semimonthly in August 1987 and April 1988). One more occultation on the 24th of this month will be the last for about five years.

Lunar occultations of Spica are relatively rare, although they have been occurring regularly now for more than a year. On the average, the moon covers Spica only once every six times or so it goes by the star. But the events occur in clumps: about twenty times in succession during a period of about one and a half years and then stopping altogether for approximately five years; occurring again for about twenty consecutive lunar months and stopping for about ten years. Then the cycle begins all over again.

We don’t notice these occultations much today; we tend to take them for granted. But the moon’s behavior was a real puzzle in the past. The fine points of lunar motion were a challenge in the eighteenth and nineteenth centuries, when finding longitudes at sea by means of “lunar distances” required accurate predictions of the moon’s future positions.

The technical explanation for the bunchy cycles in Spica’s occultations is the “regression of the moon’s orbit.” It wobbles around in space like a warped record on a turntable, and its intersections with the ecliptic—the earth’s orbit projected against the sky—shift slowly westward. Because easterly motion in the sky

Dennis Davidson

The moon crosses the ecliptic, the earth’s orbit (yellow line), during each lunar revolution around the earth. The lunar orbit slips slightly west each month, although the moon orbits to the east. The ecliptic crossing points (yellow dots) also move west in a cycle of 18½ years. The moon grazed Spica as it passed in February 1987. By November 1987, the lunar orbit shifted west to take the moon directly across the star. After the last grazing occultation, the orbit moved away from Spica.
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is normal, westerly motion is thought of as regressive, or backward.

The moon's orbital wobble is caused by variations in the gravitational fields around it. Its changing position in relation to the sun, the earth, the planets, and even the earth's equatorial bulge cause its orbit to go through long cycles of change, one of which is its westerly wobble.

As the moon moves easterly around the earth, it swings north and south across the ecliptic each month, never getting more than about five degrees above or below it. But the lunar orbit itself and the places where the moon crosses in front of all the stars once a month shift slowly west, very little each month, but all the way around in just over eighteen and a half years.

Think of the moon's orbit as a hula hoop swinging around a child's waist. As the hoop swings around, its high and low points stay about in the child's middle, but they wobble up and down. Sometimes the high point is in front of the child, sometimes behind. Those points shift, but they do not get any higher or lower as long as the "swinger" keeps the hoop moving. The moon's orbit goes through similar gyrations. Right now Spica is in the moon's path. But the "hula hoop" moon leaves Spica after June and will not return until the hoop wobbles far enough around to cover the star again—in approximately five years, as we said above.

Events in the calendar below occur in local time unless otherwise indicated.

June 1: Look sharp in the west tonight after sunset to find Venus, still bright enough to be seen but setting within an hour of sunset. If you find it today (or maybe tomorrow), you stand a chance of seeing Venus as both an evening and morning star this month. Saturn is the bright object near the rising gibbous moon after 10:00 P.M. Both are in Sagittarius, near the Teapot.

June 3–4: The gibbous moon is well up in the southeast at about midnight in Capricornus' bikini-shaped group of dim stars. The moon is at perigee (nearest the earth) on the 4th.

June 6–7: Morning sky watchers will find Mars near the moon after 3:00 A.M. on the 6th and still closer on the 7th. This is a good time to meet Mars, moving northeast, brightening rapidly, and soon to become an evening object. It will be spectacular later this summer. Last-quarter moon is at 1:21 A.M., EST, on the 7th.

June 10–11: Use the crescent moon to locate Jupiter in the dawn sky, beginning its cycle as a visible morning star.

June 12: Venus and Mercury are at inferior conjunction (between the earth and the sun) within hours of each other, both leaving the evening sky to become morning stars. We may be able to see Venus at dawn by the end of the month.

June 14: New moon is at 4:14 A.M., in Taurus.

June 15–16: If western skies are clear, the thin crescent moon may possibly be seen at dusk on the 15th, but certainly on the 16th. Gemini's Pollux and Castor are in line with the moon on the 16th.

June 18–20: The moon is an easy guide to Leo and its bright star Regulus. The Lion is above and left of the moon on the 18th; above and to its right on the 19th and 20th. A sickle-shaped group of stars, with bright Regulus at the handle, outlines Leo's head. The moon covers Regulus just before they rise over North America on the 19th and will be very close to the star that night.

June 20: The moon is at apogee (farthest from the earth) on the 20th; Saturn is at opposition with the sun (becoming an evening star) early on the 20th. The sun arrives at the summer solstice at 10:57 P.M., EST, and summer begins in the Northern Hemisphere. (The first day of summer is on the 21st in Europe.)

June 22: First-quarter moon is at 5:23 A.M., EST, in Virgo, with the constellation's bright star Spica to its left.

June 23: Today the moon is much closer to Spica. By 3:00 A.M., EST, it covers the star in Southern Hemisphere skies, the last occultation in a series that began in early 1987.

June 24: Mercury ends its retrograde motion and begins moving easterly with the sun again.

June 26–27: The waxing moon moves to Scorpius on the 26th and is very near the constellation's red star Antares on the 27th. The moon covers the star for Southern Hemisphere observers.

June 27: The second of three conjunctions this year between Saturn and Uranus takes place today with Saturn above Uranus.

June 29: The moon is back in Sagittarius when it is full at 2:46 P.M., EST. Three planets are near the moon today—Saturn, Uranus, and Neptune. Saturn, above the moon, and Antares, the reddest star to its right, are the only two bright objects visible within the moon glow.

June 30: One day past full, the moon moves from Sagittarius near to Capricornus, but its glow makes seeing the constellation's faint stars difficult.

Editor's Note: The Sky Map in the April issue shows the evening constellations and stars for this month and gives the dates and times for use.
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This Land
Arch Canyon, Utah

by Robert H. Mohlenbrock

East of Natural Bridges National Monument, in southeastern Utah, a narrow, dirt Forest Service road leads through Manti-LaSal National Forest, snaking over Maverick Point and between the two prominent Bears Ears peaks. Several overlooks here, in the Abajo Mountains, afford views of the vast Grand Gulch Plateau some 2,000 feet below. From this distance, the few defiles that dissect the plateau cannot be detected. In fact, hikers traversing that arid, sparsely vegetated terrain come upon the rims of the canyons without much warning.

One of the canyons that penetrates Grand Gulch Plateau is Arch Canyon, formed over thousands of years as a tributary of the San Juan River carved a 1,000-foot-deep trench. The canyon walls, often sheer in places, reveal colorful patches and layers of red, iron-bearing shales, red cherts, mudstones, siltstones, and blue-gray limestones in the predominantly white sandstone. Each sandstone stratum is made up of layers, which often slope at an angle to the horizontal—a phenomenon known as crossbedding. Vertical joints also intersect the horizontal strata.

Because shale weathers more quickly than sandstone, the canyon walls are grooved where the shale has eroded. The deeper grooves sometimes serve as animal trails, and some have been sites for ancient cliff houses. Elsewhere in the canyon, huge blocks of sandstone have become separated from the main cliffs and stand isolated in the gorge. Where the blocks are crossbedded with vertical joints, the loss of chunks and sheets of rock has left openings, or windows, which are as large as 100 feet wide and 140 feet high. Among these spectacular formations are Cathedral Arch, Keystone Arch, and the nearly all-white Angel Arch.

Most of the cliffs and the floor of Arch Canyon reflect the arid conditions of the region, and green vegetation is sparse except for an occasional willow or cottonwood where water accumulates in the old stream bed. But here and there on the faces of the cliffs in Arch Canyon, and many of the other canyons along the tributaries of the Colorado and San Juan rivers, are wet alcoves that support wet-habitat flora. Many of these species cling precariously to the rock face, while others cascade down the cliffs. These pockets of vegetation are called hanging gardens, and they are unique to southeastern Utah and adjacent northeastern Arizona.

John Wesley Powell discovered these green zones in 1869 while exploring the canyons along the Colorado River several miles west of Arch Canyon. He noted that "sometimes the rocks are overhanging; in other curves narrow glens are found [where] oaks grow, and other rich vegetation is seen. We call these Oak Glens." Much of this area, designated Glen Canyon, is now covered by Lake Powell.

The first botanist to explore the region was Alice Eastwood, who traveled there in 1895 with a guide. Riding mules and accompanied by one pack animal, they traversed 150 miles in eight days, from Mancos, Colorado, to wilderness beyond Bluff, Utah, and back. On encountering the hanging gardens, Eastwood described them as "a boreal oasis in the middle of a Sonoran desert."

Botanist Stanley Welch has studied the plants that grow in these hanging gardens and has suggested how these habitats are formed. As water percolates through

Stanley Welch

Alcove columbine, a hanging garden plant
For visitor information write:
Forest Supervisor
Manti-LaSal National Forest
599 West Price River Drive
Price, Utah 84501
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softer rock layers, it eventually comes in contact with a more impervious layer of sandstone. Since the water cannot readily penetrate this layer, it spreads out laterally to the edge of the exposed cliff, where a dripline is formed. Eventually, a few small plants begin to grow in the dripline, sending out roots and root hairs into minuscule crevices.

The spreading water dissolves the material that cements the particles making up the sandstone. At the same time, the growth of plants on the rock surface speeds up deterioration of the rock through the production of mild acids. As the sandstone is weakened, it gradually falls off in thin layers. In addition, some of the clinging plants become too heavy for their precarious perches and fall, often pulling some of the sandstone with them. Eventually, large pieces of rock fall from the cliff, creating alcoves. A typical alcove will have a roof, a back wall that is often flat, and a sloping floor built up from sandy detritus and fallen plant materials.

The alcove roof impedes desiccating winds and blocks direct sunlight for much or all of each day. As a result, these gardens are shielded from the very conditions that limit the growth of vegetation in the surrounding arid lands. The species in hanging gardens vary in response to altitude and possibly other factors. The wet, protected back wall may harbor such showy species as the cave primrose, cardinal flower, alcove cumbine, and Eastwood’s monkey-flower, while bog orchids and other species may flourish on the sloping floor near the mouth of the alcove. Downslope from the mouth are zones of grasses, sedges, and rushes, followed by a community of shrubs and, ultimately, small trees. As the trees attain maturity, they too provide shade that helps retain the moisture in the alcoves.

According to Bob Thompson, of the Manti-LaSal National Forest, a few species, such as the dainty Kachina daisy, are native to the hanging gardens. Welsh has found that most of the plants, however, are more familiar elsewhere in North America. Many of them, such as the cave primrose and bog orchid, are plants with boreal affinities. Several of the grasses and sedges are from the prairies and plains. Most likely, all these plants originally colonized the hanging gardens through long-range dispersal of seeds from their usual habitats.

“This Land” highlights the biological phenomena of the 154 U.S. national forests. Robert H. Mohlenbrock is Distinguished Professor of Botany at Southern Illinois University at Carbondale.
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World Without End

by Gerald Feinberg

Freeman Dyson, professor at the Institute for Advanced Study in Princeton, has had a distinguished career in science. In the first stage of this career he worked in mathematical physics, where his greatest achievements were in the field of quantum electrodynamics, the very successful theory describing the interaction of light with charged particles. In the second stage, Dyson turned his attention to technology. Much of his work involved projects at some of the defense-related companies that sprang up in the early 1950s. Many of his interests concerned technologies slightly beyond what was then feasible, but which did not conflict with any scientific laws. Perhaps his most significant work in this vein involved the regrettably cancelled Orion project, a proposal to harness thermonuclear energy for space travel by exploding small hydrogen bombs behind spaceships to propel them.

Dyson has now extended the scope of his interests to more general philosophical questions and the scope of his activities to include the writing of several successful books, including the autobiographical Disturbing the Universe and Weapons and Hope, a discussion of military policy. Both Dyson's previous writings and the present volume display an erudition and a felicity of literary style that are uncommon in the writing of scientists. Furthermore, his writing is characterized by an uncompromising willingness to follow his thought to its logical conclusion, regardless of whether it is consonant with accepted views. In reading Dyson, I have often been reminded of a remark by another Cambridge mathematician G. H. Hardy: "It is never worth a first-class man's time to express a majority opinion. By definition, there are plenty of others to do that."

Dyson's new book, Infinite in All Directions, is a collection of short essays on a wide variety of topics, which are tied together in two ways: they derive from lectures that Dyson gave in Aberdeen in 1985, and to a large extent, they are expressions of a general theme, that of the infinite variety of natural phenomena and of human responses to them. While the diversity of subject matter keeps the book from being an altogether seamless web, it is nevertheless a pleasure to read, both because of the graceful style of writing and because it is liberally salted with prose and poetical quotations from writers whom Dyson admires.

The first half of Infinite in All Directions is devoted to aspects of natural science. The topics range from an extremely brief and impressionistic description of current research on "superstrings," a novel mathematical construction that many physicists believe is the key to a unified understanding of physical phenomena, to the question of the ultimate fate of the universe and of intelligence. The centerpiece of this section is a presentation in two chapters of Dyson's thoughts on one of the foremost unsolved problems of present science: how life originated on earth. The material discussed in these two chapters is not new, having already appeared in a somewhat more technical version in Dyson's book Origins of Life.

Nevertheless, his discussion here of the origin of life is well worth reading. It is a clear account of some of the problems that must be solved by any successful theory of the origin of life, together with a succinct description of some of the theories that have been proposed by other scientists such as Oparin, Eigen, and Cairns-Smith. Dyson's own proposal about how life got started is also summarized. This involves the unorthodox notion that existing earth life, which utilizes two distinct types of macromolecules, proteins and nucleic acids, to carry out the functions of metabolism and replication, originated in two steps that may have been separated by eons of time.

The other scientific problem that Dyson deals with in some detail is the question of the long-term future of the universe, a topic that he was one of the first to consider scientifically. Here I find his discussion somewhat skewed in its emphasis. Rather than discussing some of the specifically scientific questions concerning the distant future, such as whether the nucleons that compose all of the matter that we know will eventually disappear, Dyson focuses on the question of whether some forms of life and intelligence might maintain themselves indefinitely. I am unhappy about his emphasis, not because I think that the latter question is intrinsically less interesting or less scientific than the former, but rather because I think that it is doubtful that we are able to provide reliable answers to it. That the human mind is capable of reaching across the eons to imagine what will happen in eternity is a marvel, but if this reach is to lead to a grasp of some element of truth, we must begin from the firm ground of matters within current scientific understanding. Our present understanding of neither the possible forms of life nor of intelligence is sufficient to expect that the answers that Dyson gives to his question will be relevant even in 100 years, let alone in 10100 years.

Most of the second and longer part of Infinite in All Directions deals with the general topic of technology and its effects on society. Some of the chapters stress the technology, as for example in Dyson's discussion of the means through which we will explore the solar system over the next century. Here he emphasizes the prospect that a combination of the emerging technologies of genetic engineering and artificial intelligence will allow for a decrease...
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Other chapters concentrate on the effects of technology. Several repeat some of the discussion of Weapons and Hope, with its emphasis on the development of nonnuclear defensive military technologies as a catalyst for the abandonment of nuclear weapons. In one chapter, Dyson expresses his views on the proposed "Star Wars" program of antimissile defense. Predictably, these views are idiosyncratic, and probably agree with those of no one else in the debate. He favors the notion of missile defense as one means to the elimination of nuclear weapons, regarding it as complementary to arms negotiations. He does not think that "boost-phase" destruction of missiles is practicable, but is optimistic about the possibility of destroying warheads as they are approaching their targets. He proposes that development of such "terminal-phase" defense continue, and that it be declassified. The latter suggestion does not seem very sensible if the defense is to be effective in the face of a determined aggressor, but if I understand Dyson, his main rationale for the whole missile defense program is the psychological effect it would have on the reliance on nuclear weapons, rather than the direct effect that it would have on the deliverability of the weapons themselves. Dyson's discussion of military affairs is almost entirely in the context of the relations between the U.S. bloc and the Soviet bloc. He does not discuss what effect the abolition of the nuclear weapons possessed by these two groups would have on the prospect of defense against other military powers in the world. It would have been interesting to know what he thinks about this question, which is likely to become a matter of critical importance early in the next century.

At the beginning, and again at the end, of Infinite in All Directions, Dyson presents some of his views on the philosophy of science and on religion. Views of such matters are necessarily personal and notoriously difficult to discuss in a way that will convince anyone else. Perhaps because my own views on philosophy and religion are very different from Dyson's, I found these to be the least satisfactory sections of the book. To find historical support for his announced love of diversity in science, Dyson tries to classify some prominent scientists as either unifiers or diversifiers. Among the former, he places Newton, Einstein, and Darwin, with which I have no quarrel. Among the latter, he lists the great experimental physi-
cist Ernest Rutherford, which seems entirely off the mark. Rutherford was as interested as anyone in finding unifying explanations of natural phenomena. I think that he would have dismissed out of hand the notion that in discovering the nuclear atom, he was simply adding to our knowledge of diversity, rather than finding an aspect of the world that ended up unifying much of physics and chemistry. As Dyson says, Rutherford was distrustful of much of the contemporary continental European work that was done in mathematical physics, but that attitude seems to have been more a matter of nationalism than of philosophy.

Dyson also makes much of the views of a late nineteenth century German physicist, Emil Wiechert, from whose writing he takes the title of his book. Weichert believed that the universe was inexhaustible, a view that he perhaps borrowed from the philosopher Joseph Dietzgen. But neither these writers nor Dyson present any convincing arguments for the thesis that there will be no end to the discovery of new phenomena. That statement is a prediction about the future of science, and while it may be true, to state it is not to have justified it.

Dyson’s views on religion and philosophy seem to me to be strongly motivated by a desire to find meaning somewhere in the universe. This desire leads him to make what I think are unnecessary attacks on other scientists, such as Steven Weinberg, who look at what we know of the universe and find no sign of meaning in it. I find the criticisms of their position to be unconvincing. While I start with about the same picture of the history of the universe and the same evaluation of the potential human (and posthuman) future as Dyson, I am led to conclude, not that meaning is immanent in the universe, but that intelligence will ultimately create meaning in a universe where none existed previously.

Although I found *Infinite in All Directions* unconvincing in places, it is everywhere beautifully written and stimulating to serious thought. The subjects that are covered in some detail, such as the origin of life, will amply repay reading by laypersons, who will find them presented in a readily understandable way. The book can also profitably be read by those who are expert on some of the topics that it covers, who will find much unconventional wisdom on these topics. I recommend it to both types of readers.

Gerald Feinberg is a professor of physics at Columbia University and the author of six books on science and philosophy.
Stream-dwelling black fly larvae are filter feeders, catching microorganisms such as algae, protozoans, and bacteria in their head fans. After accumulating enough food, they fold their fans toward their mouthparts and scrape off the food particles. The black fly species pictured here and in the following photographs is one of two look-alike species known as Similium vittatum.
Flies Are Busting Out All Over
If you’ve seen one species of this early summer plague, you haven’t seen them all

Text by Peter H. Adler • Photographs by Dwight R. Kuhn

I washed the blood from my face and neck, but I could not hide the welts or the blood that had stained my shirt. While working in a small stream in Pennsylvania’s northern backwoods, I had been bitten repeatedly in the worst attack by black flies that I had experienced in a decade. Several hundred years ago, settlers opening the Canadian frontier were subjected to an even fiercer onslaught. Unable to find refuge, many pioneers were temporarily blinded or driven to the brink of madness. Little wonder that black flies have been vilified for their bloodletting talents and ability to transmit disease.

Yet these attacks belied the benign existence of larval black flies hidden beneath the surface of that Pennsylvania stream. Arising from springs and seeps, the stream purled over moss-covered rocks and was shallow enough in places to support stands of sensitive fern. Fallen leaves were jammed between the rocks, creating spurts of rapid flow where the water squeezed by and spilled into pools carpeted with mats of algae. Although the stream was less than four feet wide and only three hundred feet long, more than a million larvae of seven species of black flies managed to coexist in it, clinging to leaves, stones, and strands of algae.

In many of Pennsylvania’s streams, black flies are among the most abundant insects. The larvae of some species pack themselves tightly together in stream beds and form a mat so slippery that I have had to crawl from the stream to regain firm footing. In a one-mile stretch of Pennsylvania’s Susquehanna River, I have estimated the black fly population to be more than ten billion, and my field notes indicate that black flies lived in more than 90 percent of the 300 or so streams that I surveyed in the state. Black flies not only produce huge populations, they also represent a multitude of species, many of which coexist in the same rivers and streams. A roadside trickle in western Alberta, for example, contained fifteen species. The outflow beneath a beaver dam in northern New Hampshire supported fourteen. Small streams in South Carolina regularly harbor five to ten species.

Since the late 1970s, I have studied
black flies, particularly their strategies of coexistence. At the heart of these studies has been the astounding physical similarity of many species. Although some can be readily identified, many more look virtually identical and are therefore called cryptic, or hidden, species. While they look the same, cryptic species almost always differ ecologically. For example, one may live in large rivers, and another only in small, cool streams. After scrutiny of all life stages (egg, larva, pupa, and adult), I have found minute features that distinguish some cryptic species from others. But I have also had to rely on more time-consuming analyses of larval chromosomes (see box, page 40). Each species must first be identified, either by physical or chromosomal characters, in order to construct its unique ecological portrait.

As larvae, black flies are found almost exclusively in flowing water, from frigid meltwater streams to tepid, tannin-stained rivers. A basic requirement of all immature black flies is that the water they live in must flow, even if imperceptibly, in one direction. Life in the current begins when the female, bobbing close to the water’s surface, releases her eggs into the flow or lands to place them on a leaf or rock bathed by a film of water. When the Lilliputian larvae hatch, they spin a pad of adhesive silk from their salivary glands. With it they enmesh the tiny hooks that encircle the end of their abdomen. Once a firm foothold has been established in the silken pad, which is attached to a leaf or rock, the larvae lean into the current and use their two head fans as filters to trap the small organic items continually flowing past. The sticky silk that holds a larva in place is so effective an adhesive that some species are able to thrive on the lips of thundering waterfalls. Should these larvae release their hold, they can trail out for a short distance on a silken safety line and then retatch, avoiding death in the cascade below. A few species are adapted to northern habitats, such as the headwaters of cold streams welling up from the ground or originating from glacial melting, where virtually nothing edible is transported by the water. These species have lost their head fans over evolutionary time and eat by scraping encrusted microorganisms from the stones or by gulping down filaments of algae like strands of spaghetti.

Larvae become fully grown in several days to several months, depending on the species, water temperature, and food supply. They then seek an underwater site, often a blade of trailing grass or the bottom of a stone, where they spin a silken cocoon in which to pupate. The adult emerges from the pupa and pops to the surface of the water in a bubble of air. Mating usually occurs shortly afterward, either in an aerial swarm or in a frenzied scramble at the water’s edge. Below the spillover from a small pond in New York, I once observed an extraordinary emergence of adults. Everywhere around me the ground was black with the crawling bodies of several hundred thousand adult black flies. Cattail leaves seethed with activity as the insects crawled over them. Kneeling in the stream, I too was covered with flies. Had they been seeking blood, the flies would have exsanguinated their victim in minutes. Cnephia dacotensis, however, is one of the few North American black flies incapable of piercing any kind of animal flesh. In any event, on this particular day, mating was the business at hand.

Both sexes of black fly will take floral nectar as a source of fuel, but only the females practice phlebotomy (bloodletting). Blood provides the necessary protein to insure that the eggs mature and that the life cycle begins anew. Female black flies seek blood from innumerable mammals and birds and may specialize on particular hosts. Deer, bear, and moose are typical victims, and one species of
When the larva is at last fully developed, it spins a cocoon and attaches itself to a rock, plant, or another pupa. Below: The head, part of the thorax, and the threadlike gills extend out of the open end of the cocoon. River bottoms covered with great clusters of the shaggy cocoons of some species may appear to be carpeted with moss.

black fly is so specialized that it takes blood only from loons. Perhaps 10 to 15 percent of North American black flies include humans as hosts. Armed with a natural arsenal of cutting tools and anticoagulants, some species may travel more than fifty miles from their natal waterways in search of blood. Movement, shape, color, and exhaled carbon dioxide help the female home in on a target. Many blood-seeking species prefer dark clothing, perhaps because the hosts with which they originally evolved were darkly colored.

Large numbers of black fly larvae and pupae of numerous species may be concentrated in a single stream. Species that are obviously distinct often reveal immediate differences in their mode of living. For instance, I have seen two species, one brown and one black, blanketeting a shale-bottomed stream, but segregated in the arrangement of a patchwork quilt. Cryptic species, however, interest me most. Having analyzed populations from much of the continent, I have found that cryptic species nearly always live together, if not on the same stone, then at least in the same stream or network of streams.

I first began to investigate the ecology of look-alike species in Slab Cabin Run, an eight-mile creek in central Pennsylvania that provided a succession of habitats. Issuing from sandstone springs on a forested mountainside, the creek tumbled over rocks to the mountain base, where it suddenly disappeared underground into limestone only to resurface a mile downstream. Fed by five more springs as it resurfaced, the stream negotiated the valley through unshaded fields, farmlands, and residential areas, all the while slowing in velocity and increasing in temperature and turbidity, its bed no longer of mossy rocks, but heavily silted.

The most abundant aquatic insect in the stream was the widespread North American black fly, *Simulium vittatum*. The entire lower portion of Slab Cabin Run, from the mountain base onward, was thick with the larvae of this species. But collections that I made along the stream over several years showed that these larvae actually belonged to two species, both living under the name *Simulium vittatum*. Although they appeared identical to the eye, one occupied a “minihabitat” within the stream. The first lived along the entire length of the valley, reaching its greatest numbers downstream. The second species thrived where spring water discharged, but it rapidly diminished in numbers as distance from the springs increased. The unexpected reappearance of this second species far downstream led to the discovery that an unmapped spring was rejuvenating water quality in that part of the watercourse. The ecological differences between these two carbon copies carry over into other habitats. For example, the first species is abundant below lake outlets, in large rivers, and at sites tainted by thermal pollution and sewage outflow. In these habitats, water temperatures can approach 90°F and the oxygen content of the water plummeted. Pollution has, in effect, expanded the habitat available to this hardy and versatile black fly, one of the few species that can exploit disturbed habitats.

In contrast, many aquatic ecosystems once spoiled by human activity have recovered partly, but with a twist. In recent years, many outdoorsmen have noted an increase in the number of black flies biting and swarming about them. The resurgence may be due to the improved water quality of many streams and rivers. Watercourses once ravaged by untreated sewage and waste from pulp and chemical plants have returned to a more natural state. When polluted, these systems were unsuitable for virtually all black flies. Many of these waters, now relatively clean, support a diverse black fly fauna, including species that take human blood.

While working in Slab Cabin Run, I
An adult emerges from its pupal case. After freeing itself while submerged, the adult fly pops to the water’s surface in a bubble of air and quickly flies away. Mating usually takes place shortly afterward in an aerial swarm.

found another set of cryptic species, a pair going by the name Prosimulium mixtum. The true name bearer lived only on the mountain slope where the flow was shaded by hemlocks, oaks, and rhododendron. Its identical relative lived solely where the stream passed the unshaded base of the mountain and for a short distance downstream. The upper, forested reaches of Slab Cabin Run were not occupied by either of the species known as Simulium vittatum, and the lowest reaches did not harbor either of the two Prosimulium mixtum look alikes. However, in Alberta, Canada, I had the opportunity to study a set of cryptic black flies that occupied an entire stream system, from headwaters to mouth. This waterway was home to Simulium tuberosum—actually a group of species—which rivals S. vittatum as North America’s most ubiquitous black fly. Samples from throughout the province, and later across much of Canada, revealed that one species lives only in tiny headwater streams, another occupies rivers, and a third wedges itself into the intermediate zone.

Across North America, I have found other sets of physically identical species that engage in habitat partitioning, each species uniquely molded to its environment. Temperature and velocity of the
A newly emerged female. Sometimes the rising adult does not generate enough force to break the surface tension of the water. It then rests on the surface until its wings and body are dry enough for flight.
water are probably two of the more important variables defining each species’ niche. Headwater species, adapted to cooler waters, tend to inhabit northerly parts of the continent, whereas their downstream counterparts range farther south. These geographic distributions simply reflect small-scale differences in habitat. Cool-water species probably cannot withstand physiological stresses imposed by the warm, sluggish flow characteristic of downstream reaches and southern watercourses.

I have found other sets of cryptic species in which one member is seen only during the spring, while others develop during the warm summer months. Still other cryptic species stagger their development so that young larvae of one species coincide with mature larvae of another, thereby possibly feeding on different types of food. Virtually unexplored, however, is the adult ecology of cryptic black flies. We do not know, for instance, if cryptic species have different swarming and mating behaviors or even different hosts. Perhaps one species is attracted to human hosts, while its cryptic relative prefers cattle and deer. Work currently under way in my laboratory should begin to provide some insight into these behavioral aspects of cryptic species.

Before look-alike species were known among black flies, certain species, Simulium tuberosum, for instance, were considered generalists that populated a wide variety of habitats, while others were regarded as specialists occupying restricted habitats. But I believe that any so-called species of black fly that seems to be a habitat generalist is probably at least two species. Usually, one or more of the look alikes is adapted to life in cool riffles typical of small headwater streams, whereas the others develop in warmer, slower flows. Black flies found only in a very restricted habitat, such as a spring, headwater stream, or outflow from a beaver dam, will probably prove to be only one species.

Why haven’t cryptic black fly species diverged in appearance over evolutionary time? The answer may lie in the nature of the environment in which the immatures live. Flowing water provides a variety of habitats that gradually meld into one another. A move into a new habitat may require only subtle structural changes, the same basic body plan providing ideal hydrodynamics for stability and feeding. However, a shift in habitat upstream or downstream would require different temperature and chemical tolerances. In other words, physiological and biochemical adaptations would be more pronounced than structural changes. The differences between cryptic species, then, would be primarily internal, not external.

From a broader perspective, the existence of cryptic species among black flies suggests that many other aquatic insect groups may have hidden species masquerading under the guise of a single species. The information gained from studying black fly ecology may allow us to predict which other aquatic insects, now thought to be single species, are actually two or more species with differing life styles. We are a long way from knowing all of the species that cohabit our planet, and even further from knowing how they all mesh ecologically. Perhaps the much-maligned black fly will offer insight into these challenging biological problems.

Unraveling Species Mysteries

Nearly all look-alike species of black flies have been distinguished from one another through studies of their giant chromosomes, enormous banded ribbons of DNA that are especially prominent in the larval salivary glands. The cells in which giant chromosomes are formed do not divide, even though the chromosomes continue to replicate. Eventually, about 1,000 chromosomal threads come to lie side by side. Divers—true flies—are among the few groups of organisms that have these highly visible bodies, which may be more than 100 times larger than other chromosomes. The evidence for reproductive isolation of cryptic species is actually contained in the intricate banding patterns of the giant chromosomes. Almost without exception, every species of black fly has a unique sequence of bands along at least a portion of its two or three giant chromosomes. Because black flies typically receive half of their chromosomal complement from the male parent and half from the female parent, it is possible to determine if two different banding patterns in a population represent two different species. If the two banding patterns never occur together in the same individual, then the organisms that carry the different banding patterns do not interbreed.

Over the past thirty years, chromosomal studies of black flies, pioneered by the late Klaus Rothfels and his students at the University of Toronto, have revealed many cryptic species. Although chromosomally well defined, each new species that is discovered represents an ecological mystery. For instance, what is the niche of each and how does it differ from that of its most closely related species? To unravel these mysteries and provide ecological profiles of the cryptic species, I began studying them in the field. I obtained larvae from all possible habitats, often over the course of several years. By collecting larvae from each microhabitat within a watercourse and placing them into a chromosomal preservative, I could later stain, extract, and mount the chromosomes on slides in the laboratory. Under a microscope at about 1,000 times magnification, I compared the chromosomal banding patterns of each larva with already known patterns and was thus able to identify each cryptic species and to determine whether previously undiscovered species were in my samples. The geographic distribution of each new species could usually be fleshed out from larval collections sent to my laboratory by scientists from across the continent. Developing at least a partial picture of the ecology and distribution of one set of cryptic species sometimes required the preparation and examination of more than 10,000 larval black flies.

—P.H.A.
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The Wiliest Wildflower
in the West

Scarlet gilia even takes advantage of being eaten

by Ken N. Paige

Of all the wildflowers of the western United States, scarlet gilia is perhaps the most striking. Emblazoning mountain slopes and meadows alike with its flared, red tubular flowers commonly known as skyrocket. On Fern Mountain, in the San Francisco Peaks region of north-central Arizona, scarlet gilia stands out amid the bunchgrass, bracken fern, woolly mullein, and wild lupine, displaying a range of shades from red to pink to white. The plant is a favorite food of mule deer and elk in spring, and in the summer its color attracts a variety of pollinators. In 1982, I became interested in this diverse array of color, initially wondering what the significance of such variation might be and how scarlet gilia managed to survive the extensive browsing of these ungulate herbivores. What I found over the next years was that scarlet gilia was no passive beauty, but a chameleon-like strategist that took advantage even of being eaten.

Fern Mountain is but a hilly remnant of past volcanic activity, rising about 400 feet above the surrounding montane meadows. One of 400 dormant volcanoes, it sits in the shadows of the towering San Francisco Peaks, which soar to a height of more than 12,000 feet above sea level. The peaks themselves are the spectacular remains of a dormant crater. Today, the lush vegetation is supported by a shallow layer of cinders that form a water-conserving mulch. Some 5,000 scarlet gilia plants grow on five and a half acres of Fern Mountain’s southern slopes, and in late summer each plant produces some 170 tiny seeds. In spring the seeds germinate and develop into small leafy rosettes that thrive during the heavy summer rains. A single rosette, however, may take up to eight years before it produces its single flowering stalk.

When the stalk is growing, but before it flowers, scarlet gilia is most susceptible to grazing. As the snows recede in early spring, mule deer and elk begin their yearly migration to the high mountain meadows. By mid-May, these large ungulates have reached their destination and begin their trek across Fern Mountain in search of succulent shoots. They browse many of the plants to the ground.

By early July, the scarlet gilia begin to flower. Although the flowering season lasts about two months, individual plants bloom for about three weeks. Early in the season, red flowers are most common. But red flowers are rare by late August, when the new-flowering plants produce predominantly light pinks and whites.

At times, I even found different-colored flowers on the same plant. By checking back repeatedly I found that flowers produced later in the season on the same cluster were often lighter in color than earlier ones. Over a two-week period, plants shifted from one shade to the next lighter shade, from pink, for example, to light pink. Some even shifted as much as two shades, from pink to white. Late-flowering plants were more likely to change color than plants that flowered earlier. Over a two-week period at the beginning of the flowering season, only 2 percent of all plants shifted colors, while among plants that flowered one and a half
In early summer, the rufous hummingbird, below, drawn to the bright red flowers, is the primary pollinator of scarlet gilia. To attract pollinators when these birds emigrate, the scarlet gilia on Fern Mountain change the color of their blossoms from red to pink to white. The lighter colors lure the white-lined sphinx, left, a species of hawkmoth that feeds on the flowers in the evenings of late summer.

months later, 26 percent showed a change. What these color changes meant was at that point still unclear to me.

By the end of the flowering season, following pollination and fertilization, the ovals of scarlet gilia swell and form large green fruits. The fruits dry, turn brown, and then split, exposing their seeds to the brisk fall winds. Without any structures to catch the wind, most seeds fall close to the parent plant. Seeds do best that fall into gaps created in the vegetation by the footprints of passing ungulates or that fall on the mounds of discarded soil left by burrowing gophers. Most, but not all, parent plants, having reproduced once, die. But I found that some plants produced another rosette at the base of the flowering stalk, so that even though the flowering rosette died, the second rosette survived to flower in a subsequent year.

I wondered whether any of these plants could possibly survive the grazing of the deer and elk and still flower. From mid-May through the end of August, the ungulates browsed up to 80 percent of all plants and three-quarters of these were chewed nearly to the ground, with only a small portion of stalk left behind.

To find out how browsing affected scarlet gilia, I selected forty uneaten, single-stalked plants of similar size and height early in the season after stems had fully elongated but not yet flowered. To simulate high levels of natural herbivory by mule deer and elk, I clipped twenty of the plants nearly to the ground. The remaining twenty plants served as a control group. The response of the clipped plants was rapid; within approximately four weeks they were as tall as the controls. Not only that, the plants flowered at approximately the same time and, in a few cases, even before the others, usually sprouting multiple flowering stalks from lateral buds at the base of the stem. Browsed plants produced an average of four new flowering stalks, and the plants with multiple stalks then produced approximately two and a half times as many flowers and fruits as unbrowsed plants. The experiment showed that being eaten by mule deer and elk increases flower and fruit production—in the same flowering season. Interestingly, natural and simulated herbivory resulted in plants with larger roots; therefore aboveground growth did not come at the expense of the roots.

Although plants that were naturally browsed or experimentally clipped produced more fruits than uneaten individuals, I wondered whether the fruits were of poorer quality, producing fewer seeds or seeds of poor quality. But as comparisons proved, there were no differences in the number of seeds produced per fruit, seed weight (a measure of seed quality and the level of stored food reserves), germination success, or seedling survival in all three groups. The clipped and browsed plants were simply two and a half times more fit than the others, and as later studies showed, their offspring are also more fit and more likely to survive.

These results surprised me. In the evolutionary battle between plants and their consumers, most plants suffer when chewed or browsed—the resources put into restoring stems and leaves usually diminishing the size of roots, the number of fruits, and the number and quality of seeds. But the scarlet gilia on Fern Mountain have adapted to the grazing of the elk and deer, and now mammalian herbivores play a role in the plant’s survival and reproductive success. I soon found that much of the rest of the plant’s success comes from its ability to change flower colors.

In early summer, broad-tailed hummingbirds, which have been breeding on Fern Mountain since early spring, begin to skirt the tops of scarlet gilia in anticipation of their flowering. When the gilia flower, the rufous hummingbird arrives at Fern Mountain on its way from its breeding grounds in Canada to winter feeding grounds in Mexico. These two birds, along with the white-lined sphinx, a species of hawkmoth, all begin moving pollen from flower to flower, enticed and repaid by the gilia’s sugary nectar. During the early part of the season as many as forty hummingbirds vie for territories on the slopes of Fern Mountain. The domineering rufous hummingbirds inevitably
The change to white blossoms, below, is an adaptation that apparently occurs only on Fern Mountain. In the lowlands, the hummingbirds remain throughout the summer, making a color change unnecessary. Mule deer, right, migrate across Fern Mountain in the early spring, grazing scarlet gilia plants to the ground. The plant responds to being eaten by growing faster and producing more fruit and seed.

hold the best of all territories, made up of large numbers of scarlet gilia, goldenbeard penstemon, and Indian paintbrush (all hummingbird pollinated). Each territory is actively defended against nectar-robbing intruders, primarily broad-tailed and juvenile rufous hummingbirds, which perch along the periphery of a territory awaiting an opportunity to steal across its well-defined borders to obtain a meal. If spotted, the intruder is met with angry buzzing and chased back over the boundary.

I soon found that hummingbirds had clear preferences. They preferred the red blooms of penstemon, Indian paintbrush, and scarlet gilia to the lighter-colored flowers of gilia. One other important pattern emerged. The hummingbird population remained relatively stable through July, but declined steadily until no birds remained by early September. Shifts to lighter color coincided with hummingbird emigration. When the hummingbirds left, hawkmoths became the sole pollinators, and their numbers remained relatively stable to the end of the flowering season.

At sunset I saw as many as forty-six hawkmoths foraging primarily on red flowers of scarlet gilia. But as darkness fell the moths began to visit lighter and lighter colored flowers until by dark, hawkmoths were visiting white flowers almost exclusively. They continued to forage for at least two hours after dark, mostly on lighter-colored plants.

All of this led me to hypothesize that the shift to lighter flower color was an adaptation for taking advantage of hawkmoths when hummingbirds emigrate. But to confirm this theory I had to determine the relative importance of hawkmoth and hummingbird pollination on each of the color variants of scarlet gilia to see if there was any advantage to the shift in flower color when only the hawkmoths were present. To accomplish this I placed nylon tricot covered wire cages over plants to exclude one of the two pollinators. I covered thirty plants (six per color variant) only at night to exclude hawkmoths and thirty during the day to exclude hummingbirds. As a control, I exposed ten plants (two plants per color variant) to both pollinators. At the end of the flowering season, I compared the amounts of fruit and seed.

When both pollinators were still feeding there were no differences in fruit set among the color variants. When the plants were exposed to only one type of pollinator, however, different color variants had a selective advantage. With only hummingbirds available, red flowers were twice as likely to set fruit as white flowers. Just the opposite was true when only hawkmoths were present: lighter-colored flowers produced nearly twice as much fruit as red. Further, plants with flowers only one shade lighter set as much as 22 percent more fruit than plants whose colors remained unchanged.

Although scarlet gilia recovers a proportion of its reproductive loss by shifting flower color when there are only half as many pollinators, not all plants are guaranteed good pollination. So scarlet gilia has yet another option that helps insure its reproductive success.

What I found was that plants that flowered early in the season were likely to die after flowering, while late-flowering plants more often formed a new rosette and survived. More rosettes formed as hummingbirds began to leave and fruit set declined. When unpollinated plants failed to fruit, they apparently formed rosettes instead. To test whether this was so, I caged some plants early in the growing season to exclude pollinators. These plants were five times more likely to form a new rosette than were uncaged plants. I then removed the buds of some plants so they couldn’t form fruits. These plants were seven times more likely to form a new rosette than were the controls. Scarlet gilia is somehow able to reallocate resources to form rosettes that may offer it another chance to flower in a year when there are more pollinators.

Is scarlet gilia’s behavioral repertoire unique? Its abilities to change color in response to the change in pollinators and circumvent the damage done by herbivores are adaptations that give it a great advantage on Fern Mountain. And I suspect other plants have similarly dynamic ways of assuring their survival.
Stretching its long, slim body, a stoat gets a better look around than it could ever get while on all, short fours.

Cynthia and Amor Klotzbach
Stop-and-Go Stoats

Whether the object is food or sex, stoats seem to be forever deciding whether to go full steam ahead or screech to a halt

by Mikael Sandell

A cold, crisp February night in southern Sweden—temperatures dropping well below zero. This radio-tracking shift will last twelve hours. The signal in my earphones remains a steady beep—no activity. I jog back and forth over the snowy field in a futile attempt to keep warm. A small pine grove gives some protection against the wind. Less than 150 feet away, in a small marsh almost filled in with willows, a female stoat lies in her nest under the snow. She is inactive and has been so for hours. Maybe she’s sleeping. Just after 1:00 A.M., the strength of the signal begins fluctuating, but the steady pulse returns again after only a few minutes. She probably changed position. At 3:46 A.M. she becomes active for about thirty minutes, hunting in the area close to the nest. Thereafter, she remains inactive until I leave at 7:00 A.M.

The stoat (also known as ermine or short-tailed weasel) seems to have everything going against it during winter. Its small size and long, thin body give it a large surface-to-volume ratio, so it has a problem retaining heat. Making matters worse, the stoat’s fur is thin, providing little insulation. These physical characteristics are the evolutionary consequences of its life as a hunter of voles; pursuing the little mouselike mammals down into their tunnels dictates a streamlined body plan. As a result, the weasels are almost constantly expending energy on heat production. Their resting metabolism is nearly twice that of other mammals of similar size. Most carnivores are known for their ability to eat ravenously when food is available and then go for long periods without food. Weasels, however, with their small body size and high energy needs, cannot feast and fast. Their stomach is small, and even when engorged, it is empty again after four hours. Stoats die of starvation after only one or two days without food.

During the winter, the only feasible thing for the weasels to do is minimize energy consumption. One of the ways they do this is by restricting activity to about four hours in every twenty-four. The remainder of the time, they rest, often in the nests of their prey. Energetics studies of
Left: Stoats, also known as short-tailed weasels or ermine, undergo a winter molt in northerly parts of their range, their coats turning white for camouflage against the snow. Below: Sticking its nose into a dense tangle of last year's marsh grass, this stoat is probably sniffing for voles, a favorite prey.

Gertrud and Helmut Dietsch

small mammals have shown that nest use reduces the metabolism of resting animals by up to 35 percent. Weasels not only take over prey nests, they also remodel them. A nest that has been used by a weasel for a while is lined with a thick, insulating layer of the prey’s hair.

Since hunting is metabolically three to five times more costly than resting, an animal that rests quietly in a nest prolongs the time it can stay alive without eating. It also, of course, misses out on any chance to catch prey and thus replenish its energy reserves. One way or another, starvation is probably the main cause of death.

In the winter, each stoat maintains a territory from which animals of the same sex are excluded. Being territorial helps a stoat secure prey, the primary goal of all stoats during these difficult months. Male ranges are large and may partly overlap those of females. This overlap is probably the result of both sexes establishing winter ranges in areas with lots of food. Thus the potential for competition between the sexes for food exists but is reduced in two ways. First, both the male and the female tend to use these overlapping areas less intensively. Second, the sexes take somewhat different prey: the males, being larger, concentrate on bigger animals, while the females can enter smaller vole tunnels inaccessible to males.

By March, winter is on the wane in my study area, and by late April, females are about to give birth and immediately reenter the breeding season. The stoat is one of a group of species in which gestation is slowed by delayed implantation of the embryo in the uterine wall. Females mate soon after giving birth and while still nursing their young, but the fertilized eggs stop developing at the blastula stage, when the embryo is little more than a layer or two of single cells surrounding a central cavity. The blastulas lie dormant in the uterus until the next spring (about ten months), when development resumes. Young females are sexually mature at an extremely early age and are already fertile three to four weeks after birth—two weeks before their eyes open. Adult males often enter the nests, drag out the still blind females, and mate with them, apparently without any interference at all from the mothers.

The number of young a female can raise is a function of how much food she can find. Thus, she continues to defend her territory against other females during the breeding season. A mother stoat has her work cut out for her. The animal I called female 34, for example, bore eight young in the spring of 1984. (Typical litter size is six to eight.) By late June, the young stoats were weaned but still totally dependent on their mother for food. The juvenile females were about the same size as the mother, but her sons were some 50 percent heavier.

To find food for herself and her family, female 34 rushed around incessantly. Sometimes she moved several hundred yards away to hunt in a patch of dense vegetation. After some hours she would return to her nest-bound young and lead them to the new area. Although the young followed her closely, she usually took only two to four of them at a time and consequently had to make several trips to relocate the litter. After such a move, she generally hunted close to home for a while, bringing all the voles she caught back to the nest. When prey became harder to find, she went off to hunt in a new location. Thus, the family was constantly on the move.

Even areas rich in voles may be quickly depleted, testimony to the stoats’ skills as hunters. On my study site, the water vole is the stoat’s main prey, although other small mammals and birds are also taken. Water voles are large, as voles, go: full-grown, they weigh as much as, or more than, a female stoat (4.5 to 5 ounces). But their size is little protection against the weasels. One of my colleagues was conducting a radio-tracking study of water voles when a female stoat with young arrived at the study area. Mothers with young hunt with special intensity, and in less than two days, the stoat had killed fifteen to twenty rodents. My colleague found all of her transmitters in a heap of half-eaten voles. I was excited by this unequivocal proof of a stoat’s hunting efficiency; curiously, my colleague wasn’t as enthusiastic.

Even when rearing young, female stoats are only active for about nine hours each day. The period during which I radio tracked families—just before the young become independent—is probably the most critical one for the female. The family’s demand for food is at its highest, and during the next period, when the young
Even when alarmed or scared, in this case by the photographer, a stoat, below, shows the curious, alert posture typical of its species. Approximately ten weeks old, these young stoats, right, are not quite ready to hunt for themselves. Until they are, their mother will lead a hectic life, providing food for up to eight youngsters, some bigger than she.

Joe McDonald

Even when alarmed or scared, in this case by the photographer, a stoat, below, shows the curious, alert posture typical of its species. Approximately ten weeks old, these young stoats, right, are not quite ready to hunt for themselves. Until they are, their mother will lead a hectic life, providing food for up to eight youngsters, some bigger than she.

Joe McDonald

start to hunt for themselves, it is probably crucial that they are in good condition. Why then do mothers rest fifteen hours a day? One possibility is related to the hypothesis that the amount of energy an animal can metabolize is limited. A relation between this limit and body size has been shown by physiologist James Kirkwood of the University of Bristol, and my calculations reveal that the energy budget of a female stoat during the late rearing period is close to this limit. A female stoat that hunts for nine hours per day is probably working at maximum capacity.

Some weeks later, the young begin hunting for themselves. For a short while, the whole family stays on the mother's territory although each member hunts and sleeps alone. But, since female stoats exclude other females from their range all year, juvenile females are eventually forced to leave their mother's range. (In one case I know of, an old female moved some 300 feet away, and a presumed daughter took over her original area. I do not know if this is a common pattern.) For the most part, however, young females do not go far. They usually establish ranges within several hundred feet of their birth-places and stay there for the rest of their lives. The few females that do move far away are usually no longer young.

In contrast, males invariably leave their natal area, usually during their first autumn, although sometimes they remain for the winter and leave the following spring. The last time I saw male stoat 9 was July 12, 1982, when I trapped him in the barn of an abandoned farm a few miles from the place where he was born. As I took off the radio collar and prepared to release him, I thought about how old he looked. He had damaged his right eye; it was cloudy, and he was probably unable to see with it. And although his weight was normal, he looked shabby and worn out. I had first marked this male as a juvenile in the autumn of 1980, and he had already exceeded the expected lifetime for a stoat of a year and a half. Male 9 had taken part in two mating seasons, and I had been able to follow him during both of them. He was the stoat I had spent the most time with: in total I was within 100 yards of him for three to eight hours per day for more than 100 days.

During the mating season, males have only one goal: to achieve as many matings as possible. They take no part in rearing the young, instead concentrating their time and energy on mating. But what tactic should a male use to maximize his number of matings? Should he stay and defend one or a few females or roam around and try to visit as many as possible? In general, the answer depends on the distribution of females. When they live in groups or at least near one another, a male may be able to prevent other males from visiting them; when females are widely spread out, such defense would be next to impossible and a male is better off roaming and competing for many females. Female stoats in my study area were widely spaced, with a mean distance of about a half mile between neighbors, and
so I expected the males in the area to wander. What I found, however, was considerably more complicated.

Some males did indeed move about. On April 29, 1982, male 9, two years old by that time, left his ordinary range and traveled to a marsh about two miles away, where he spent the night. I found him the next morning at the same place. He became active about 10:00 A.M. and moved away shortly thereafter; this time he wandered a distance of about three miles, moving along ditches and hedgerows and ending up about two miles from where he had started that morning. The next day I found him in a marsh area about a half mile from the place I had left him the day before. After staying here for five days he moved about a mile and stayed one day, then moved a half mile and stayed for two days, and so on. He returned to the starting point twelve days after beginning his journey, having wandered about nine miles. During that spring he moved over a ten-square-mile area (about 6,400 acres). Data I gathered on the stoats’ movements showed that all males two years or older roamed this way during the mating season: moving for a day or two, staying at a new place for one to five days, then moving on again. Almost all of the stays within my study area were near established females.

Roving males can be successful only if they are able to take over at least some of the females they encounter. Studies of stoats kept in enclosures have demonstrated that old males always dominate yearlings. Thus, an old male can expect to mate with a female even if a yearling is already with her, and since yearlings constitute about half of the breeding males, older males can be fairly confident of coming out on top in at least 50 percent of their encounters—a high enough success rate to make roaming a sensible tactic for nearly all two-year-olds.

Yearling males displayed one of two tactics. Some stayed within a restricted area the entire mating season; I called these the stationary males. For example, during his first breeding season, male 9 remained within a three-quarter-square-mile area that encompassed the ranges of
two females. He visited both females almost daily. As a stationary male, his tactic was one of patience: he was sure to be close by when the females within his range came into estrus, and if there were no roamers around at the time, the female would be his. If an older male did show up, however, the patience would be for nought. When old male 76 passed through my study area, for example, he went right into the range of male 9 and took over one of the females there.

Other yearling males, the transients, were on the move constantly, never staying in one place for a whole day. One of these males moved almost three miles in less than one hour, and that was only one of his activity periods that day. Some of these males passed through the study area several times during spring. I do not know what these males were doing. They seemed to be the lowest-ranked yearlings, and maybe their only chance for mating was to encounter a receptive female when there were no other males around.

Males on the move, whether roamers or transients, made all of their long trips during daytime, following stone walls, ditches, fences, hedgerows, and other lines in the landscape wherever possible. To
two consecutive years, two different males moved through my study area, both following almost exactly the same path. They first crossed a little creek, entering it at the same spot and swimming to a hedgerow directly opposite. They then moved over a large, grazed field to the safety of a pine grove.

During autumn, the males again establish small, exclusive territories where prey is plentiful. These winter ranges may be ten to twenty times smaller than the mating ranges. In winter, food—not receptive females—is the most important resource, and freed from the need to wander in search of females, all the males settle down. Because of this shift, males adopt two totally different social structures during the course of the year.

Males almost never establish their winter range in the same area two years in a row. The winter population in my study area thus changed every year, but I did not completely lose touch with males from the previous winter because several passed through during the spring. One male that wintered in the central part of my study area one year was trapped four miles away the next winter, and most males probably moved much farther away than that. Male 9 was the only one to stay within the study area for two consecutive winters. He spent the first winter about a mile from his place of birth, and after his first mating season, during which he did not roam, took up the same winter range the following winter.

Although I was tracking several males in the same area at the same time, I saw a meeting between two males only once. A marked male, moving through my study area, became inactive in a heap of stones beside the fence he had followed. An unmarked stoat subsequently came along the fence from the other direction and entered the same heap of stones. Suddenly, intense, high-pitched screaming broke the silence and continued for several minutes. Shortly thereafter, the unmarked individual rushed out with the radio-collared male at his heels. The chase continued for several hundred yards. Usually, however, males seemed aware of one another's presence; for example, as long as a roaming male was keeping company with a female within the range of a stationary male, the latter avoided that part of his range. Most likely, the animals know

Water voles, left, make up the bulk of the stoat's diet in the marshes of southern Sweden, but the widespread weasel species has very catholic tastes. The little weasel below, snapped napping in Canada's Northwest Territories, has just dined on a snow goose nestling. Overleaf: Although primarily terrestrial, stoats are perfectly capable of climbing trees to seek their supper.

Jan and Des Barrett, Bruce Coleman, Inc.
of one another's whereabouts primarily through smell, which is really the only way for small mammals moving around in high vegetation to communicate without close contact. An active stoat is constantly marking its path with scent, either by pressing its anal region against the ground and advancing with wriggling movements or by rubbing its belly or sides against the ground, branches, stones, and other objects. I find that it is easy to detect and interpret signs of these behaviors while tracking the animals in the snow, and I have found similar signs while snow tracking least weasels, minks, polecats, and martens—all, like the stoats, mustelids. Mustelids have well-developed anal glands. The skunk uses these glands for defense, and a cornered stoat will also release its pungent anal gland contents. The secretion is mainly used for scent marking, however, and is deposited during the anal drag.

Scent marks function as strict territory markers for females and for males, although only during the winter for the latter. In the less rigid system used by the males during the mating season, however, scent marks can also provide information about the presence and social status of individuals in an area. In enclosure studies, yearling males that encountered a fresh scent mark of an old male often showed submissive behavior. In some cases, the younger animal screamed and fled, even though no old male was in the enclosure. When an old male encountered a fresh scent mark, however, he sniffed it and promptly covered it with his own scent.

Stoats can be found in tundra and forest regions across much of Eurasia and North America. Admired by some for their great speed and skill at overcoming prey as big as, or bigger than, themselves, persecuted by others as marauders of small game and poultry, these little mustelids are holding their own. In a world where so many of our fellow creatures are not faring well, it gives me pleasure to know that, as I am writing this, new generations of stoats are growing up in my study area, each individual taking up its struggle for survival and reproductive success.
During the mating season, a two-year-old male in his prime may roam over a large area in search of females. A first-year male is more likely to adopt a stationary lifestyle, waiting patiently for any females in his range to come into estrus. With any luck, no older, dominant male will happen along to steal his prize.

Joe McDonald
The Far Reach of Tambora

Why the 1815 eruption of a volcano in the East Indies caused crop failure in India, summer snow in Nantucket, and red skies over London

by Haraldur Sigurdsson and Steven Carey

We step cautiously to the very rim of the Tambora caldera. At our feet is a 3,600-foot cliff that ends in a parched, circular floor, some four miles in diameter. Bordering the caldera floor, yellowish, steaming vents, or fumaroles, emerge from a huge, ringlike fault that caused the catastrophic subsidence of the center of the volcano in 1815. The distinct smell of sulfurous gases reaches us high up on the rim, and the fumaroles' distant roar sounds like the operation of some great machine. Despite the many years that have passed between the eruption and our visit in 1986, Tambora's core still has large reserves of thermal energy.

Unleashed in 1815, Tambora was the largest explosive eruption of historic times, one that surpassed even the cataclysmic destruction in 1883 of Krakatau, a thousand miles to the west along the Indonesian volcanic island arc. Yet many aspects of this unique geologic event remain virtually unstudied, largely because the volcano, located on the island of Sumbawa, is so difficult to reach. After two months of research around the coastline of the island, we had set out for the summit of Tambora accompanied by an Indonesian guide and three porters. We wanted to collect information from the topmost layer of rocks in the caldera rim: the deposit of the 1815 eruption. This deposit is neatly sliced by the ring fault, and while easily visible from afar, it is nearly inaccessible. We reached the edge of the caldera after three days of a grueling trek that entailed slicing a path with machetes through the dense rain forest and through meadows of two-foot-high stinging nettles on Tambora's slopes. Even though we reached our goal, injuries and lack of water forced us to turn back with only a scrap of the information we had hoped to collect at the summit. But thanks to our coastline research and the time spent studying deposits on neighboring islands, we returned to the United States with a wealth of new information about the 1815 eruption.

The only contemporary account of the 1815 eruption was that of Sir Thomas Stamford Raffles, governor of the British East Indies colony at the time and the founder of the Singapore colony. Prior to 1812, Tambora was generally thought to be extinct, but in that year minor activity was first observed, and it continued intermittently during the next three years. People living in Sanggar, a village twenty miles southeast of Tambora, noted that a dense cloud frequently shrouded the volcano's summit. The cloud was not affected by strong winds, and each month it grew darker and denser and sank lower. From time to time the villagers heard weak rumbles from the mountain, but they gradually grew louder.

On the afternoon of April 5, 1815, the first major eruption from the summit crater sent a column of ash and pumice to an estimated height of twenty miles, well into the earth's stratosphere. That explosion was heard in Jakarta, 775 miles to the west, and even in Ternate, more than 850 miles away, and ashfall was widespread as far as eastern Java. Our examination of the deposits laid down during this phase of the eruption indicates that the rate of energy release was very high in comparison with most historic eruptions. The first gi-
ant mushroom cloud over Tambora was probably slightly larger than the one that rose from Vesuvius in A.D. 79, burying the cities of Pompei and Herculaneum with a blanket of pumice and ash. The April 5 event at Tambora began with a small explosion that deposited fine ash around the volcano, followed by a larger, pumice-producing eruption that lasted approximately two hours and ejected pumice at a rate of 100,000 tons per second.

Minor activity persisted during the next five days, but on April 10 the major eruption began. About 10,000 people were killed on Sumbawa by the immediate effects of the eruption, and an additional 38,000 died the following year from hunger and disease. The total death toll on Sumbawa represented about 35 percent of the island's population. One hundred miles to the west, a twenty-inch-thick layer of ash fell on Lombok. The effect on agriculture was so severe that 44,000 people, about 22 percent of the population, died from hunger and disease in subsequent years. The death toll from the direct and indirect effects of the Tambora eruption was thus about 92,000 people, or almost three times the toll of the Krakatau eruption. The results, however, went far beyond Indonesia and were felt worldwide for the next three or four years.

Our field studies of the pumice deposit from the April 10 explosion, together with a computer simulation, indicate that the eruption sent a column of ash and pumice at least thirty miles above the volcano. Magma, ejected at a rate of 300,000 tons per second, fell as a thick pumice layer on the flanks of the volcano. Ashfall was heavy on many of the islands to the west along the Indonesian chain. Madura, for example, although 300 miles away, remained in complete darkness for two or three days because of the Tambora ash veil. The sound waves generated by the explosion were heard as far away as Bengkulu on Sumatra, more than 1,000 miles from the volcano, and earthquakes were felt as far away as Surabaya, 400 miles distant, in eastern Java.

In the first stage of the eruption, the fountain of pumice and ash ejected from the volcano mixed with the atmosphere, leading to the efficient transfer of heat from the hot volcanic particles to the surrounding air and greatly reducing its density. The heated air rose rapidly, like a hot-air balloon, to heights of thirty miles, carrying with it the erupted mass of ash and pumice. Such eruption plumes are comparable to the plumes rising from industrial smokestacks but on a vastly greater scale. Volcanologists call this type of behavior plinian, in honor of Pliny the Younger, who first documented the phenomenon during the A.D. 79 eruption of Vesuvius. The April 10 Tambora plinian phase is the most energetic volcanic activity ever recorded and has been exceeded in intensity only once in the geologic record—by the ultraplinian Taupo eruption in New Zealand in about A.D. 130.

After some three hours of sustained plinian activity, the character of the eruption changed dramatically, as the emerging fountain of material began to pour hot ash and pumice, known as pyroclastic flows, over the flanks of the volcano. We believe that the sudden change was due to a less efficient transfer of heat from the erupting hot particles to the surrounding atmosphere. When the rate at which magma is erupted from a volcano increases beyond a critical threshold, the resultant fountain of ash and pumice can no longer mix effectively with the atmosphere and the hot-air balloon collapses. Thus, instead of producing a high eruption column, the products of the most vigorous phase of an eruption cascade down the flanks of a volcano as hot, density-driven currents of ash and pumice. Such ash flows are well known from many eruptions and include the deadly glowing avalanche in 1902 from Mount Pelee, on the island of Martinique, which claimed 29,000 lives.

Our studies on Tambora revealed that
The smooth, tan surface, 3,000 feet above the caldera floor, is the final layer of ash laid down by Tambora’s 1815 eruption. Indonesia (map below) has more volcanoes (black triangles) than any other country in the world. The country’s island arc is part of the so-called Ring of Fire, the band of earthquake and volcanic activity that encircles the Pacific Ocean.

The 1815 eruption produced at least eight pyroclastic flows, which almost completely covered the Sanggar peninsula and extended out to sea. On April 10 at about 7:00 p.m., the sultan of Sanggar saw three fiery columns rise above the volcano. They climbed very high, combined into one, and moments later the entire volcano was like a sea of fire in what the sultan described as “a whirlwind on the south-east slope of the volcano, which hurled whole forests and villages with people and cattle, in short everything, into the air and devastated the country.” These observations record the arrival of pyroclastic surges at the village of Sanggar, as the eruptive style changed from a high-altitude plume to a collapsing fountain, generating turbulent pyroclastic flows and surges that raced down the slopes toward the sea. During the eruption, the 15,000-foot-high summit collapsed, as the upper third of the volcano founded into the partly emptied magma reservoir. The resultant collapse structure is the modern Tambora caldera.

Because the vast majority of the products fell into the ocean, researchers have encountered great difficulty in estimating the total amount of material ejected during the Tambora eruption. In 1929 the Dutch oceanographic vessel Snellius took samples of the ocean floor in the Java Sea. The Snellius cores show that Tambora ash forms a ten- to fifteen-inch-thick surface layer on the ocean floor. This information aids greatly in determining the total erupted mass, estimated at between twenty-four and thirty-six cubic miles of pumice and ash, corresponding to about twelve cubic miles of magma.

For Indonesia, the Tambora eruption was clearly a major disaster. For the rest of the world, the effects were dramatic but not as fatal. Brilliant sunsets and twilights were observed in England in June, July, September, and October, 1815, and those volcanic sunsets are suspected to have influenced the work of the British artist J. M. W. Turner, many of whose paintings from that period contain colorful red skies. Those spectacular optical phenomena were due to the huge quantities of volcanic aerosol particles that the Tambora eruption introduced into the earth’s stratosphere, where they remained suspended at altitudes of ten to twenty-five miles above the earth for several years. In any explosive eruption, the ejected magma originally contains a small percentage of various gases dissolved under high pressure. The dominant gas is usually water vapor, which expands a thousandfold when the magma reaches the low pressures at the earth’s surface. The sudden expansion of gas bubbles causes a violent disruption of the magma, producing pumice and volcanic ash. In addition to water vapor, volcanic gases include carbon dioxide, sulfur dioxide, hydrogen chloride, and hydrogen fluoride, which escape into the atmosphere where they can cause changes in the earth’s climate, affect the stratospheric ozone layer, and produce other atmospheric effects, such as spectacular sunsets.

The erupted pumice and volcanic ash are relatively dense and coarse grained, and consequently fall rapidly out of the atmosphere during an eruption, usually within a few thousand miles downwind of the volcano. The atmospheric residence time of the volcanic gas molecules, on the other hand, is much longer, and they or their products may stay in the earth’s stratosphere for several years. Sulfur dioxide gas molecules, for example, react with...
At least eight light-colored bands can be seen in the caldera's steep walls. The material, a mix of pumice and ash, was ejected at different intervals during the 1815 eruption. Darker ashfall layers separate the light bands. The diagram gives the estimated heights of five major volcanic eruptions.

Joe LeMannon

![Diagram of volcanic eruptions]

water vapor in the atmosphere and form tiny aerosol droplets of sulfuric acid that, because of their minute diameter of about one-tenth of a micrometer, remain suspended in the stratosphere for several years. Such volcanic aerosols can have important effects on the heat balance of the earth's atmosphere. The aerosols absorb solar radiation and backscatter some of it out to space. The effect of the volcanic aerosol is an increase in the temperature of the stratosphere, but a reduction in the amount of solar radiation reaching the earth's surface. The surface cooling caused by this veil of volcanic aerosol is largely dependent on the amount of volcanic gases emitted by the volcano.

How much gas was emitted by the 1815 Tambora eruption can be estimated by using three types of evidence. First, the contemporary reports of a variety of optical phenomena observed in the years after the eruption have recently been reinterpreted by Richard B. Stothers, an atmospheric scientist at the Goddard Institute for Space Studies, in New York, to arrive at an estimate of the mass of the atmospheric aerosol ejected. In addition to brilliantly colored sunsets, these phenomena included dry fog (a mist of particles condensed from volcanic gases), which dimmed the sun sufficiently to make sunspots visible to the naked eye; the moon's blackness during a lunar eclipse; and the abnormal dimming and tremulous appearance of stars more than two years after the eruption. The large atmospheric turbidity following the eruption indicates that at least 200 million tons of volcanic aerosol were introduced into the stratosphere worldwide.

Second, the gradual settling of the volcanic aerosol particles out of the stratosphere results in a microscopic "rain" of acid droplets onto the earth's surface. The volcanic acid rain is preserved within the annual snow accumulation and thus the chemistry of the volcanic aerosol and its amount can be determined by studies of polar ice cores. Pioneering studies of this sort on Greenland ice cores by the Danish glaciologist Claus Hammer have shown that volcanic acids deposited in the four years following the Tambora eruption amount to about 150 million tons.

Third, we have estimated the mass of volcanic gases emitted by Tambora by chemical analyses of the pumices erupted from the volcano. Prior to an eruption, the volatile gases that lead to the formation of volcanic aerosols are largely dissolved in the molten silicate liquid, or magma, in the volcano's deep reservoir. At the time of the eruption, the volatiles separate from the magma and escape to the atmosphere, leaving the relatively gas-free pumice fragments to fall out around the volcano. Thus, information on the initial gas content of the magma prior to eruption is obliterated. All is not lost, however, as some crystals, which grow deep in the magma before an eruption, occasionally trap droplets of the gas-rich magma. These crystals are expelled with the bulk of the magma, but the minute, trapped droplets of magma turn to glass and freeze in the volatile components, thus providing a record of the pre-eruption volatile content of the magma. The glass inclusions in crystals are on the order of 100 micrometers in size and therefore very difficult to analyze. We used an electron microprobe to determine the content of sulfur, chlorine, and fluorine in these glass inclusions and calculated from these data the mass of volcanic gases released during the erup-
tion. Our estimate is about 400 million tons of total volcanic aerosol.

Scientists have proposed that very large eruptions may cause cooling amounting to global climate change with a duration of several years, but fortunately our planet is very rarely subjected to volcanic explosions of such magnitude. The idea of climatic change resulting from volcanic eruptions originated with Benjamin Franklin. In 1783, when he was the young American republic’s minister to the royal court of France, a persistent haze spread over Europe, bringing with it cold weather. Not like a normal fog, it was a dry fog, which so attenuated the sun’s rays that paper could scarcely be kindled with a magnifying glass, as Franklin’s experiments demonstrated. Franklin had received word of an ongoing huge volcanic eruption of the fifteen-mile-long Laki fissure in Iceland, and he made the brilliant deduction that the haze originated from that distant event and was responsible for the deteriorating weather in Europe that year, as well as the unusually low temperatures recorded in the eastern United States the following year by Thomas Jefferson in Virginia and the theologian and scientist Ezra Stiles in Connecticut. In 1816 a persistent dry fog was again reported in the eastern part of the United States, but apparently no one linked this with the Tambora eruption at the time, even though Franklin had made that connection for the Icelandic eruption thirty-two years earlier. In the United States, the summer of 1816 was so cold that the year became legendary and was known colloquially as “eighteen hundred and froze to death.” A succession of cold waves struck New England, where temperature records were set, and the time was described as the “year without summer.” In June, the mean temperature in New Haven was about 7°F below normal. On Nantucket Island the temperature plunged to 22°F and a storm deposited three to six inches of snow on the ground. In Vermont at least one person died of the cold. Damage to the corn crop was severe and gardens were left blackened by frost. Warm-weather birds were driven south by the storm and large flocks dropped dead in the streets of New York City.

A second cold wave struck on July 9, when water in Maine froze as “thick as window glass,” killing the corn crop again. A third cold wave hit on August 21: frost killed corn, potatoes, beans, and vines in New Hampshire, Massachusetts, and Maine, and snow covered the mountains of Vermont. The final storm hit the New England region on August 30, destroying the remaining harvest, except for the hardest grains and vegetables. Corn was nor-
mally the staple crop of New England, and the failure of the 1816 crop was a disaster. Because of the crop failures, grain prices rose sharply in North America and Europe. The price of wheat did not have such a spectacular rise again until the great Soviet wheat shortage of 1972.

The climate deterioration also affected Europe, where the crop failure led to the highest wheat prices on record in 1817, and caused social and economic disorder and famine throughout the continent. In May, the cold in Germany was so severe that wells froze solid. Eerie electrical disturbances in the atmosphere were common, and sparks from exposed metal lit up entire church spires. July of 1816 became the coldest July in England's entire two-hundred-year weather record and snow fell near London in August. The famine resulting from local crop failure led to a typhus epidemic, which spread from Ireland to England and Scotland in 1816, causing more than 65,000 deaths. Similarly, bad harvests in India in 1816 led to a famine that is believed to have triggered a local cholera epidemic, which eventually spread across Asia and into Europe as the great cholera pandemic of the century.

Among the many side effects of the Tambora eruption, perhaps the most exotic was that on the English poet Lord Byron and his friends Percy Bysshe Shelley and Mary Wollstonecraft Shelley. They were vacationing in Switzerland on the shores of Lake Geneva, but the summer of 1816 was too cold to spend much time outside so they stayed inside and wrote. Mary Shelley produced her notable novel *Frankenstein*, and Byron wrote his poem “Darkness,” in which these lines serve well as a commentary on the effects of the Tambora eruption:

The bright sun was extinguish'd, and the stars
Did wander darkling in the eternal space,
Rayless, and pathless, and the icy earth
Swung blind and blackening in the moonless air;
Morn came and went—and came, and brought no day,...
At various spots along the edge of the volcano's four-mile-diameter floor, sulfurous gases continue to escape from vents. Whitish ash covers part of the caldera floor.
Evidence of Things Seen

by Bruce Stutz

In 1980, soon after the National Park Service put him in charge of the natural resources at the 600-acre William Floyd estate at Mastic on Moriches Bay, Long Island, New York, Richard Stavdal came across two turtles bearing similar inscriptions carved into their hard undersides: JTN-25-43 and JTN-34-9.

Although the 300-year history of the estate, from precolonial land grant to diminishing family compound, were well established, the natural history of the woodlands, open fields, vernal ponds, and salt marshes was not, as far as Stavdal knew, very well documented. Amidst suburban development, the estate was now an island of wild land. Stavdal could drive his pickup from the old house and see nothing but low forest until he reached the open salt marsh on the bay nearly a mile away. Across the bay the view was clear to the low, open dunes of Fire Island. Shorebirds and migrating ducks were Stavdal’s major interest, until—on different paths and days apart—he came across the marked turtles.

Stavdal soon found that these common box turtles were most conspicuous by the roadbeds at the edges of the woods where they sunned or sometimes mated in the low brush and weeds. Several more bore similar markings. The local historian suggested that Stavdal might find a clue to the markings in the two dozen journals that came with the house, along with the antique furniture and memorabilia of eight generations of Floyds, among whom were colonial farmers, a signer of the Declaration of Independence, Civil War officers, and New York merchants. The last of the Floyds to live in the house was Cornelia, who died in 1977 at age 95. She had bequeathed the estate to the National Park Service for preservation. Cornelia had been married to John Treadwell Nichols (1883–1958), a naturalist and curator at the American Museum of Natural History.

The journals had been written by Nichols and from them Stavdal learned about his box turtles and more: snapping turtles, painted turtles, spotted turtles, and mud turtles—nearly a thousand box turtles alone—had been marked and released on the Mastic estate between 1910 and 1950. If Stavdal’s reading of Nichols’s notations was right, the two turtles he had found had to be at least sixty years old.

How long do box turtles live? Despite the ubiquity of the animal along the East Coast, the answer, until recently, has been as vague as “a long time.” Most of the evidence collected on long-lived turtles has been anecdotal or based on captive animals. In only a few cases were marked animals released into the wild and recaptured. The record is so bad that one herpetologist even suggested that the longevity of box turtles might be an illusion, a consequence of poor record keeping, a
conclusion drawn from a few specimens and not applicable to the entire species. Stavdal brought the journals to the American Museum.

There he found that although Nichols had had an office in the Museum’s Department of Ichthyology from 1907 until 1952, he was nearly a forgotten man. Some had vague remembrances of a tall, lanky, reticent pipe smoker in a rumpled blue serge suit and beat-up felt hat. Some recalled that he had been considered an anachronism, a nineteenth-century naturalist who had not kept up with the times.

The library had a collection of Nichols’s thin pamphlets on fishes of various parts of the world, mostly taxonomic disputations, an apparently slim output for such a long career. But a bibliography in his last journal listed more than a thousand publications—most, however, were not on fishes at all, but on birds.

Mastic. Sunday, July 25, 1915

It had been blowing strong from the east under a dazzlingly clear sky, but the wind was hauling more and more to the south, so that when the canoe shot around a curve in the green meadow and headed across the bay, the cool sea breeze came in my face. Finally, approaching the opposite shore, poling across the shallows brought me to still water under tall grass on the beach side where a dozen snake stew were scientifically placed facing the wind and Little Beach Point. A few minutes more and I was reclining on the edge of the grass, the camera ready. A single cry, far off, had doubtless been a ring-neck plover, but it was not repeated, no bird came near and I was a little inclined to doubt my own hearing. Nevertheless, it gives me enthusiasm for the vigil now at hand with the sun beating down... and blazing on the stool which stand motionless in the still water.

Nichols’s enthusiasm never waned, his vigil was continuous. On his frequent high seas sailing adventures he revels in every sighting, distinguishing the markings, flight patterns, and calls of Mother Carey’s chickens, shearwaters, Wilson’s petrels “with white rumps, skimming and fluttering over and among the waves, dipping their feet in the water,” and kittiwakes “wheeling overhead, outlined against the clouds which reeled dizzily in the wind-swept sky with the motion of the ship.” In 1906, on a sailing vessel hove to for thirty days in a gale off Cape Horn, Nichols is most fascinated by the easy flights of albatrosses and fulmars.

In the preface to his 1923 handbook Birds of the New York City Region, Llew Griscom wrote that Nichols “knows more about Long Island birds than anyone living.” Nichols began the tradition of a Christmas bird count on the Mastic estate in the early 1900s. He contributed to all the major scholarly birding publications. At Mastic, Nichols spent hours in blinds, noting bird calls and movements (a painstaking technique, now—too often by some accounts—replaced by audio and videotape). He speculated on the evolution of these shorebird voices: Are they related to common calls or simply imitations of the calls of other birds?

A 1912 entry has Nichols trailing behind a brood of downy, young spotted sandpipers following their mother along the beach:

“Pip! Pip! Pip!” is the old bird’s alarm. “Kerwee, kerwee, kerwee,” a sweet note, now loud, now very low, evidently to assemble the young. When with the young she called “pip, pip” low, apparently an address. Then, as a young bird cries “beep” for assistance, but when caught in my camera box for banding it called “wit, wit!” which seems to stand for parent lost, then “pit wit wit,” a note of departure. To make the list complete: “hay hay weet weet weet weet weet weet” is a regular advertisement frequently heard in spring.

Nichols writes on everything he sees. In equatorial seas he times the leaps of flying fish; from the platform of the Garden City, Long Island, station waiting for his commuter train to Manhattan, he notes the flight patterns of gulls and counts the
number of times they flap their wings. In a few weeks of journal entries Nichols records box turtles at Mastic, wood frogs in Manhattan, Wilson’s petrels in lower New York Bay, and sharks washed up on the beach at Babylon, Long Island.

**Mastic. August 14, 1916**

Latter part of a cool clear morning, sun very bright and warm. Some green frogs singing among tussocks of grass, at the head of a narrow meander of Home Creek: “tsis!” and “tsis tsek tsek!” From time to time one or two marsh hawks drift across the meadows and chick least sandpipers would fly up in alarm in close noisy flocks using the “kree!” note very sharp and loud. Walking through the woodland was attracted by the low “chuck chuck” of a young hermit thrush. A whippoorwill in song.

In December at Mastic he notes four canvasbacks on the edge of the bay, a great horned owl hooting off in the woods at sunset, “a wild, weird sound.” On Staten Island he sees wintering chickadees and eagles drifting down the Hudson on ice floes.

In the 1920s Nichols drew on his journal notes to write a twice-weekly column on New York City’s natural history for the *New York Evening Post*. Characteristically, Nichols signed them only “The Naturalist.” After all, pieces entitled “A Mud Turtles Nest,” “A Little Kildeer,” “The Spring Canker Worm,” and “What Fish Eat” would not have been considered the work of a serious scientist.

“One reason that my father never received the credit due him was that the emphasis in science was shifting,” says David Nichols, professor emeritus of psychology at the University of Colorado. “When he began, natural history was not yet organized and specialized, so he could give his attention to birds, mammals, plants, reptiles, fish, and the relationships among them. Looking back on his material shows us what we’ve lost in specialization. He never got his doctorate and he did not specialize.”

The elder Nichols had such a dim view of formal education that even though he and both of his older sons received undergraduate degrees from Harvard and his daughter received a degree from Bryn Mawr, he took young David out of high school and got him a desk at the Museum, where he assisted in collections and took part in expeditions. (David was nearly lost on an expedition to Alaska when he decided to remain on his own after the main group departed. A friend with a seaplane eventually saved his life.)

David says, “My very earliest memo-

**At The American Museum**

**Identification Day**

Once a year, the American Museum of Natural History offers the public a unique opportunity to discover the names and histories of unidentified objects they have collected. This year, Identification Day will be held on Saturday, June 11, from 1:00 to 4:30 p.m. in the Dana Education Wing on the Museum’s first floor. Scientists from the departments of anthropology, entomology, invertebrates, mammalogy, and mineral sciences will be available to help solve the mysteries of found objects. The public is invited to bring animal or mineral specimens, with the exception of gemstones, to be examined by experts at no charge. For more information call (212) 769-5305.

**Middle East Month**

June is Middle East Month at the Leonard H. Pfeiffer Center. Each weekend, films, lectures, demonstrations, and performances will be presented from 1:00 to 4:30 p.m. Kadija al Nakhla will present a program of women’s dances and a hands-on demonstration of women’s traditional use of the veil. Slide lectures will be given on mythology in literature, religious and secular life in the Islamic world, the origins of the mosque, medieval Persian ceramics, the culture of Kurdistan, historical and contemporary impressions of Egypt, and the role of dance in Israeli culture. Performances will feature a one-woman show portraying Israeli women, as well as Kurdish and other dances. These programs are free and open to the public. For a complete schedule of events call (212) 769-5182.

**Spanish Dance**

The history of dance in Spain will be recreated by the Spanish Dance Society in the Main Auditorium at 7:30 p.m. on Thursday, June 16. Richly costumed performers will present classically oriented dances, traditional folk dances, and flamenco to live musical accompaniment. Dances of Celtic origin from Galicia in northwest Spain will be featured, as well as Moorish-influenced dances of southern Spain. The Spanish impact on Latin American dance styles will also be explored. Tickets are $5 for members and $8 for nonmembers. For more information call (212) 769-5600.

**Small Secrets**

Macrophotography is the art of photographing subjects that are too small for an ordinary camera but too large for a microscope. Macrophotographer and entomologist Arthur Gladstone will show his pictures of arthropods taken in their natural habitat, and his wife, Helen Worth, will illuminate his presentation with accompanying verse. The program, *Small Secrets: A Creature Garden of Verses*, takes place in the Kaufmann Theater on Thursday, June 2, at 7:30 p.m. Tickets are $3 for members and $5 for nonmembers. For more information call (212) 769-5600.
Nichols marked many mud turtles, but Klemens points out that there are no recent records of mud turtles from Mastic. Nichols himself apparently realized that when a hurricane in 1936 permanently opened up a gap in the barrier beach, the salinity of the streams changed and the mud turtles could no longer survive.

The journals refer to the calls of toads and frogs everywhere on the estate, but Richard Stavdal says he has yet to see any. David Nichols suggests their absence is due to the DDT sprayed on the property by the county's mosquito control commission in the 1950s. His father, he says, tried to stop the spraying. Stavdal says recent tests on some of the ponds on the property show residual levels of DDT.

This spring Stavdal will make the first concerted effort to round up all the surviving marked turtles at Mastic. As he drives from the old house in the direction of the bay, he points out how difficult his collecting will be now that woods have overgrown most of the open fields and streams tunnel through a thick briery understory before they empty into the marsh. On the marsh, the salt hay is still hard packed with winter ice and the view is obstructed to the Fire Island dunes—just as JTN would have seen them. (Since finding the first turtles, Stavdal always refers to Nichols as JTN.) Down this creek, sometimes in the thickest fog or worst gale, JTN would paddle his canoe Ardea (named for the genus of the great blue heron). A gaunt, stooped silhouette, pipe clenched between his teeth, he would pole across the mudflats, disembark, set out his stool, as he called his shorebird decoys, crouch in a dim blind of beach wrack and salt hay, and pencil his notes.

Mastic. Saturday, August 14, 1915.

The long afternoon hours pass away with occasional oystes and a few very occasional larger birds (probably lesser yellowlegs). At about 5:30 a flock of birds appeared from the direction of the eastward meadow flying low over the water in a compact bunch of about fourteen. As they passed swiftly by outside the stout the characteristic bunch-necked form proclaimed them dowitchers. Then suddenly they turned and showing here and there a white diamond back exploded over stool and into our very faces as though thrown from an invisible hand. Their pleasant twittering whistle sounded, and they were again on their westward way.

"I was with my father at the very end," recalls David Nichols. "He was working on some bird banding notes when he said his hand was tired and asked me if I could get him a pencil with a softer lead. I gave him one, he finished writing, set down his notebook, and closed his eyes."
Bread and Water, Spanish Style

Spain's cosmopolitan soup had humble beginnings

by Raymond Sokolov

M. F. K. Fisher once wrote, “I always see it that I have made too much gazpacho.” She later added an equivocal little headnote:

Within the past few years I have found myself involved in a discussion, esoteric as well as practical, about the correct way to make gazapcho. I still stay loyal to this recipe, while accentuating the fact that it, like rules for all good native soups, can vary with each man who makes it.

I have not made bold to press Mrs. Fisher about those former gazpacho debates from her early days as a food writer just after World War II. Her silence has, however, spurred me on to snoop about in the history and gastroethnography of this soup. I am here to report that in all of our Western culinary tradition, you will be hard pressed to find a dish with so ancient a lineage, so cosmopolitan an evolution, so diverse an identity. When Mrs. Fisher decided to stick by her cold, usually water-based soup of mixed herbs, tomato, onion, and cucumber, spiked with oil and lemon juice and sprinkled with bread crumbs (see below), she was midway between the dish’s origins as a Mediterranean bread salad and its current efflorescence as a breadless liquid salad, colored with tomato and filled out with almost anything else the chef fancies.

There are many gazachoes, and I have never, or almost never, tasted one I did not like. But if we are going to try to find out what this chameleon-like soup started out as, we had better go to Spain, which is its home base. More specifically, we must travel to the region of Andalusia, in the south of Spain, the non-Castilian, non-lisping point of entry for the invading Moors and for the exotic foods brought after 1492 from Las Americas. Andalusia is the world capital of gazpacho. And so it makes sense to look and see what an Andalusian cookbook has to say about this totemic soup.

I was not disappointed when I turned to Miguel Salcedo Hierro’s La Cocina Andaluza (1984). It is a long, literate, serious cookbook that contains no fewer than twelve recipes for gazpacho. Some have tomato, some do not. There is one based on fava beans and another on pine nuts. This is not a book influenced by the nouvelle cuisine; these are all traditional recipes collected by a hardworking traditionalist. So what makes them all gazpachos? What are the common traits of all these soups? They are: oil, vinegar, garlic, and bread. These ingredients are mashed and then diluted with water. Then seasonings and other flavorings are added. The soup is served cold.

Gazpacho is one of the ancestral soups of the Western world, a liquid food made from stale bread. The word soup itself shows this origin, since soup is an etymological first cousin of sop, a piece of bread soaked in liquid and then eaten. A soup, then, is a sop left to soak—and then mixed into the liquid as a thickener.

Gazpacho is obviously an example of a primitive peasant soup of a kind that must have originated over and over again in every place where there was bread. But Andalusian food is heavily permeated with exotic Moorish influences, and the word gazpacho looks as though it just might be an Arabic loanword, which is why Paula Wolfert convinced herself, in her book Couscous and Other Good Food From Morocco, that gazpacho comes from the Arabic for soaked bread. The notion was so persuasive that other American cookbook authors have repeated it. The etymology is wrong, and Wolfert now says she never meant to say gazpacho came from Arabic, only from the Arabic-speaking cooks who came to Andalusia and taught the locals to make a soup based on bread soaked in oil and vinegar and then diluted with water.

Investigation of this theory in medieval Arabic sources has found no support. The Near Eastern bread salad called fattoush did not, it seems, travel westward to North Africa. The Moroccan salads that Wolfert says reflect the Moorish ur-gazpacho contain tomato and green pepper, but no bread, whereas all of Salcedo Hierro’s gazpachos have bread in them. Only in America have we eliminated bread from gazpacho. Well, that’s not quite true. Penelope Casas says, in The Foods and Wines of Spain, that her gazpacho recipe (which is breadless except for croutons) comes from the recipe files of her Spanish mother-in-law, who claims that “most gazpachos contain too much bread and oil and consequently are unnecessarily heavy and fattening.”

In Portugal, apparently, they haven’t yet succumbed to counting calories, because the Portuguese gazpacho in Jean Anderson’s The Food of Portugal “contains so much bread,” the author says, “it qualifies as an açorda (dry soup).” Elsewhere she delineates three kinds of thick soups: açordas; the even thicker and drier migas (whose name means bread crumbs); and sopas secas. Here is a full gamut of bread-based soups that no one connects with the Moors.

In any case, the gazapacho—bread connection in Spain itself does seem very solid, and the connection with Arabic cookery nonexistent. All standard Spanish dictionaries include bread as an ingredient of the soup and none of them refers to an Arabic etymology. One dictionary sug-
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ggests that the word derives from the pre-Roman caspa, for “fragment,” meaning the bread crumbs and chopped vegetables that form the dish. Another translates gazpacho as the dregs or remnants of food preparation, a possible connection with the crumbs from stale bread. A third dictionary gives, as a secondary meaning of gazpacho, crumbs made by field hands from a torta cooked in hot coals. And a gazpachero, it says, was a farmhouse cook for hired hands.

None of this is conclusive evidence of a hard and fast etymology, but it certainly does support the notion of a rough peasant context in which day-old bread or its crumbs play a central role in people’s sense of the identity of gazpacho. I have not been able to date the first appearance of the word in a printed text or manuscript in Spanish, but all the evidence points to great antiquity, if not for the origin of the word itself, certainly for dishes all over the Mediterranean based on soaked bread. The oldest I have found is in the Old Testament.

You will recall what Boaz says to Ruth when he comes upon her gleaning among the sheaves (Ruth 2:14): “At mealtime come thou hither, and eat of the bread, and dip thy morsel in the vinegar.” Vinegar itself was apparently considered a healthy drink by Roman soldiers, according to Spartanus, the ancient biographer of Hadrian. They diluted it with water. And in the Gospel according to John, when Christ on the cross says, “I thirst,” a sponge soaked in vinegar is raised to his mouth, and after he received the vinegar, he “gave up the ghost.”

The Romans also liked to eat bread soaked in vinegar. Apicius gives recipes for salads in which vinegar-soaked bread, combined with seasonings and olive oil, is the central element. A version of this dish survives today in Italy. It is called pansarella, a combination of bread, salad, oil, and vinegar. To make soup of this salad required little more than water and, for finesse, some work with mortar and pestle. Recipes for a bread soup called pancotto are plentiful in the Italian repertoire. All of them are essentially stale bread boiled in water with oil and seasonings.

I give these ancient and Italian parallels because they show how easily gazpacho could have come to Spain with Roman legions and Roman settlers. The Italian influence on Spanish cookery reasserted itself in the sixteenth century, when the first printed Spanish and Catalan cookbooks began to come out and were either translations of Italian books or heavily influenced by Italian practice. But the basic food ideas that resulted in gazpacho might easily have evolved separately in Spain without help from the Latin-speaking invaders or from their descendants in Naples and Milan. Frugal peasants anywhere around the Mediterranean would have wanted to make use of stale bread. Soaking it in available liquids was an obvious solution, and depending on what and how much liquid you used, you had either salad or soup.

The special Spanish mark that separates gazpacho from other very plain garlic soups and gruels around the Mediterranean is that it is never exposed to heat, but is prepared raw and served cold. And before Columbus made it possible for Spanish cooks to put the tomato in their gazpachos, the dish took on local color with two ingredients contained in no other country’s soups: almonds and grapes.

The paragon of pre-Columbian gazpachos, an improbable but brilliant cold soup still popular in Spain, is a white gazpacho usually called ajo blanco, literally, “white garlic.” Medieval Spanish cookery is full of almond-flavored and almond-thickened dishes, and the counterpointing flavor of white grapes is also an idea far from anything we might come up with today. I highly recommend this soup, but I want to stress, despite its strangeness, at bottom it is really a gazpacho. It is thickened not only with ground almonds but also with stale bread.

Ajo blanco is a far cry from the post-Columbian gazpachos most of us know today. But it is probably the classic soup, the one that Cervantes mentions in Don Quixote. He makes it into a symbol of simple enjoyment. In Book II, chapter 53, Sancho Panza tires of being the governor of the island of Barataria. The main problem with his apparently exalted post is that every time he starts to eat something, an official called Dr. Recio snatches the dish from under Sancho’s nose, to protect his health. Sancho resigns, eloquently: “Make way, my lords, and let me return to my former liberty.... I would rather stuff myself with gazpachos than be subject to the misery of an impertinent physician who kills me with hunger.”

We don’t really know what Sancho meant by gazpachos. Probably he was talking about ajo blanco. But by the end of the sixteenth century, when Cervantes was writing Don Quixote, the tomato had long since arrived in Spain. So it is possible that Sancho’s gazpachos were red and not white. But it’s also worth noting that Sancho talks about gazpachos, plural. Could he mean not a soup at all but the crumbs and fragments and leftovers from which the soup takes its name? He is, after
all, retreating from a lordly banquet hall to the food of his lowly past. It may indeed make better sense of the passage to construe its meaning as, "I’d rather stuff myself with stale bread than die of hunger in the lap of luxury." The evidence just does not exist to decide this. We have no dates for gazpacho, either as an evolving word or an evolving dish. But we do know that today in Spain it refers to a family of cold, uncooked soups based on the ingredients of bread salad.

In the early sixteenth century, the tomato was naturalized in Spain and became the dominant ingredient in gazpacho. Before long the soup traveled back across the Atlantic to the tomato’s native hemisphere. Mary Randolph, in *Virginia Housewife* (1796), speaks of a gazpacho salad—greens, tomatoes, cucumbers, onions, bread crumbs, and salad dressing. According to *The Dictionary of American Food and Drink*, the first American printed recipe for a soup called gazpacho appeared in 1845.

It took more than a century and the arrival of the blender to popularize gazpacho as we know it in this country. Then, in less than a generation, the nouvelle cuisine seized on this simple salad of a soup and made it a metaphor of its former self. For a group of food writers juketing as the guests of Campbell Soup in 1984, chef Jeremiah Tower invented what he calls lobster gazpacho. It is essentially a purée of tomatoes, flavored with lemon and oil, chilled, and garnished with diced cucumber and bell peppers, as well as sliced, cold, cooked and shelled lobster pieces, chives, and three caviars, each a different color. That is not how they make soup at Campbell’s—or in Spain. All links with the past have been severed except olive oil (here its taste is modified by the addition of sesame oil). There is no bread, vinegar, or garlic. The original dish has been stood on its head and almost completely claimed for New World ingredients: tomatoes, peppers, and Maine lobster.

God bless America.

*Raymond Sokolov is a writer whose special interests are the history and preparation of food.*

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### Blanco de Ajo

*(Bread and garlic soup with grapes. Adapted from a recipe in Steven Raichlen’s *A Celebration of Seasons*, Poseidon Press)*

¾ pounds (3 cups) white seedless grapes
State French or Italian bread (in other words, any traditional, yeast-risen white bread)
3 ounces (¼ cup) blanched almonds
2–3 cloves garlic, peeled
Salt
Black pepper
¼ cup olive oil
2–3 tablespoons white vinegar

1. Stem the grapes and cut about one-third of them in half.
2. Pour 2 cups of cold water in a shallow bowl. Begin cutting away the crusts from the bread and add the decrusted pieces to the water until there is no more room for bread to be fully submerged. This is the best way to measure the quantity of bread, since loaf size varies. You can figure that a two-foot length of an average cylindrical French loaf will suffice. Just pluck the pieces in easily. Don’t force. Let the bread soak until softened.
3. Put the uncut grapes, the almonds, the garlic, and ¼ cup cold water in a food processor and process with the metal blade until almost smooth. Add the bread with its soaking water and process until almost smooth. Then add remaining ingredients, pouring in the oil and vinegar slowly while the motor is running.
4. Pour soup into a serving bowl. Stir in the cut grapes and chill until ready to serve. (The cut grapes, in my experience, do not float and therefore function as a decorative garnish, but as a charming surprise, adding variety to the overall gravy texture of the dish.)

Yield: Four servings

### M.F.K. Fisher’s Gazpacho

1 generous mixed handful of chives, chervil, parsley, basil, marjoram—any or all, but fresh
1 garlic clove
1 sweet pepper, pimento or bell
2 peeled and seeded tomatoes
1 small glass olive oil (or really flavorful nut oil or substitute)
Juice of 1 lemon
1 mild onion, sliced paper thin
1 cup diced cucumber
Salt and pepper
½ cup bread crumbs

Chop the herbs and mash thoroughly with the garlic, pimento, and tomatoes, adding the oil very slowly, and the lemon juice. Add about 3 glasses of cold water [I still say this is the correct liquid, but often I use good meat or fish stock] or as much as you wish. Put in the onion and the cucumber, season, sprinkle with bread crumbs, and ice for at least four hours before serving.

Yield: Four servings
High Five

In the swamp at Montezuma National Wildlife Refuge in Seneca Falls, New York, great blue herons build stick nests high in elm snags, on limbs that seem as delicate as those of the bird itself. Yet the nests hold up, cradling two to four eggs that hatch in late May, which is when this photograph was taken. These birds, which return to the nest at dusk to share parenting duties, are part of a colony that began with two nests in 1982 and has since grown to more than a hundred nesting pairs, some crowded five or six nests to a tree. Last year the rookery fledged 285 young. Still, no one at the refuge—flooded farmland that serves as a stopover for migrating waterfowl—is certain where the birds came from, just that each spring there are more great blue herons that share the rookery and leisurely fish for carp and bullhead in the refuge's shallow canals and impoundments. “They may have come from an area where the trees were cut down for development,” suggests refuge biologist Tracy Gingrich. “And when these trees finally rot out and fall, they'll have to move again.” —B.D.S.

Photograph by Steve Myers
Entomologist Peter H. Adler (page 34) has had an uninterrupted interest in insects since he was four years old, when he began collecting butterflies and moths and taping their wings to pieces of cardboard. An almost equally deep interest in birds caused a brief dilemma over what field to pursue after he graduated from Washington and Lee University in Lexington, Virginia. But insects carried the day, and Adler went on to earn a master’s in zoology and a doctorate in entomology from Pennsylvania State University. A love of the outdoors, especially mountains and streams, led to his choice of black flies as a subject of research. Now an assistant professor at Clemson University in South Carolina, Adler is also investigating feeding behavior, egg-hatching, cannibalism, and interaction with parasites in the corn earworm, a caterpillar that feeds on food crops and cotton. For those who want to learn more about the aquatic community in streams, he recommends Aquatic Entomology: The Fishermen’s and Ecologists’ Illustrated Guide to Insects and Their Relatives, by W. Patrick McCafferty (Boston: Jones & Bartlett Publishers Inc., 1981).

Bats were the subjects of Ken N. Paige’s (page 49) first research project: investigating how barometric pressure enables them to track insect prey. But a course in ecology suggested to him that plants might have as dynamic a life as animals and he took to the field looking for proof. Scarlet gilia turned out to be a better subject than he imagined, and his studies of the plant on Fern Mountain, begun in 1981 when he was a doctoral student at Northern Arizona University, continue to produce new findings. He is now a research assistant professor at the University of Utah and in late summer will join the faculty of the Institute for Environmental Studies at the University of Illinois. Although most of his time is spent studying plants, he still takes time out to net bats and explore their caves. For reading on plant adaptations, Paige recommends The Sex Life of Flowers, by B. Meeuse and S. Morris (New York: Facts on File, Inc., 1984).
Mikael Sandell (page 54) received his doctorate in 1985 from the University of Lund, Sweden, and has been working as a research assistant at the university since then. Next month, however, he will start a new position as an associate professor in the Department of Wildlife Ecology at the Swedish University of Agricultural Sciences in Umeå. Sandell is continuing his studies of the mating tactics of solitary mammals, working mainly with small rodents these days. Although he is interested in all mammals, he has a soft spot for carnivores and hopes to turn his research attention back to them soon. When not tracking living animals, Sandell enjoys pursuing them elsewhere, browsing in antiquarian book shops for old zoological literature. More information about weasel ways is in pages 108-33 of David Macdonald’s Encyclopedia of Mammals (New York: Facts on File, 1984) and in a November 1974 Natural History story: “The Graceful and Rapacious Weasel,” by E. Raymond Hall. One of the stoat’s larger relatives is the subject of Fishers: Life History, Ecology, and Behavior, by Roger A. Powell (Minneapolis: University of Minnesota Press, 1982).
Born and raised in Iceland, which has about two hundred volcanoes, Haraldur Sigurdsson (page 66) was doing what came naturally when he decided on volcanology as a career. He has investigated at least fifteen volcanoes around the world and has written about several of them for *Natural History*. Sigurdsson (right) earned a doctorate in geology from the University of Durham in England, and although remaining an Icelandic citizen, he has resided in the United States since 1974. When not on the rim of a volcano or inside one, he teaches at the Graduate School of Oceanography at the University of Rhode Island. Coauthor Steven Carey (left), also on the staff of the university, earned a doctorate in marine geology there. His interest in Tambora was an outgrowth of theoretical work he had done on "the fallout of volcanic ash from explosive eruptions." Indonesian geologist Rizal Erfan (center) was another collaborator on the Tambora research. For readers whose curiosity about Tambora has been aroused, the authors recommend *Volcano Weather: The Story of 1816, the Year Without a Summer*, by Henry Stommel and Elizabeth Stommel (Newport: Seven Seas Press, 1983). For information about volcanoes in general, there is *Volcanoes*, by Peter Francis (New York: Pelican Books, 1976).

Since birds are loath to pose for pursuing photographers, Steve Myers resorted to shooting from a truckblind with a high-powered lens (a Nikor 600-mm F-4 Supertelephoto) to get the great blue herons returning to their roosts ("The Natural Moment," page 84). Although long known for his studio photography—Myers shot the bowl of corn flakes and strawberries on the Kellogg cereal box—he began working as a photojournalist for *New York Magazine* twenty years ago and has recently turned his camera toward environmental issues. Myers says his work at the American Museum of Natural History photographing Northwest Coast Indian art for the Museum's new book *From the Land of the Totem Poles* inspired him to do more work in the field. He now ventures out as often as he can from his home and studio in Almond, New York.
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Cover: The rare and elusive tiger (shown in an Indian zoo) is the subject of a new book, Tiger Moon, reviewed on page 72. Photograph by Fiona Sunquist.
Carthaginian Cannabis

I am a hand spinner and weaver with a special interest in cellulose fibers. Flax, stinging nettles, and hemp are all bast fibers (from the stems of plants) with similar morphologies and other properties that are difficult, if not impossible, to differentiate when found in situations such as the site of the Punic ship ("How Carthage Lost the Sea," December 1987). These three fibers were spun, then woven into fabric or twisted into cordage at least 3,000 years before the First Punic War. Of the three, hemp is particularly resistant to degradation by salt water, and so is commonly used at sea. Today the word canvas, a variant of cannabis, which once meant sailcloth of hemp, persists in our everyday language.

Very likely the Punic ship left Carthage caulked with oakum made of hemp, rigged with hempen sails and shrouds, perhaps even manned by sailors clad in hempen loincloths and tunics. As late as the nineteenth century, ships' crews included fiber craftsmen—artisans who spun, knotted, netted, knitted, wove, sewed, and made rope. There was more reason to stow hemp fibers on a vessel than the "tot of pot" suggested by Honor Frost. Take Herodotus with a grain of salt. He was more a spinner of fantasy than a historian, especially in matters pertaining to textile fibers. Among other misinformation, he claimed that cotton trees grew miniature sheep that nibbled all the grass within reach, then died and gave up their wool, a tale that caused cotton to be called tree wool in much of Europe.

Caroline T. Miller
Minneapolis, Minnesota

Editor's Note: According to Honor Frost, author of the article and investigator of the Punic wreck, rope was found on the ship, but all of it was made, not from hemp, but from a type of grass. The two small baskets of cannabis on board would not have been suitable or sufficient for rope making.

The Beautiful Winter Banana

In the March 1988 issue of Natural History, Raymond Sokolov wrote for-

lornly of the paucity of apples of yester-
year. A focus of his discussion was an apple named Winter Banana. Having never sampled that "all but vanished taste," Mr. Sokolov wonders if it is "worth the trouble." I am writing to tell him that it is and that the apple is readily available at the Ann Arbor, Michigan, Farmers Market every fall and early winter. Some may wonder that he has not previously taken his search to Ann Arbor, a town that is modestly believed by many of its residents to be the center of the nation.

The description given of the flavor of the Winter Banana in the article was most accurate, but for me, its great appeal is in its appearance. The combination of the soft yellow and pastel red is most pleasing. Although there are other apples whose tastes I prefer, I often purchase Winter Bananas just to look at.

Lee Burton
Brighton, Michigan

Big and Not-So-Big Cats

Tangling with big cats is indeed risky business. However, in "Leopard Killers of Mahale" (March 1988), Richard and Jennifer Byrne overstate the degree of risk to the chimps they watched by failing to mention that leopards exhibit pronounced sexual dimorphism in anatomy and behavior. Thus, the besieged female leopard at Mahale certainly weighed much less than the 200 pounds the authors allude to. Even males rarely exceed 160 pounds. Based on size alone, a 70- to 90-pound male chimp is a much more even match for a female leopard than your readers were led to believe. Several male chimps easily present a mismatch.

Likewise, hominoid killing is almost exclusively the domain of male leopards. Peter Turnbull-Kemp reports in his book The Leopard that 94 percent of 152 known man-eaters were males, and I know of no evidence to suggest that females are any more likely to prey on adult chimps or gorillas. Therefore, the Byrnes' indirect reference to hominoid killing by leopards as a measure of risk seems inappropriate.

Nevertheless, these clarifications do not detract from the Byrnes' point that "early hominoids, too, could have successfully tangled with big cats"—one of the primary insights derived from their exciting observations.

Joseph P. Skorupa
Department of Anthropology
University of California, Davis

Winter Banana

From The Apples of New York, N.Y. Botanical Garden
In a land far away, amidst the lush green serenity of the forest, stands a sacred temple, around which blooms a tranquil Oriental garden. Gentle birds lace in and out of the branches, the sound of their flight adding harmony to the scene. A mulberry tree, laden with its fruit, hangs gracefully over a still pond. Above the walk bridge are two "Doves of Fidelity," revered symbols of enduring love and faithfulness.

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The Marriage of Yongsu’s Mother

A Korean woman tells her tale of disappointment

by Laurel Kendall

The most nerve-wracking days came early in anthropological fieldwork. My assistant and I went from door to door in Enduring Pine Village, administering a routine questionnaire. How many people live in this house? What are their ages? We asked about childbirth, miscarriages, and abortions; about spirit possession, exorcisms, and divinations. We took great pains to explain the purpose of the survey, which was to compile background information on family life and women's experiences in this Korean community. But our carefully rehearsed and excessively polite introductions did not lull my own discomfort at intruding upon the lives of busy countrywomen. We were still seeking the least offensive way to ask our questions and struggling to make sense of the things that we were told.

In the lingering April dusk, we went to Yongsu’s Mother’s house because we needed a lift, and this would be an easy interview. I had already spent more than a month in the company of this mansin, or “shaman,” observing her at divination sessions and rituals. She knew that my work included a barrage of questions, and I knew that she loved to talk. She fielded our queries with an air of amusement, prompting my giggling assistant to conduct the interview as if it were a parody.

“Do you practice birth control?”

“Am I a chicken? Can I lay eggs without a mate?”

The anthropologist and her assistant were an appreciative audience, a sympathetic audience, and the mansin would give us more than the routine answers our tedious questions solicited. She told us about the little sister who had contracted smallpox. To entertain and propitiate the smallpox spirit, the family held a kut, an elaborate ritual in which all of the family’s gods and ancestors appear and speak in the person of the costumed, possessed shamans. The shamans jumped up and down on the porch with such enthusiasm that the floorboards caved in. When the smallpox spirit visits the house, nails should not be driven into wood. But her father ignored the prohibition and repaired the broken porch, and the sick child went blind. They searched for the nails, found one, pulled it out, washed it, and the little girl regained sight in one eye. Still, she remained sickly and soon died, cradled in her elder sister’s arms.

Yongsu’s Mother keeps the little girl’s spirit with the gods and ancestors in her shrine. When she performs a kut to feast and entertain her own gods, she ties a child’s brightly colored skirt and jacket to the belt of the costume she wears to summon the Special Messenger, the smallpox spirit. Her dead sister comes to the kut in the god’s entourage; I would meet her at a kut later that spring. Speaking through the lips of a possessed mansin, she would announce herself as a princess and claim that she had come to play.

From the loose threads of the survey questions, Yongsu’s Mother began to spin bits of tales, constrained and abbreviated by the structure of our interview and the list of questions yet to be posed. When we asked about marriage, the dam burst and the words poured out, rising and falling until the tale was told:

It was market day, I can never forget it. We’d been boiling beans to make soy sauce. I was dressed up in a yellow jacket and a pink skirt, silky stuff, the best you could get back then. I had on my best Korean dress and fresh white stockings. I thought I’d go down and see what the Willow Market was like, and I was on my way out of the gate when a man and a woman arrived. The man asked me, “Is your elder sister home?” I just bawled back, “Sister, someone’s here!” She came bustling out to greet them and took them straight to our mother’s room. I told Mom I was going out, but she sent me to stoke the fire under the beans.

I kept tossing twigs into the flames while my sister, behind the paper door, kept saying, “Yes, yes, yes.” I stuck my head in and asked, “What’s going on?” She told me to get them some noodle soup from the Chinese restaurant. I asked, “What about me?” “You can do as you like.” So I went and ordered their noodle soup, and when the restaurant boy delivered it, I set it on a tray with some kimchee and shouted in, “Here’s the noodles!” My sister told me to come in and sit down. I just plopped the tray down and trudged back outside. I didn’t think anything of it, didn’t realize they’d come to look me over. I thought that they had come to see my sister and I’d just brought them some noodles for lunch. The man sat by the desk with a handkerchief on his lap and he looked very old. I remembered that afterward. I’d just walked in and out when I brought the noodles.

My sister called for me to take away the tray, so I went back in. That guy hadn’t eaten more than three mouthfuls. I took his noodles out to the kitchen to save for later. When my mother came out, I asked

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her if I could go to the market. She said, “What’s all this about going to the market? Where’s the money?” I told her I had money, and she asked me where I’d kept it hidden. There wasn’t anything to buy out in the country anyway. I just wanted to have a look around.

The man was ready to leave, and every one stood around saying their goodbyes. I stayed in the kitchen, but as soon as the man left, the matchmaker came looking for me. She said she wanted to have a talk. I told her I was going to the market. She said, “You come right over here and tell me what you think of that guy.”

“What do you mean?”

“He’s looked over you and you please him. Just say the word and it’s settled.”

I was flabbergasted. “What nonsense is this? Who says I want to get married? Anyway, I wouldn’t marry an old guy like that. Don’t even say such things!”

The matchmaker went right back into my sister’s room. I wasn’t in the mood for the market anymore. I waited for the matchmaker to come out and she started in again, “Tell me what you thought of that guy, just say the word. He’s all right, isn’t he?”

I howled that I couldn’t go through with it. I told them, “Do you think I can’t find a husband anywhere? Do you think I have to settle for an old guy like that? I’m going back to Seoul.”

Then my sister raised a fuss. “You’re so stubborn. With your wretched horoscope, you should marry an older man, someone who’s already been married once. I’m your sister. Do you think I’d arrange something that was bad for you?”

When she said that, I was so furious I couldn’t hold it in, I ran to the chimney behind the house and sobbed. “She brought us down here because she was lonely. She’s made us sell our house. Why is she doing this to me? When the right time comes, I’ll gladly get married. Why do they have to marry me off to an old guy?” I raged and cried, and raged some more….

We passed into the twelfth month, the empty time that we don’t consider part of the old year. About five days before the wedding, the man gave my sister some money for my permanent and bride’s makeup. I took the money and threw it on the ground. “What does this have to do with anything? Does he think I haven’t gotten married because I can’t afford to permanent my hair?” My sister tried to coax me, but this threw me into a deeper rage. “If I’m set against him, why are you all so anxious to throw me out like this? If our ages were similar it would be all right, but he’s old. If you’re so keen on this marriage, why not go and investigate him? Do you expect me to marry someone who lives so far away on just the strength of the matchmaker’s words?”

“The matchmaker knows the whole story. How come you’re so suspicious?”

After the wedding, I left Willow Market with him and cried all the way on the bus. My eyes were swollen. It must have been embarrassing for him.

We got to the Imjin River. That was as far as the bus would go. We needed passes to board the boat, but I said I didn’t have one. We had a huge fight right there on the dock. Here I was, all done up in a Korean dress made of silk from Hong Kong, and the angrier I got, the more I wanted to throw myself into the river. By the time my husband had cleared things with the guards and dragged me away to the boat, my feet were frozen stiff. On the other side there was another checkpoint. The guard asked me, “Auntie, do you have a citizen’s identification card?” This time I just slipped out my Seoul registration card, showed it to the guard, and walked on through.

As we reached the far side of the river, someone rode up on a bicycle, parked it on the sand, and pulled in the boat. I thought it was just another passenger going to cross the river, but when I looked I saw that he resembled my husband. I’d heard that he had six brothers so I just assumed that this was one of them, but when I asked my husband, he denied it, said it was a distant relation. Even on the way to his home he lied to me.

We walked and walked. My feet swelled up like balloons. I wasn’t used to walking. Finally, we came to the village. A girl emerged from one of the houses and threw out a basin of dishwater. She gave me the strangest look. In some odd way she seemed to resemble my husband. She was standing in front of a straw-roofed house, a tumble-down house. It was falling apart at the seams. I hoped with all my might that we would not turn into that house. I followed behind my husband with my eyes cast down to the backs of his shoes. His feet turned into that very gateway. Could he just be stopping by? No such luck. As soon as we were inside the gate, I heard, “Daddy’s home, Daddy’s home!” Despair!

I stood there in the gateway, stunned. I heard them ask me, over and over again, to come in. There was a three-year-old boy, a little frog baby looking mischievous, and a nine-year-old daughter, the one who works in Seoul now. There was also a twenty-one-year-old daughter; I was barely five years older than her. I thought she was my husband’s niece. I thought that she had just come over to help with the housework.

They kept asking me to come inside, so I went in and looked things over. It was laughable. The house was bare. The cupboard held one battered little dish for shrimp sauce. Oh, I was disappointed! I just stood there in the empty kitchen until my husband took me by the hand and led me to the inner room. It was a sorry show there too, only a wooden chest and some quilts piled up. I cursed my sister! Why did I deserve this? That bitch! I had told her to check everything before she married me off. I cried and cried. I couldn’t stop. My husband said, “What’s done is done. You won’t get anywhere by crying about it.” But I was fuming. If my sister had lived nearby, I’d have gone right over and grabbed her. I’d have dragged her there and said, “Feast your eyes on this!”

But I didn’t know the way back; I had never been in this village before.

The older girl brought in a tray of food. All of the relatives came over. The elder brothers’ wives and the elder cousins’ wives served the food—rice, toasted seaweed, and kimchee. Since it was the twelfth month, we ate winter kimchee. They kept asking me to eat and I kept saying that I didn’t want any. They asked and I refused, again and again. That person, my husband, couldn’t eat either. When the elder brother’s wife came in and begged me to eat, I had a few mouthfuls just to make them happy.

Then I had to bow to them all. The room was full of people; they swarmed around like maggots. I had no idea who they were. There were relatives to the third degree and relatives to the fourth degree. I was dropping down to the floor and bobbing up all night. Finally, the third brother’s wife said, “She’s had a long journey. She must be tired. Those who haven’t received her bows can come back tomorrow.” My husband told them that my feet were swollen.

After everyone left, that man, my husband, went outside too. The brothers’ wives were fixing a late-night snack. The girl came into the room to get something. She looked at my hand and said, “What a lovely hand!” She asked how old I was. My husband had told me to say that I was thirty-six but I told the truth, “I’m twenty-six.”

The girl started, “Twenty-six?”

The elder brother’s wife said, “Your skin is still soft like a baby’s. With such a lovely face and hands, how can you do a countrywoman’s work?” They said, “Your ages are too far apart.” They chattered on about how young I was and how old he was while I just sat there. The girl came back
I nodded.

The brother’s wife explained, “My husband’s brother is forty-one.” Now it dawned on me that this girl was my husband’s daughter. I thought, “It will be difficult enough to raise my own children, but how am I ever going to raise these?”

It was already one o’clock in the morning. They rolled out the quilts and told me to rest. My husband came in and sent them all home so I could sleep. He went out to see them off and came back. I couldn’t even cry. I just sat there without a word. He came over and tried to take off my jacket. When he reached for the ribbon, I slapped his hand away. I said, “You should have told me the truth. You should have told me that you’re forty-one years old and have a twenty-one-year-old daughter. After lying like this, how dare you put your hand to my body!”

Now he was angry. “Who told you that?” But then he said, “Don’t worry about my daughter. I’ll just marry her off. If I said I had so many daughters, they wouldn’t have given you to me. I lied about that, but I really am thirty-seven.”

I said, “All right, tomorrow we’ll go to the district office and just see how you’re registered. I’ve come all this way. If you turn out to be thirty-seven, I’ll stay, but if that’s not so, I’m leaving.”

I didn’t sleep. I held my ground all night. Whenever he reached out to touch me, I slapped his hand away. What could he do? He sat there smoking. He offered to help me take off my padded socks because my feet were sore. I said, “If my feet hurt, that’s my business. You leave me alone.”

In the morning, the older daughter fixed breakfast and the elder brother’s wife came over to help. I stayed in the inner room. When the nine-year-old girl brought water for me to wash my face, she said, “How can this person be my mother?” My husband hit her. He scolded her in a loud voice that all the relatives could hear. It did not bode well for a daughter to be disrespectful to her new stepmother.

They brought in the breakfast tray and again I said that I wasn’t going to eat. I hadn’t eaten anything for so long that my eyes were turning back inside my head. My husband went out and spoke to his brother’s wife. She came in and coaxed, “Since you’re here, you might as well eat something. Here, let’s eat together.” I could have eaten everything on that tray, but I just had a couple of spoonfuls. When she took out the tray, I heard my husband

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ask how I was. I sat in the room all day without saying a word. He fretted and paced back and forth, back and forth. I can still hear the sound of his feet. He was worried that I might run away.

Hours had passed as Yongsu's Mother narrated the tale of her wedding, a saga well polished by countless retellings for audiences of village women and clients. We were summoned to a late dinner while she hastened to cook up the evening rice for herself and Yongsu. We returned again in the evening and listened into the night. She told us how her elder stepdaughter ran away in rebellion and how, as a consequence, her husband began to drink himself to death in shame; how "that man" left her a widow when her own son, Yongsu, was barely a year old; and how she had been forced to survive on slim resources until, a few years later, the gods made her a shaman. Later, when we had translated all that we had heard and recorded, we knew that we were hooked, avid to hear more. Not only did Yongsu's Mother provide a rich ethnographic narrative, she was also a skilled storyteller, rendering her images with delicious turns of phrase. Her feet swelled up like balloons. She kept stoking the fire while her sister kept saying, "Yes, yes, yes." She modestly lowered her gaze to the backs of her husband's feet and saw them turn into the doorway of the hovel that would be her new home. She remembered details: the handkerchief on her future husband's lap, the pot of boiling beans, the half-eaten bowl of noodles, the basin of water in her stepdaughter's hands.

I toyed with the idea of recording a full biography, but was soon preoccupied by my research on shaman rituals. My assistant, who had relished the task of translating Yongsu's Mother's vivid language, left the field when she landed a promising job in Seoul. But Yongsu's Mother took the initiative, announcing that she would tell me the full story of her life. She had already mapped out the narrative: "The story of my childhood and of my father's taking a concubine, the story of my capture and escape during the war and my meeting with the Mountain God, the story of my lover and the birth of my daughter, the story of my marriage, and the story of my becoming a mansin." She told me that when I knew it all my tears would flow. The recurrent themes of her life had already been sounded in the initial interview: betrayal by kin, disappointment in human relationships, the bother and ingratitude of stepchildren, and the power of gods and ancestors to alter human destiny for good or ill.

I suspect that Yongsu's Mother often exaggerates, both to vindicate herself and also to heighten the drama of her performance. Hers is a melodramatic account, told among people who appreciate the purgative value of a good cry. This is not to say that she consciously deceives her audience, but rather that she plays her material for all it's worth. When she told us the story of her marriage, she re-created the innocent maiden of a fairy tale, oblivious to the machinations of a greedy sister who was sealing her fate behind closed doors. But how naïve could she have been? Not only was she twenty-six years old when she married the widower, she had already given birth to an illegitimate child. By the bitter standards of her own society, the bride was past marrying age and damaged goods besides. The scheming sister might rather have tried to make the best of her younger sibling's limited options. And although Yongsu's Mother protested every inch of the way to her husband's house, once there she recognized her lack of alternatives, cut her losses, made a life, and spun out her anger in a tale. Her art was to make old disappointment a good story.

I first heard Yongsu's Mother's account of her marriage in the spring of 1977. I returned in 1985 to tell her that I had finally translated the story of her life, to see if she was still willing to have me publish it, and to ask her help in completing the manuscript. I brought her a copy of my first book, inscribed "to my mansin honorable teacher," and heard her cap a discussion with "I've even come out in a book in America." But days passed before I could explain to Yongsu's Mother the real purpose of my visit. I wanted to be certain that she understood what I was about, and I wanted to discuss this project in privacy. This last condition was difficult to achieve in her sociable inner room, but one afternoon, when the last guest had departed and just before her son, Yongsu, returned home from another date, I brought out one of the old tapes and slipped it into my machine.

"You still have those old things," I tell her about the translations and about the book I plan to publish. "But in America, what if Koreans read it? They'll think it's shameful." Her world has broadened. When I first knew her, America was on the other side of the earth, the home of the odd-complexioned soldiers who ran in formation on the road by her house, a land she had seen in movies. In 1985, America is where her brother and the kin of her neighbors live, a place where Koreans live. Appreciating her concern, I take a deep breath. I want to protect her and perhaps it is safest to abandon the project, but I also want her to know the worth of her storytelling.

"Americans won't find it shameful; they'll think it's interesting, as interesting as a novel." "As interesting as a novel," she repeats the phrase to herself. "It has social and historical significance," I continue, using a Korean vocabulary that I read rather than speak, the words that do not ordinarily enter village conversation. "Of course, there are people who are incapable of understanding. I know this. I don't want any harm to come to you or Yongsu. As I have done in the past, I will try to keep your name a secret. In the book I've called you 'Yongsu's Mother.' When my friends from Seoul came here for the kut the other day, they kept asking, 'Where's Yongsu's Mother?'" She laughs, and agrees to help me.

I was leaving again. About to depart for a kut with her closest friend and colleague, Songjuk Mansin, Yongsu's Mother presented me with some Korean accoutrements for my American kitchen. She gave me a pair of covered rice bowls—a high chubal, such as men use, and a woman's short, broad hap—and a large rice pot, and then a smaller one, "so that your husband can cook rice when you are away." She saw the very un-Korean premise of my married life and was amused.

"What's her husband like?" Songjuk Mansin asked Yongsu's Mother.

"Nice, steady-going," she said, and told a story from our visit in the summer of 1983. "It was the middle of the day, no one was around. I heard a faint splashing sound in the bath...I tiptoed in...And there was the husband doing the laundry!" The prospect of my husband quietly doing laundry to surprise his absent wife was an image so droll as to provoke extended gales of laughter.

"And this," she said, returning to her bag of gifts and drawing out the gourd dipper that I had requested to replicate a birth charm for the American Museum, "this has historical significance. Why, people used to eat their rice out of these. We did that when we visited my grandfather in the country."

"Historical significance." She had taken my words because they intrigued and pleased her. She has observed my life and now tells stories about my household as I tell stories about her telling stories.

Laurel Kendall is an associate curator in the Department of Anthropology of the American Museum of Natural History. Her previous book was Shamans, Housewives, and Other Restless Spirits: Women in Korean Ritual Life.
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Kropotkin Was No Crackpot

Under the spell of his homeland, a peace-loving Russian anarchist argued cogently against a narrow Darwinian view of evolution

by Stephen Jay Gould

In late 1909, two great men corresponded across oceans, religions, generations, and races. Leo Tolstoy, sage of Christian nonviolence in his later years, wrote to the young Mohandas Gandhi, struggling for the rights of Indian settlers in South Africa:

God helps our dear brothers and co-workers in the Transvaal. The same struggle of the tender against the harsh, of meekness and love against pride and violence, is every year making itself more and more felt here among us also.

A year later, wearied by domestic strife, and unable to endure the contradiction of life in Christian poverty on a prosperous estate run with unwelcome income from his great novels (written before his religious conversion and published by his wife), Tolstoy fled by train for parts unknown and a simpler end to his waning days. He wrote to his wife:

My departure will distress you. I'm sorry about this, but do understand and believe that I couldn't do otherwise. My position in the house is becoming, or has become, unbearable. Apart from anything else, I can't live any longer in these conditions of luxury in which I have been living, and I'm doing what old men of my age commonly do: leaving this worldly life in order to live the last days of my life in peace and solitude.

But Tolstoy's final journey was both brief and unhappy. Less than a month later, cold and weary from numerous long rides on Russian trains in approaching winter, he contracted pneumonia and died at age 82 in the stationmaster's home at the railroad stop of Astapovo. Too weak to write, he dictated his last letter on November 1, 1910. Addressed to a son and daughter who did not share his views on Christian nonviolence, Tolstoy offered a last word of advice:

The views you have acquired about Darwinism, evolution and the struggle for existence won't explain to you the meaning of your life and won't give you guidance in your actions, and a life without an explanation of its meaning and importance, and without the unfailing guidance that stems from it is a pitiful existence. Think about it. I say it, probably on the eve of my death, because I love you.

Tolstoy's complaint has been the most common of all indictments against Darwin, from the publication of the Origin of Species in 1859 to now. Darwinism, the charge contends, undermines morality by claiming that success in nature can only be measured by victory in bloody battle—the "struggle for existence" or "survival of the fittest" to cite Darwin's own choice of mottoes. If we wish "meekness and love" to triumph over "pride and violence" (as Tolstoy wrote to Gandhi), then we must repudiate Darwin's vision of nature's way—as Tolstoy stated in a final plea to his errant children.

In a way, the charge against Darwin is unfair for two reasons. First, nature (no matter how cruel in human terms) provides no basis for our moral values. (Evolution might, at most, help to explain why we have moral feelings, but nature can never decide for us whether any particular action is right or wrong.) Second, Darwin's "struggle for existence" is an abstract metaphor, not an explicit statement about bloody battle. Reproductive success, the criterion of natural selection, works in many modes: victory in battle may be one pathway, but cooperation, symbiosis, and mutual aid may also secure success in other times and contexts. In a famous passage, Darwin explained his concept of evolutionary struggle (Origin of Species, 1859, pp. 62-3):

I use this term in a large and metaphorical sense including dependence of one being on another, and including (which is more important) not only the life of the individual, but success in leaving progeny. Two canine animals, in a time of dearth, may be truly said to struggle with each other which shall get food and live. But a plant on the edge of a desert is said to struggle for life against the drought... As the mistletoe is disseminated by birds, its existence depends on birds; and it may metaphorically be said to struggle with other fruit-bearing plants, in order to tempt birds to devour and thus disseminate its seeds rather than those of other plants. In these several senses, which pass into each other, I use for convenience sake the general term of struggle for existence.

Yet, in another sense, Tolstoy's complaint is not entirely unfounded. Darwin did present an encompassing, metaphorical definition of struggle, but his actual examples certainly favored bloody battle—"Nature, red in tooth and claw," in a line from Tennyson so overquoted that it soon became a knee-ner cliché for this view of life. Darwin based his theory of natural selection on the dismal view of Malthus that growth in population must outstrip food supply and lead to overt battle for dwindling resources. Moreover, Darwin maintained a limited but controlling view of ecology as a world stuffed full of competing species—so balanced and so crowded that a new form could only gain entry by literally pushing a past inhabitant out. Darwin expressed this view in a metaphor even more central to his general vision than the concept of struggle—the metaphor of the wedge. Nature, Darwin writes, is like a log with 10,000 wedges hammered tightly in along its entire length. A new species (represented as a wedge) can only gain entry into a community by driving itself into a tiny chink and
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forcing another wedge out. Success, in this vision, can only be by direct takeover in overt competition. (Darwin often describes ecological replacement by the term "wedging.")

Furthermore, Darwin's own chief disciple, Thomas Henry Huxley, advanced this "gladiatorial" view of natural selection (his word) in a series of famous essays about ethics. Huxley maintained that the predominance of bloody battle defined nature's way as nonmoral (not explicitly immoral, but surely unsuited as offering any guide to moral behavior).

From the point of view of the moralist the animal world is about on a level of a gladiator's show. The creatures are fairly well treated, and set to fight—whereby the strongest, the swiftest, and the cunningest, live to fight another day. The spectator has no need to turn his thumbs down, as no quarter is given.

But Huxley then goes further. Any human society set up along these lines of nature will devolve into anarchy and misery—Hobbes's brutal world of bellum omnium contra omnes (where bellum means "war," not beauty): the war of all against all. Therefore, the chief purpose of society must lie in mitigation of the struggle that defines nature's pathway. Study natural selection and do the opposite in human society:

But, in civilized society, the inevitable result of such obedience [to the law of bloody battle] is the re-establishment, in all its intensity, of that struggle for existence—the war of each against all—the mitigation or abolition of which was the chief end of social organization.

This apparent discordance between nature's way and any hope for human social decency has defined the major subject for debate about ethics and evolution ever since Darwin. Huxley's solution has won many supporters—nature is nasty and no guide to morality except, perhaps, as an indicator of what to avoid in human society. My own preference lies with a different solution based on taking Darwin's metaphorical view of struggle seriously (admittedly in the face of Darwin's own preference for gladiatorial examples): nature is sometimes nasty, sometimes nice (really neither, since the human terms are so inappropriate). By presenting examples of all behaviors (under the metaphorical rubric of struggle), nature favors none and offers no guidelines. The facts of nature cannot provide moral guidance in any case.

But a third solution has been advocated by some thinkers who do wish to find a basis for morality in nature and evolution. Since few can detect much moral comfort in the gladiatorial interpretation, this third position must formulate the way of nature. Darwin's words about the metaphorical nature of struggle offer a promising starting point. One might argue that the gladiatorial examples have been oversold and misrepresented as predominant. Perhaps cooperation and mutual aid are the more common results of struggle for existence. Perhaps communion rather than combat leads to greater reproductive success in most circumstances.

The most famous expression of this third solution may be found in Mutual Aid, published in 1902 by the Russian revolutionary anarchist Petr Kropotkin. (One must shed the old stereotype of anarchists as bearded bomb throwers furtively stalking about city streets at night. Kropotkin was a genial man, almost saintly according to some, who promoted a vision of small communities setting their own standards by consensus for the benefit of Tolstoy

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all, thereby eliminating the need for most functions of a central government.) Kropotkin was a Russian nobleman, living in English exile for political reasons. He wrote Mutual Aid (in English) as a direct response to the essay of Huxley quoted above, “The Struggle for Existence in Human Society,” published in The Nineteenth Century, in February 1888. Kropotkin responded to Huxley with a series of articles, also printed in The Nineteenth Century and eventually collected together as the book Mutual Aid.

As the title suggests, Kropotkin argues, as his cardinal premise, that the struggle for existence usually leads to mutual aid rather than combat as the chief criterion of evolutionary success. Human society must therefore build upon our natural inclinations (not reverse them, as Huxley held) in formulating a moral order that will bring both peace and prosperity to our species. In a series of chapters, Kropotkin tries to illustrate continuity between natural selection for mutual aid among animals and the basis for success in increasingly progressive human social organization. His five sequential chapters address mutual aid among animals, among savages, among barbarians, in the medieval city, and amongst ourselves.

I confess that I have always viewed Kropotkin as daftly idiosyncratic, if undeniably well meaning. So is he always presented in a standard course on evolutionary biology (if he is mentioned at all)—as one of those soft and woolly thinkers who let hope and sentimentality get in the way of analytic toughness and a willingness to accept nature as she is, warts and all. After all, he was a man of strange politics and unworkable ideals, wrenched from the context of his youth, a stranger in a strange land. Moreover, his portrayal of Darwin so matched his social ideals (mutual aid naturally given as a product of evolution without need for central authority) that one could only see personal hope rather than scientific accuracy in his accounts. Kropotkin has long been on my list of potential topics for an essay (if only because I wanted to read his book, and not merely mouth the textbook interpretation), but I never proceeded because I could find no larger context than the man himself. Kooky intellects are interesting as gossip, perhaps as psychology, but true idiosyncrasy is the worst possible basis for generality.

This situation changed for me in a flash last month when I read a very fine article in Isis (our leading professional journal in the history of science) by Daniel P. Todes: “Darwin’s Malthusian Metaphor and Russian Evolutionary Thought, 1859–1917” (vol. 78, 1988, pp. 537–51). I learned that the parochiality had been mine in my ignorance of Russian evolutionary thought, not Kropotkin’s in his isolation in England. I can read Russian, but only painfully, and with a dictionary—which means, for all practical purposes, that I can’t read it. I knew that Darwin had become a hero of the Russian intelligentsia and had influenced academic life in Russia perhaps more than in any other country. But virtually none of this Russian work has ever been translated or even discussed in English literature. The ideas of this school are unknown to us; we do not even recognize the names of the major protagonists. I knew Kropotkin because he had published in English and lived in England, but I never understood that he represented a standard, well-developed Russian critique of Darwin, based on interesting reasons and coherent national traditions. Todes’s article does not make Kropotkin more correct, but it does place his writing into a general context that demands our respect and provides substantial enlightenment. Kropotkin was part of a mainstream flowing in an unfamiliar direction, not an isolated little arroyo.

This Russian school of Darwinian critics, Todes argues, based its major premise upon a firm rejection of Malthus’s claim that competition, in the gladiatorial mode, must dominate in an ever more crowded world, where population, growing geometrically, inevitably outstrips a food supply that can only increasearithmetically. Tolstoy, speaking for a consensus of his compatriots, branded Malthus as a “malicious mediocrity.”

Todes finds a diverse set of reasons behind Russian hostility to Malthus. Political objections to the dog-eat-dog character of Western industrial competition arose from both ends of the Russian spectrum. Todes writes:

Radicals, who hoped to build a socialist society, saw Malthusianism as a reactionary current in bourgeois political economy. Conservatives, who hoped to preserve the communal virtues of tsarist Russia, saw it as an expression of the “British national type.”

But Todes identifies a far more interesting reason in the immediate experience of Russia’s land and natural history. We all have a tendency to spin universal theories from a limited domain of surrounding circumstance. Many geneticists read the entire world of evolution in the confines of a laboratory bottle filled with fruit flies. My own increasing dubiousness about universal adaptation arises in large part, no doubt, because I study a peculiar snail that varies so widely and capriciously...
across an apparently unvarying environment, rather than a bird in flight or some other marvel of natural design.

Russia is an immense country, underpopulated by any nineteenth-century measure of its agricultural potential. Russia is also, over most of its area, a harsh land, where competition is more likely to pit organism against environment (as in Darwin's metaphorical struggle of a plant at the desert's edge) than organism against organism in direct and bloody battle. How could any Russian, with a strong feel for his own countryside, see Malthus's principle of overpopulation as a foundation for evolutionary theory. Todes writes:

It was foreign to their experience because, quite simply, Russia's huge land mass dwarfed its sparse population. For a Russian to see an inexorably increasing population inevitably straining potential supplies of food and space required quite a leap of imagination.

If these Russian critics could honestly tie their personal skepticism to the view from their own backyard, they could also recognize that Darwin's contrary enthusiasms might record the parochiality of his different surroundings, rather than a set of necessarily universal truths. Malthus makes a far better prophet in a crowded, industrial country professing an ideal of open competition in free markets. Moreover, the point has often been made that both Darwin and Alfred Russel Wallace independently developed the theory of natural selection after primary experience with natural history in the tropics. Both claimed inspiration from Malthus, again independently; but if fortune favors the prepared mind, then their tropical experience probably predisposed them to read Malthus with resonance and approval. No other area on earth is so packed with species, and therefore so replete with competition of body against body. An Englishman who had learned the ways of nature in the tropics was almost bound to view evolution differently from a Russian nurtured on tales of the Siberian wasteland.

For example, N. I. Danilevsky, an expert on fisheries and population dynamics, published a large, two-volume critique of Darwinism in 1885. He identified struggle for personal gain as the credo of a distinctly British "national type," as contrasted with old Slavic values of collectivism. An English child, he writes, "boxes one on one, not in a group as we Russians like to spar." Danilevsky viewed Darwinian competition as "a purely English doctrine" founded upon a line of British thought stretching from Hobbes through Adam Smith to Malthus. Natural selection, he wrote, is rooted in "the war of all
against all, now termed the struggle for existence—Hobbes' theory of politics; on competition—the economic theory of Adam Smith,... Malthus applied the very same principle to the problem of population.... Darwin extended both Malthus' partial theory and the general theory of the political economists to the organic world.” (Quotes are from Tode's article.)

When we turn to Kropotkin's Mutual Aid in the light of Tode's discoveries about Russian evolutionary thought, we must reverse the traditional view and interpret this work as mainstream Russian criticism, not personal crankiness. The central logic of Kropotkin's argument is simple, straightforward, and largely cogent.

Kropotkin begins by acknowledging that struggle plays a central role in the lives of organisms and also provides the chief impetus for their evolution. But Kropotkin holds that struggle must not be viewed as a unitary phenomenon. It must be divided into two fundamentally different forms with contrary evolutionary meanings. We must recognize, first of all, the struggle of organism against organism for limited resources—the theme that Malthus imparted to Darwin and that Huxley described as gladiatorial. This form of direct struggle does lead to competition for personal benefit.

But a second form of struggle—the style that Darwin called metaphorical—pits organism against the harshness of surrounding physical environments, not against other members of the same species. Organisms must struggle to keep warm, to survive the sudden and unpredictable dangers of fire and storm, to persevere through harsh periods of drought, snow, or pestilence. These forms of struggle between organism and environment are best waged by cooperation among members of the same species—by mutual aid. If the struggle for existence involves two lions and only one zebra, then we shall witness a feline battle and an equine carnage. But if lions are struggling jointly against the harshness of an inanimate environment, then fighting will not remove the common enemy—while cooperation may overcome a peril beyond the power of any single individual to surmount.

Kropotkin has therefore created a dichotomy within the general notion of struggle—two forms with opposite import: (1) organism against organism of the same species for limited resources, which leads to competition; and (2) organism against environment, which leads to cooperation.

No naturalist will doubt that the idea of a struggle for life carried on through organic nature is the greatest generalization of our century. Life is struggle; and in that struggle the fittest survive. But the answers to the questions "by which arms is the struggle chiefly carried on?" and "who are the fittest in the struggle?" will widely differ according to the importance given to the two different aspects of the struggle: the direct one, for food and safety among separate individuals, and the struggle which Darwin described as "metaphorical"—the struggle, very often collective, against adverse circumstances.

Darwin acknowledged that both forms existed, but his loyalty to Malthus and his vision of nature chock-full of species led him to emphasize the competitive aspect. Darwin's less sophisticated votaries then exalted the competitive view to near exclusivity, and heaped a social and moral meaning upon it as well.

They came to conceive of the animal world as a world of perpetual struggle among half-starved individuals, thirsting for one another's blood. They made modern literature resound with the war-cry of wo to the vanquished, as if it were the last word of modern biology. They raised the "pitiless struggle" for personal advantages to the height of a biological principle which man must submit to as well, under the menace of otherwise succumbing in a world based upon mutual extermination.

Kropotkin did not deny the competitive form of struggle, but he argued that the cooperative style had been underemphasized and must balance or even predominate over competition in considering nature as a whole.

There is an immense amount of warfare and extermination going on amidst various species, that is inanimate and hostile as much, or perhaps even more, of mutual support, mutual aid, and mutual defense.... Sociability is as much a law of nature as mutual struggle.

As Kropotkin cranked through his selected examples, and built up steam for his own preferences, he became more and more convinced that the cooperative style, leading to mutual aid, not only predominated in general but also characterized the most advanced creatures in any group—ants among insects, mammals among vertebrates. Mutual aid therefore becomes a more important principle than competition and slaughter:

If we... ask Nature: "who are the fittest: those who are continually at war with each other, or those who support one another?"

We at once see that those animals which acquire habits of mutual aid are undoubtedly the fittest. They have more chances to survive, and they attain, in their respective classes, the highest development of intelligence and bodily organization.

If we ask why Kropotkin favored cooperation while most nineteenth-century Darwinians advocated competition as the predominant result of struggle in nature, two major reasons stand out. The first seems less interesting, as obvious under the slightly cynical but utterly realistic principle that true believers tend to read their social preferences into nature. Kropotkin, the anarchist who yearned to replace laws of central government with consensus of local communities, certainly hoped to locate a deep preference for mutual aid in the innermost evolutionary marrow of our being. Let mutual aid pervade nature and human cooperation becomes a simple instance of the law of life.

Neither the crushing powers of the centralized State nor the teachings of mutual hatred and pitiless struggle which came, adorned with the attributes of science, from obliging philosophers and sociologists, could weed out the feeling of human solidarity, deeply lodged in men's understanding and heart, because it has been nurtured by all our preceding evolution.

But the second reason is more interesting, as a welcome empirical input from Kropotkin's own experience as a naturalist and as an affirmation of Tode's intriguing thesis that the usual flow from ideology to interpretation of nature may sometimes be reversed, and that landscape can color social preference. As a young man, long before his conversion to political radicalism, Kropotkin spent five years in Siberia (1862–66) just after Darwin published the Origin of Species. He went as a military officer, but his commission served as a convenient excuse for his desire to study the geology, geography, and zoology of Russia's vast interior. There, in the polar opposite to Darwin's tropical experiences, he dwelled in the environment least conducive to Malthus's vision. He observed a sparsely populated world, swept with frequent catastrophes that threatened the few species able to find a place in such bleakness. As a potential disciple of Darwin, he looked for competition, but rarely found any. Instead, he continually observed the benefits of mutual aid in coping with an exterior harshness that threatened all alike and could not be overcome by the analogues of warfare and boxing.

Kropotkin, in short, had a personal and empirical reason to look with favor upon cooperation as a natural force. He chose this theme as the opening paragraph for Mutual Aid:

Two aspects of animal life impressed me most during the journeys which I made in my youth in Eastern Siberia and Northern Manchuria. One of them was the extreme severity of the struggle for existence which most species of animals have to carry on.
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against an inclement Nature; the enormous destruction of life which periodically results from natural agencies; and the consequent paucity of life over the vast territory which fell under my observation. And the other was, that even in those few spots where animal life teemed in abundance, I failed to find — although I was eagerly looking for it — that bitter struggle for the means of existence among animals belonging to the same species, which was considered by most Darwinians (though not always by Darwin himself) as the dominant characteristic of struggle for life, and the main factor of evolution.

What can we make of Kropotkin's argument today, and that of the entire Russian school represented by him? Were they just victims of cultural hope and intellectual conservatism? I don't think so. In fact, I would hold that Kropotkin's basic argument is correct. Struggle does occur in many modes, and some lead to cooperation among members of a species as the best pathway to advantage for individuals. If Kropotkin overemphasized mutual aid, most Darwinians in Western Europe had exaggerated competition just as strongly. If Kropotkin drew hope for social reform inappropriately from his concept of nature, other Darwinians had erred just as firmly (and for motives that most of us would now decry) in justifying imperial conquest, racism, and oppression of industrial workers as the harsh outcome of natural selection in the competitive mode.

I would fault Kropotkin only in two ways — one technical, the other general. He did commit a common conceptual error in failing to recognize that natural selection is an argument about advantages to individual organisms, however they may struggle. The result of struggle for existence may be cooperation rather than competition, but mutual aid must benefit individual organisms in Darwin's world of explanation. Kropotkin sometimes speaks of mutual aid as selected for the benefit of entire populations or species — a concept foreign to classical Darwinian logic (where organisms work, albeit unconsciously, for their own benefit in terms of genes passed to future generations). But Kropotkin also (and often) recognized that selection for mutual aid directly benefits each individual in its own struggle for personal success. Thus, if Kropotkin did not grasp the full implication of Darwin's basic argument, he did include the orthodox solution as his primary justification for mutual aid.

More generally, I like to apply a somewhat cynical rule of thumb in judging arguments about nature that also have overt social implications: when such claims imbue nature with just those properties that make us feel good or fuel our prejudices, be doubly suspicious. I am especially wary of arguments that find kindness, mutuality, synergism, harmony — the very elements that we strive mightily, and so often unsuccessfully, to put into our own lives — intrinsically in nature. I see no evidence for Teilhard's noosphere, for Capra's California style of holism, for Sheldrake's morphic resonance. Gaia strikes me as a metaphor, not a mechanism. (Metaphors can be liberating and enlightening, but new scientific theories must supply new statements about causality. Gaia, to me, only seems to reformulate, in different terms, the basic conclusions long achieved by the classically reductionist arguments of biogeochemical cycling theory.)

There are no shortcuts to moral insight. Nature is not intrinsically anything that can offer comfort or solace in human terms — if only because our species is such an insignificant latecomer in a world not constructed for us. So much the better. The answers to moral dilemmas are not lying out there, waiting to be discovered. They reside, like the kingdom of God, within us — the most difficult and inaccessible spot for any discovery or consensus.

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.
Saw palmettos tangle with other plants in the understory of the Florida scrub, below. Opposite page: The Florida scrub jay breeds in isolation, more than a thousand miles from the nearest scrub jay population of western North America.

David Muench
Big Scrub, Florida

by Robert H. Mohlenbrock

Fifty years ago, while hiking in central Florida, biologist Maurice Mulvania recorded that the "nearly pure white sand of the ground surface, when viewed from a short distance, gives the impression of a thin rift of wind-driven snow. The vegetation is mostly dwarfed, gnarled and crooked. Here the sun sheds its glare and takes its toll of the unfit." Mulvania was in the Big Scrub section of the Ocala National Forest, a habitat that extends for thirty-five miles north to south in the forest and nearly fifteen miles east to west, stopping a short distance from the rapidly growing community of Ocala. South of the forest, the scrub extends for another 110 miles to Lake Okeechobee.

A notable feature of the terrain is the way areas of white and cream-colored sand alternate in a continuing but irregular pattern. The white sand apparently derives from ancient dunes of wind-blow sand, while the cream-colored sand was deposited by marine currents. The usually abrupt change in sand color is accompanied by a contrast in vegetation. In 1895, botanist George Nash noted that "these two floras are natural enemies and appear to be constantly fighting each other. A bare space of pure white sand that usually separates the two is neutral ground."

The vegetation on the white sand is mostly tangled and scraggly. It is dominated by stands of sand pine with a thick understory of short Chapman's and evergreen scrub oaks and densely branched shrubs that include rosemary, staggerbushes, tough buckthorn, and saw palmettos. This is the true scrub. In the cream-colored sand, which extends as slightly elevated tongues into the scrub or sometimes is completely surrounded by it, grows an open forest of tall longleaf pines, which tower over deciduous turkey oaks, blackjack oaks, and Margaretta's post oaks. These plant communities enclosed by a "sea of white sand" are sometimes called high pine islands. An understory of narrow-leafed grasses gives them a park-like appearance.

Some nineteenth-century botanists thought that the distribution of plants in the two sand types was accidental and depended on which plants got there first. However, when a region of the scrub is burned, the revegetation is always only by plants that are tolerant of the white sand conditions, not by a mixture of scrub and pine island species. The white sand has very little potash, clay, and humus, while the cream sand has ample amounts of these ingredients. This accounts not only for the difference in vegetation but also for a contrast in animal life. The lack of cohesive material prevents many animals from burrowing into the white sand, since they are unable to keep their tunnels open. In the cream sand, however, salamanders, gophers, ants, and other burrowing organisms are common.

Rainfall is limited in this part of Florida, and what rain does fall percolates rapidly through the white sand to a depth beyond the roots of the plants. Scrub plants are well adapted to this moisture-deficient habitat. Sand pines have very short needles and scaly branches that prevent excessive water loss, while the leaves of the rusty staggerbush are covered with a dense felt of hairs. Rosemary has short leaves that are rolled up like little needles, lessening exposure to the sun's rays.

Where there are not enough nutrients...
and moisture in the white sand to support leafy green plants, the substrate is often covered by rounded, crunchy, gray-green tufts of deer moss. Deer moss is a lichen whose fungal component gives the plant its light gray color and whose algal part contributes the green hue. Other lichens clinging tenaciously to the bark of the sand pine, including one that imparts a pinkish red color.

In the porous white sand, everything dries out rapidly. Dead organic matter is easily blown away, resulting in little accumulation of humus, which would protect potential seedlings. Bare sandy patches, beneath which the decayed roots of long-dead plants may be found, indicate the difficulty of seedling establishment in the sand. Most scrub plants produce great numbers of seeds, improving the odds that a few will develop into mature plants.

The Big Scrub harbors some species and subspecies that are found nowhere else in the world. These organisms developed under austere living conditions and have adapted to deficiencies in nutrients and moisture. Among the animals is the foot-long, bluish Florida scrub jay, which nests in the sand pines, and the Florida sand skink, which lives most of its life buried in the white sand, feeding on termites and beetle larvae. This skink—with its wedge-shaped head, partially recessed lower jaw, tiny front legs that fold into grooves in its body, and highly reduced hind legs that have only two digits each—is streamlined to “swim” in the loose sand. Among the most beautiful plants is the Florida bonamia, a prostrate type of morning-glory with a pale blue, funnel-shaped flower that measures up to two inches across. This creeping plant grows beneath the sand pines in sunny areas where the understory has been opened up by occasional fires.

With the accelerated development of much of Florida during the past several decades, much of the scrub habitat has been altered or destroyed by housing developments, conversion to citrus groves, and industrial complexes. Even large tracts in the Ocala National Forest have been clear-cut to harvest the pines for the production of paper pulp. As a result of the diminished habitat, many of the sand scrub endemics—from the Ocala National Forest to Lake Okeechobee—are now threatened with extinction.

"This Land" highlights the biological phenomena of the 154 U.S. national forests. Robert H. Mohlenbrock is Distinguished Professor of Botany at Southern Illinois University at Carbondale.
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Down to the Sea

Ancient murrelet chicks become mariners at just two days of age

by Tony Gaston

One of more than a hundred islands that constitute the Queen Charlotte archipelago, off the coast of British Columbia, Reef Island is clothed in a dense temperate rain forest of tall Sitka spruce, western red cedar, and western hemlock. This luxuriant forest, with its carpet of emerald mosses and dense litter, is the breeding ground of the ancient murrelet, a small, marine diving bird belonging to the auk family (Alcidae). Although the species is widely distributed across the northern rim of the Pacific, from China and Korea to British Columbia, more than half the world’s population of ancient murrelets is believed to nest in the Queen Charlotte Islands. About a half million birds are scattered among a score of the smaller islands of the archipelago.

Like all auks, ancient murrelets spend most of their lives at sea. They are adept at swimming underwater, using their wings for paddles as penguins do. Although not closely related to penguins, auks are their ecological counterparts in the Northern Hemisphere. Auks differ from penguins, however, in that all the surviving auk species are able to fly (although the largest member of the family, the extinct great auk, had lost this capacity).

The smaller auks, including the ancient murrelet, which weighs about a half pound, feed on zooplankton, such as copepods, euphausiids, and larval fish. Ancient murrelets remain in British Columbia waters throughout the year, but feed mainly out of sight of land and visit their breeding grounds for only a short time each year to lay and hatch their eggs in underground burrows. On their colonies they are active above ground only at night. Because of their nocturnal habits and the inaccessibility of most of the islands on which they nest, the murrelets’ biology was comparatively little known until recently.

In the late 1960s, Spencer Sealy, of the University of Manitoba, conducted pioneer studies of the species’ breeding biology. Thereafter no investigations were carried out until 1980 when Gary Kaiser and Kees Vermeer of the Canadian Wildlife Service initiated a series of detailed censuses of the species in the Queen Charlotte Islands. To improve the interpretation of the census results, I began a program to expand the information available on the species’ biology and to provide a thorough description of its reproductive ecology. At the same time, Ian Jones, a graduate student at the University of Toronto, worked with me to study the ancient murrelet’s behavior. We have now completed four years of research at Reef Island, and a detailed picture of the bird’s remarkable life is emerging.

By day, Reef Island betrays few signs of the ten thousand breeding murrelets; those ashore are nestled in burrows among the roots of the forest trees, while their mates are far out at sea. Only some feathers and eggshell fragments, scattered among the spruce cones, and the many small, dark holes at the bases of trees and stumps betray the presence of the subterranean colony. Adventurous campers, who have to arrive by kayak, might be...
totally unaware of the birds until they are awakened in the middle of the night by a whirring of wings and a chorus of explosive calls echoing in the gloom.

Only when darkness falls is it possible to appreciate the life of the colony. And in June in the Queen Charlottes that may be past midnight. The first birds do not begin to arrive until the last glimmer of daylight has faded. These are usually breeding murrelets, relieving their mates of nest duty. On arrival, they disappear immediately below ground, where they and their mates begin a twittering dialogue that may continue for half an hour. Later arrivals include younger birds prospecting for mates or excavating burrows. Young males perch high in the trees and proceed to deliver a far-carrying song that is answered by others nearby. On a calm, moonless night, hundreds of such prospectors turn the stillness of the forest into a wall of sound until the break of dawn.

Singing from trees in the dead of night seems strange enough for a seabird, but this is not the only remarkable aspect of ancient murrelet behavior. Like Xantus', Japanese, and Craveri's murrelets, the other members of their genus, ancient murrelets never feed their chicks on land. Instead, after two or, at most, three days in the burrow, the chicks leave for the sea. Our banding results show that most will not return to land until they have reached two years of age.

The early departure of the young ancient murrelets saves their parents the time-consuming and potentially hazardous business of making regular trips to the colony to feed their growing offspring. In contrast, the young of other species of seabirds depend on food being delivered to them for a long time. King penguin and wandering albatross parents must spend more than half a year regularly carrying out this chore, and even small auks and petrels devote more than a month to chick provisioning. How is it that other seabirds must allot so much time to feeding their chicks at their colonies while ancient murrelets escape this responsibility altogether? Our research has shed light on the advantages and disadvantages of the ancient murrelet's chick-rearing strategy.

As Sealy noted previously, ancient murrelets lay two relatively enormous eggs. Each is approximately a quarter of the weight of the female that lays it. Sitting in the darkened forest, we could easily tell whether an arriving bird was carrying a fully developed egg. If the bird hit the ground with a heavy thump and was scarcely able to become airborne again, then it was probably a female ready to lay. Such birds could be readily caught by hand.

The two eggs are laid seven to ten days apart. During the interim, the first egg lies unattended in the burrow, and even after the second has been added, several days usually elapse before incubation commences. Of necessity, the eggs are very resistant to chilling. Even just before hatching, eggs allowed to cool to burrow temperature (48° to 50°F) for one or two days hatched successfully once incubation was resumed. Each parent takes incubation shifts that may last as long as five days, and the pair are extremely wary of disturbance. Any adult removed from its burrow for banding or measurement will definitely desert its eggs. This severely limits the research that can be carried out during the incubation period. To band the adults, we wait until the day that the chicks hatch. Subsequent retrapping shows that handling at that stage does not affect the behavior of the parents.

The chicks usually leave their burrow on the second night after hatching. They wait for complete darkness and the arrival of the off-duty parent. Then both parents begin to give a characteristic call. After a few minutes the parents emerge from the burrow, still calling, and the chicks follow, each giving a loud “peep.” The parents lead the chicks a short distance from the burrow and then fly off to the sea. As soon as their parents have gone, the chicks stop calling and begin to run at great speed toward the beach, up to 500 yards away. Their route may involve scrambling over fallen logs, wriggling through dense ground vegetation, and tumbling down small cliffs. Once they reach the shore, they plunge into the waves and, bobbing like tiny, downy corks, swim out to rendezvous with their parents.

We wanted to know how the chicks find their way to the sea in the dark, and having found it, how they make contact with their parents. There are three obvious guidance cues that you or I might use to find the sea: downward slope; the sound of the waves; and light, always brightest over the water. To examine these possibilities we set up a simple T maze inside a blacked-out hut near the shore. The chicks were placed in the leg of the T and had the choice of going left or right at the junction. When a glimmer of light was placed at one end the response was immediate; all the chicks turned toward the light. We then replaced the light with a recording of the sound of surf. The majority of chicks made for the sound, but some were indecisive, and a few turned the wrong way. When we tilted the T downward at an angle of five degrees the chicks turned in either direction, but when we increased the slope to fifteen degrees most of them turned downhill.

Ancient murrelet chicks appeared to use all the obvious cues available to them, despite having encountered the world outside the burrow only a few moments before. Of the three cues, light seemed to override the other two; chicks would even run uphill and away from the sea in response to a faint light. We discovered this in the course of catching chicks for banding. We had to be careful to shield our lights completely, otherwise we found chicks that we had previously banded and released at the sea returning to our station.

Reunion with the parents usually takes place within 200 yards of the shore. Both parents and chicks recognize one another’s calls from among the throng of competing voices on the sea. We tested the chicks’ powers of recognition by placing them, one at a time, in a large, water-filled tank and playing recordings of their parents’ calls and those of another adult alternately from either side. Ignoring the voice of the strange adult, the chicks rushed straight to the speaker playing their parents’ calls and tried to jump inside it.

Once reunited, family groups move rapidly farther from the shore. By daybreak most are more than three miles from the colony. By tracking them with small radio
transmitters that we attached to both the chicks and their parents, we were able to determine that they continued heading away from the colony for about twenty-four hours.

The departure is fraught with dangers for the chicks, both on land and sea. Weighing only about one ounce, they are tempting targets for the local saw-whet owls and the large deer mice native to the area. Once on the water, but still close to shore, they are often taken by large fish or harassed by unrelated adult murrelets that dive and surface underneath them. To pass this dangerous inshore zone, the chicks make a tremendous spurt as soon as they are on the sea, virtually running across the surface of the water, propelled by their disproportionately large feet.

Since sea surface temperatures are below 50°F, two-day-old murrelets have to be equipped to minimize loss of heat. Thanks to an efficient heat-exchange system, however, the chicks lose practically no heat through their naked lower limbs (which constitute perhaps a third of their total surface area), even though their huge legs churn through the water at high speed. A chick in the hand feels like a warm cupcake with two icicles attached.

David Duncan of Bamfield Marine Station, who worked with us on Reef Island, found that in addition to the dense, downy coat that all young auks enjoy at hatching, the murrelets lay down a layer of fat just below the skin. From their first contact with the water, they dive readily and can remain below the surface for as long as fifteen seconds. Their down appears impervious to wetting even in the surf, which in rough weather may batter the chicks about as they struggle out to sea.

Despite all the perils of their departure, the chicks are surprisingly successful. Most family groups that we saw at sea the day after the young left the burrows included two chicks, suggesting that the majority survived. Only rarely did we see a lone chick peeping forlornly near the shore or find a small, downy corpse floating in the kelp.

The efficiency of the murrelet system reinforces the question raised at the outset: If ancient murrelets can take two-day-old chicks to sea, why don’t other seabirds do the same? For many species, the answer lies in the way that they find food. Birds, such as gannets, shearwaters, and terns, that feed close to the surface must fly long distances every day to find the shoals of fish and swarms of zooplankton that appear at the surface only periodically and unpredictably. Because flight is essential to their feeding strategy, these birds must deliver food to their chicks until the young are strong enough to follow them far out to sea to feed for themselves. Ancient murrelets, able to pursue their prey to greater depths, can find sufficient food within swimming range of the colony, and thus have no need to wait until their chicks fledge. But surely, suitable insshore feeding conditions must be available to some cormorants, penguins, or even some other auks, all of which are expert swimmers and divers but which still feed nestbound young.

Michael Rodway and Moira Lemon of the Canadian Wildlife Service have found that adult ancient murrelets throughout the Queen Charlotte Islands suffer heavier predation on their breeding colonies than is typical of other seabirds. At Reef Island and other colonies, feathers are everywhere, each little pile marking the death of an adult bird at the claws or talons of a bald eagle, raven, or river otter. Below the local peregrine aerie lie little piles of small, gray wings, each pair signifying a mate that will never return to its burrow. We believe that the high risk of predation may be the factor that gives the murrelets their strong incentive to reduce the number of visits they make to the colony. Since each visit presents an additional chance of being caught, anything that reduces the number of visits made to the colony improves an individual bird's chance of returning to breed again. Under these conditions, any adaptation that allows the chicks to leave the colony at a younger age will spread throughout the population even if the chance of the chick surviving the first few weeks of life is thereby reduced.

The ancient murrelets’ abbreviated chick-rearing schedule allows them to breed even where predators occur in very large numbers. The Queen Charlotte Islands support the densest known population of peregrine falcons in North America, as well as a concentration of bald eagles. Among seabirds, only ancient murrelets have been able to colonize the archipelago in large numbers. Most other seabird species breed on tiny, isolated offshore islets where a lack of other resources keeps the number of predators low.

The unusual life style of the ancient murrelet is not without cost. The enormous egg contains 40 percent yolk, compared with 25 to 35 percent in most seabirds. As yolk contains six times the energy of albumen, the total energy content of a murrelet egg is a quarter again as much as a typical seabird egg of the same size (laid by a much larger bird). The female ancient murrelet must produce this energy-rich egg twice and very early in the season compared with other seabirds breeding in the same region. This effort must be close to the physical and physiological limits of any bird. Likewise, few seabird hatchlings face such a range of immediate challenges as does the ancient murrelet chick. Within minutes of first leaving the burrow, it must run like a hare and swim like a seal.

If the small and relatively insignificant genus to which the ancient murrelet belongs had, like the great auk, become extinct before coming to the attention of scientists, few researchers would have considered the bird’s biology and behavior within the realm of the likely. The ancient murrelets are a reminder that not all strategies and designs are necessarily exploited in the current species complement of the planet. As the rate of extinction continues to accelerate, our view of the diversity of animals, and their capabilities, is likely to narrow even further. We shall be the poorer for that.

Zoologist Tony Gaston is a research scientist for the Canadian Wildlife Service in Hull, Quebec.
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Father of the Brood

The male pipe-organ mud-dauber goes to great lengths to protect a nest of offspring that may not be his.

By H. Jane Brockmann • Photographs by D. Wilder

About twenty-five thousand species of wasps, bees, and ants belong to the insect group called the Hymenoptera, and almost all of them follow consistent sex roles. Females build nests and collect food to provision the brood cells that contain their developing offspring. Males rarely attend to the nests or the brood in any way. In wasps, males usually ignore the brood entirely or are dead by the time it is produced. One of the rare exceptions is the pipe-organ mud-dauber wasp, a common North American species. The male guards the tubular mud nest that the female constructs, drives away rival males, parasites, and ant predators, and copulates with the resident female. The male spends most of her day hunting for spiders, which she seals into the brood cells as food for her larvae.

Such cooperation between male and female hymenopterans is all the more remarkable because it seems—on the surface at least—that the male is not acting in his own best interests. Because of an odd system of sex determination in hymenopterans, the male and female do not have an equal genetic relationship to the young in their nest. Females store sperm after copulation and may or may not use it to fertilize an egg as it is laid. Unfertilized eggs develop into sons, while fertilized eggs become daughters. Females are related only to daughters. Given this form of sex determination, I wondered how paternal care could have evolved.

In the populations of mud daubers that I have studied, sons are far more common than daughters, so the males are investing a lot of effort guarding broods that, in great proportion, are not related to them. One would expect that males should be programmed through natural selection to behave in a way that maximizes their long-term reproductive success. The question is, Does a male’s guarding behavior increase the number of his own offspring, that is, daughters, that will survive to reproduce in future generations?

I began to study pipe-organ mud-dauber wasps in part because I was interested in the genetic conflict of interest between males and females created by their unequal relatedness to offspring. Mud-dauber wasps are perfect for studying evolutionary questions of this sort. They are abundant in the eastern United States, where they nest on homes, barns, sheds, and other man-made structures near permanent sources of mud. The insects have not entirely forsaken their natural habitat, however. They also nest on cliff faces, under palm fronds and tree branches, and in preexisting cavities of the right diameter, such as hollow plant stems or holes made by wood-boring insects. I studied those that live under bridges, where they are easy to observe. These wasps are large and can be marked with dots of enamel paint. Their brood cells can be opened, cocoons removed, and the young wasps reared out individually. The size and sex of the young produced by parents whose behavior has been observed can thus be determined, as well as which brood cells were parasitized or failed to develop.

Despite the ubiquity of pipe-organ mud-dauber wasps, their biology has not been well studied. They look a little like social wasps, such as hornets, but are only distantly related to them and are normally solitary (one female in each nest) in their nesting habits. Unlike social wasps, solitary wasps do not sting to defend their nests but only to subdue and paralyze prey. Also unlike social wasps, the female solitary wasp carries the whole prey back to her nest and packs it into a brood cell. The prey remains alive for several weeks, providing fresh food for the larvae during their development.

After building her mud nest on a vertical surface, the female hunts for web-building spiders in nearby woods and fields. Pouncing on her prey, she stings it, instantly paralyzing it with her venom. After squeezing the spider’s body and causing it to regurgitate its stomach contents, she feeds for a few minutes from its mouth. Finally, holding the live but motionless quarry in her mandibles, she flies back to her nest and pushes it up into the top of the brood cell.

After one or two days of provisioning, she lays a single egg on the accumulated store of many spiders and seals off that brood cell with a plug of mud. She then begins provisioning the next brood cell down in the nest pipe. (Each tubular nest can hold two to five brood cells, stacked from top to bottom.) The first egg hatches into a larva in about two days, consumes all the provided food in about a week, and then spins a cocoon. Larvae usually enter a state of diapause for the winter and metamorphose into adults the following spring, but in the South, they may forgo diapause and pupate immediately, emerging as adults six weeks later. The young adult chews its way out of its cocoon and then out of the nest. Because mud daubers tend to nest in the area where they themselves emerged, successful sites quickly become dense aggregations.

While the female is building and provisioning the brood cells, the male does not sit idly by. He may spend hours (including the whole night) sitting in one nest, guarding the accumulating provisions and helping out with odd jobs. If he enters the nest while it is being constructed, he may, for
A male will almost invariably attempt to mate with a female whenever she arrives at the nest. The pair pictured below copulate even as the female continues to build. When the female has finished packing the brood cell with spiders, she will lay an egg; if the male is not present at that moment, he may be sacrificing his chance at paternity. Opposite: A parasitic fly approaches a guarded nest.

example, smooth the wet mud on the inside walls, a most unusual behavior for a male wasp. If, in the female’s absence, a spider begins to slip out of the brood cell, the male pushes it back up. After the female has amassed an adequate store of provisions, the pair copulate several times and an egg is laid. The male continues to stand guard while the female completes the mud plug. He may then remain with her and assist her with the next brood cell. In dense colonies, however, he may leave and nest with another female.

Male guards are very effective at chasing away the parasitic and predatory insects that threaten the brood cells. Cuckoo wasps commonly lurk around the nest entrance; if they find it unguarded, they sneak in and lay a single egg that later hatches into a larva that kills the developing mud dauber. Males also keep out parasitic flies that deposit their tiny larvae in unattended nests. These maggots develop quickly and consume the wasp’s provisions, often before the wasp larva has hatched. Ants are particularly destructive, since they can rapidly carry off a nest’s entire store of provisions. Male mud daubers frighten the scout ants away from the nest entrance before they discover the provisions, and thus prevent the scouts from laying a chemical trail to recruit other ants to the food source.

This scenario—male and female working together to rear their offspring—is a fairly accurate picture of what goes on when nests are few and far between. But dense populations of from 50 to 300 females are also common. In this situation, nesting does not proceed so smoothly. Frequently, females maraud one another’s nests. One may enter a brood cell that is being provisioned by another, remove one of the spiders, feed on fluids from its mouth, discard it, and return for more. Some females may even forsake their normally solitary ways and jointly occupy a nest—an arrangement that is never amicable. If two females that are provisioning the same brood cell return to the nest at the same time, a vicious fight ensues, often lasting fifteen minutes or more. With stinglike movements, the two slap each other with their abdomens, and although they withhold the sting, they bite fiercely with their large mandibles. Such fights generally result in one female being driven from the nest.

Nest sharing may also end when one of the two females returns to the nest with her last prey item, lays an egg, and seals the brood cell with a plug of mud. If the plug has had time to dry and harden, the rival is out of luck, but if she returns while the plug is still wet, she chews through the wet mud seal, chews off the other female’s egg, and discards it. Then she lays an egg of her own and rescales the brood cell.

A male’s help does not extend to driving off females of his own species. Instead, he tries to mate with them, even if they have invaded the nest to steal spiders. Presumably, he gains more by placing his sperm in another female’s sperm storage sac and potentially fertilizing other eggs than he would from exerting himself to defend a spider or two. Or, being smaller than females, males may be unable to deter raiders and, in failing to defend the nest, may be making the best of a bad situation.

If the female whose nest he is guarding is slow at bringing in spiders, the male is more clearly opportunistic. He may fly around inspecting the nests of other females and switch his allegiance to one of them. For a female, the loss of a male guard is a setback. If she returns from hunting to find that the male is not in the nest, she stays to guard it. After several hours she may leave, but not for long. If she finds a spider in half an hour or so, she brings it back, but often she returns empty-handed to continue guarding. If a male appears, the female leaves immediately and resumes hunting. Females with guards are more likely to lay an egg and close up a brood cell after a single day of provisioning, as long as the cell has been stocked above a minimum level. But females without guards are at greater risk from parasites because they may be forced to leave a cell open overnight if it is insufficiently provisioned. Unguarded females provision significantly more slowly and have fewer surviving offspring than their more fortunate rivals; the offspring they do have are significantly smaller than those from guarded nests. This is a high price to pay for losing a guard, since, in insects, smaller individuals are usually less fecund, less successful at hunting, and less able to compete with larger individuals of their own species.

The benefits to the female of having a male guarding her nest are clear enough. But what’s in it for the males? In part, sitting in the nest seems simply to be a way of sequestering a female and mating with her (since, as far as I know, the nest is the only spot where copulation takes place). Since males usually outnumber females, they compete vigorously for access to nests. Once inside, a male can usually defend his position, although there are occasional, intense fights that can be fatal. Whenever the female returns to her nest the male tries, often successfully, to mate with her. If the male is not at the nest when the female is ready to lay an egg, he will not father the offspring of that brood cell. Therefore, when a brood cell is close to completion, he rarely leaves.

When the female returns to the nest before egg laying, she packs spiders for several minutes. If there is no male in the
Mud daubers often nest on buildings and under bridges and may return year after year to the same sites, constructing their tubular nests near or on top of nests from previous years. The holes in the nests below were made by emerging adults from previous years; nests without holes contain not-yet-emerged larvae. Opposite: A female returns to her nest with a live spider, which she has paralyzed with her venomous sting, and will store it to feed her offspring.

nest by then, she simply turns around and lays an egg within a few minutes. If a male is on the scene, however, the pair copulate while the female is packing spiders. When she turns around and assumes the egg-laying position, the male grasps her head-on, wrapping his forelegs around her neck in a kind of judo-hold, his head resting on her back. After about forty seconds, the male backs away and pulls the female by an antenna, causing her to walk toward him. Then he lets go, and she turns around and resumes her spider packing, whereupon they copulate again. This sequence is repeated three to eight times for five to twenty minutes before the female finally lays an egg during one particularly long bout of holding.

When I first observed this extraordinary pattern of repeated copulations and holds, I thought the male might be forcing the female to fertilize the egg she was about to lay. As it turned out, however, my hypothesis was not supported by the data: whether or not the wasps performed this egg-laying sequence, their brood cells produced the same ratio of male to female offspring. This was true both in natural cases when no male was in the nest (about 10 percent of the brood cells are completed without males) and in cases where I experimentally removed the male just prior to oviposition.

Although repeated matings cannot apparently force the female to fertilize the egg she lays, they can, I think, increase the male’s chances of being the father if she does fertilize the egg. Females are highly promiscuous and copulate frequently with any male that enters their nest. Being able to store sperm, they are capable of laying fertilized eggs even when they have not mated recently. There is good evidence from other species of insects that exceptionally long or multiple copulations just before fertilization help assure paternity, so I suspect that this may be true for mud daubers as well.

While the male does not directly alter the chances of the female’s producing a daughter by his behavior during the egg-laying sequence, his guarding behavior throughout the provisioning period may improve his odds by influencing the female’s decision to fertilize. My data show that a female is more likely to fertilize an egg laid in a well-stocked cell and that brood cells that are well guarded by males are more likely to produce daughters than those that are unguarded. The clear inference is that male guards help make females more efficient providers, and efficient providers fertilize eggs.

Males may also increase their chances of producing daughters by searching the nesting area for several minutes before they choose a nest. They are more likely to choose to guard nests that are being actively provisioned or near completion than those that are proceeding slowly or that still require many more hours of hunting. Thus, males concentrate their efforts on nests that are somewhat more likely to produce daughters.

But how might nest guarding have evolved in the first place? In most species of wasps, females mate only once, and males are short-lived. Males either find females on the flowers where they feed or they patrol emergence sites and mate with newly emerged females. In a few species, however, including all members of the subgenus to which mud daubers belong, the females continue to remate throughout their lives, and long-lived males remain in the nest for years. But not all males in this group guard nests from within. In some cases, they defend a territory in which several females are nesting close together, pouncing on and chasing off intruders, including conspecific males and parasitic insects. These males normally remain outside the females’ nests, attempting to mate with whichever female returns to build or provision. Occasionally, however, a male takes refuge inside a nest when he is under attack by another male. Interestingly, in some species, males seem to be even more tightly associated with females than are pipe-organ mud daubers and follow females around as they scout out new nesting sites. These varying degrees of male guarding suggest that the behavior may very well have evolved primarily as a territorial mating strategy and rather fortuitously acquired a nest-guarding function as a result of the males’ intense aggressiveness.
Negotiating a wet lot in Cedar City, Missouri, 1985 (Carson & Barnes)
The uniqueness of the American circus has often been associated with mobility, multiple rings, and spectacle. In contrast, the European and Russian forms of the circus have tended toward permanency, the one-ring form, and a focus on the individual circus act. This is still in large measure a real distinction, although as part of the American experience, the major circuses have changed over the years as society has changed, and concessions have been made to adapt to current tastes and methods. Even the multiple rings are often something of a deception, for many contemporary three-ring American circuses rarely have more than one ring active at a time. Perhaps the most obvious physical change over the years has been the trend toward performing in venues other than the traditional tent.

The most notable exceptions to modern trends are the types of circuses captured here—generally small, sometimes one-ring affairs that still travel many miles playing short dates under the big top. This tradition is one that has almost been eliminated by America’s best-known circus, Ringling Brothers and Barnum & Bailey. As dominant as this circus is, it should not be the only image of the circus in America today, for many smaller towns and cities still see only the smaller traveling circuses, and the few larger tented shows still play the major cities.

These circuses are frequently called mud shows. Originally, a mud show traveled overland by a horse-drawn wagon, whose wheels were frequently mired in mud. Prior to 1872, all circuses were mud shows, and some continued to travel that way until the early 1920s. Later, the term was applied to any circus that traveled overland by wagon, truck, or automobile. Such a show, sometimes called an overland trick or mud

Elephant act in Eau Claire, Wisconsin, 1984 (Carson & Barnes)
op'ry, usually played small towns or the suburbs of large cities. Today, mud show is a derogatory term used by the large circuses that move by private train to refer to any show not using the luxury of steel rails.

By today's standards, all circuses except Ringling Brothers and Barnum & Bailey could be termed mud shows. Ironically, most tent show workers and performers consider their circuses the spiritual descendants of the Ringling operation during its big-top heyday, before it became the antiseptic and almost mechanized show that now plays in permanent arenas. Certainly a mud show today does not always mean the circus is small or uncoordinated. Two of the larger contemporary circuses, Carson & Barnes and Clyde

Lion tamer, Bullhead City, Arizona, 1984 (Carson & Barnes)
Routes for Two Circuses during 1987 Season (March - November)

Clyde Beatty - Cole Brothers Circus
486 performances, 9,291 miles through 17 states

Carson & Barnes Circus
452 performances, 14,322 miles through 16 states

Joe Le Monnier
Beatty-Cole Brothers, qualify as mud shows by today’s standards or when compared with the enormous operations of the past. But over an eight-month period, Clyde Beatty-Cole Brother’s three-ring show travels more than 9,000 miles and plays approximately 115 cities, primarily in the mid-Atlantic states and New England. Carson & Barnes travels almost twice that distance through twenty states to find its audience. When it took to the road in March 1987, its numbers included 250 people, 80 brightly painted vehicles, 22 elephants, a hippo, a rhino, a giraffe, and assorted lions, tigers, llamas, horses, donkeys, zebras, and goats.

Most circuses today lead tenuous existences and are but faint shadows of what once was. While a circus
renaissance is not on the horizon, as of 1988, the circus is not a totally endangered species; a few showmen with affinities to earlier traditions continue to try to return it to some of the ways it used to be. According to The Bandwagon, the journal of the Circus Historical Society, during the 1987 season, roughly mid-March to late October for most tented circuses, there were more than a hundred shows that called themselves circuses, although only about two dozen really came close to the real thing. A large number of contemporary circuses play for Shrine charities, although about half of the total are very small shows that play fairs, ball parks, outdoor arenas, shopping malls, gyms, or similar existing spaces, frequently on an ad hoc basis, not with the community atmosphere and cooperative living of the traveling tent show. Still, as Bandwagon concludes, unlike the some 280 carnivals that tour the country, the American circus today still has a kind of purity about it; it is still what we thought it was when we were kids. Many performers continue to come from old circus families; many are serious artists perfecting their skills, skills that are certainly more wonderful to watch in their live, imperfect form than in edited versions on television.

Despite all that has been written about the demise of the American circus, why has this form of live popular entertainment managed to defy competition from radio, television, and motion pictures when other forms have become nothing more than a nostalgic memory—or, like the dime museum, been forgotten altogether?

For Mark Twain’s Huckleberry Finn, the circus was simply “the splendidist sight that ever was.” The late William Lyon Phelps, a noted professor of English at Yale University, once commented that “Heaven lay about me in my infancy, and it took a circular shape. From the moment I entered the great tent until I emerged some hours later I was in Paradise.” Phelps went on to say that even after he was over sixty he still loved the circus. He continued to attend performances, not to see if he could “recapture” his childish enthusiasm, but “because I want to go, because the circus ring draws me, and it ought to, with centripetal force.” Indeed, Phelps and others have noted that if you have imagination, the delight of the circus does not lessen much with age, changing little from year to year. Certainly if we lose the circus one more piece of life’s magic will disappear with it.
Catching up with the wash, Barstow, California, 1984 (Carson & Barnes)
A dry-season fire sweeps across grassland in Madagascar's interior. Fossil charcoal particles found in ancient sediments show that fire was part of the island's ecology long before humans arrived.

Frank Lanting
Mysterious Island

What killed Madagascar's large native animals?

by David A. Burney and Ross D. E. MacPhee

Sometime between 1,000 and a few hundred years ago, at least seventeen species of the largest native mammals, birds, and reptiles disappeared from the island of Madagascar. Among them were cow-sized hippos, giant tortoises, and elephant birds. These last, immortalized in H. G. Wells's short story "Aepyornis Island," vaguely resembled African ostriches and other giant flightless birds, but were much more robust. The biggest, Aepyornis maximus, probably weighed half a ton and laid soccer-ball-sized eggs. For carnivores, add Cryptoprocta, a relative of the mongoose, the size of a large lynx but sleeker, and other mongoose relatives in various shapes and sizes. The lemur stock, unique to Madagascar, lost three large-bodied genera that to some suggest orangutans, small gorillas, and bear-sized koalas. Two other vanished lemur types were partly ground dwellers, like African baboons. To students of prehistoric extinctions, these creatures may be less familiar than the saber-toothed cat and the mastodon. However, a play in which almost all the characters die suddenly of unknown causes makes a compelling mystery.

Today Madagascar supports no indigenous mammal weighing more than about twenty-five pounds (except the bush pig, which was probably introduced by prehistoric humans). The only surviving native animal that is truly large is the crocodile. This exception is no surprise, for the crocodile is the ultimate survivor; that toothy grin even weathered the mighty extinctions that swallowed up its cousins, the dinosaurs.

Although the extinctions in Madagascar occurred only a short time ago, they resemble those that came at the end of the Pleistocene (the epoch of frequent glaciation that lasted from about 1.8 million to about 10,000 years ago). Thirty thousand years ago, every continent but Antarctica supported a range of large mammals roughly comparable to that of the present-day game parks of East Africa. First in Australia, then in North and South America, many species with an adult weight of about forty pounds or more became extinct during an apparently short span of time. More gradually, large mammals
Typical of Madagascar's two dozen or so surviving species of lemurs, the white-fronted lemur is small compared with its extinct relatives.

Illustrations by Stephen Nash

were lost in Europe and Asia, and to a lesser extent in Africa. Within the past few thousand years, similar extinctions occurred on certain large oceanic islands, notably in the Caribbean and Mediterranean. New Zealand's giant flightless birds, the moas, became extinct within the present millennium.

Madagascar was the most recent place where such an event occurred on a large scale, but for a variety of reasons, which mostly stem from the remoteness of the island, it was one of the last places where the extinctions were studied with modern methods. Along with other scientists from various Malagasy institutions and American universities, we set out six years ago with the notion that if we collected enough data, we might be able to identify the causes and clarify the timing of the extinctions in Madagascar. If this relatively recent series of events could be deciphered, we reasoned, puzzling aspects of older fossil records elsewhere in the world might suddenly make more sense.

The widely held explanation for the extinctions in Madagascar had been proposed more than sixty years ago but never seriously tested. The most familiar and complete version of this explanation comes from the writings of two French botanists, Henri Perrier de la Bâthie and Henri Humbert, who worked in Madagascar during the first half of the twentieth century. Central to this view is the observation that, in what must be one of the greatest flukes of human dispersal in the tropics, Madagascar was apparently not settled until 1,500 or perhaps 2,000 years ago. At that time, people who spoke an Indonesian language expanded into the western Indian Ocean and colonized the island. They brought or soon acquired a mixture of cultural practices, including an East African style of cattle husbandry and Oriental agricultural techniques.

Perrier and Humbert believed that Madagascar was once covered by forests—an idea that suited early twentieth century concepts of what the tropics were like before the arrival of people. According to their hypothesis, human colonists intentionally converted much of the island to grassland by burning vast tracts of forest. The assumption, carried to its most extreme form by some later authors, is that Madagascar's vegetation had evolved in the near or complete absence of fire and could have been rapidly transformed by exposure to fire. An important consequence, they believed, was that many animal species became extinct owing to the loss of their customary habitat. Some versions of the argument call on the role of

With its long arms and short hind limbs, Palaeopropithecus ingens resembled the orangutan, but in other respects its skeleton suggests that it moved along branches like a sloth. This extinct lemur weighed at least sixty pounds; the illustration is based on fossil remains.
“man the hunter” to finish the job. Others emphasize the felling of trees or the introduction of domestic herbivores and other foreign animals as important secondary forces in the extinctions.

This hypothesis seems to account for a whole series of phenomena. First, about 70 percent of modern Madagascar, including most of the central region, is covered by grassland communities made up of relatively few plant species. Yet the total annual rainfall over much of the area is sufficient to support forest. Second, the red soils of much of the interior are eroding rapidly on slopes, producing a characteristic type of giant gully. The presence of these great gullies (called lavaka in Malagasy) seems to suggest an instability in the terrain caused by recent deforestation. A third convincing feature of the traditional explanation is that the modern Malagasy are busy felling the remaining precious trees in some areas and annually firing thousands of acres of grass and bush for a “green bite” to feed their burgeoning livestock herds. As a consequence of these activities and others, such as illicit hunting, most of the larger extant lemurs of Madagascar have very restricted ranges, and some (notably the aye-aye) are thought to be in danger of extinction in the wild. Unfortunately, the process of extinction may still be going on.

Recently, however, this traditional view has met with several objections. Studies in Australia and the Amazon suggest that fires occurred in prehistoric tropical environments (even fairly wet ones) without people to set them. Cases have also been recorded in modern times in which tropical forest fires have been set by lightning, volcanoes, landslides, and other causes. In addition, many of Madagascar’s interior grasslands support only a sparse human population today, and the archeological record suggests that people did not live there in greater numbers in the past. Could such a small population have been responsible for so much deforestation? There are other arguments as well. If the hippo and tortoises of Madagascar were grazers, as are most of their surviving relatives in other parts of the world, the expansion of grassland at the expense of forest would have been more likely to benefit than hurt them.

Finally, while some biogeographic evidence, chiefly the distribution of certain species of butterflies and lemurs, does imply that a forest connection existed across the center of the island some time in the past, we cannot tell when or for how long. We also cannot tell whether the past connections were through widespread upland forests that are now grassland or merely through corridors of forest that paralleled the banks of rivers. Similarly, botanist Jean Koechlin has questioned whether the separated patches of forest scattered over the western part of the island could have been one continuous forest only 1,000 years ago, since the combinations of plant species that grow in these now-isolated patches are in some cases quite different.

In 1983, Elwyn Simons, director of the Duke University Primate Center, and Ross MacPhee began a search for new sites and a survey of the classic sites that had yielded the bones of Madagascar’s extinct animals. They were joined by other members of our group, including paleontologist Martine Vuillaume-Randriansanantenina, archeologist Robert Dewar, and geologist Neil Wells. These scientists reopened Madagascar’s most famous fossil site, Ampasambazimba, in the volcanic district known as the Itasy Massif. Careful excavation, followed by analysis of sediments and radiocarbon dating, showed that Ampasambazimba was an old lake basin, dammed more than 8,000 years ago by a lava flow and
Although only 200 miles from the African coast, Madagascar remained uninhabited until about 2,000 years ago. Scholars have long debated the role of early settlers in the creation of the island's large areas of grassland.

Joe LeMonnier

breached perhaps four millennia later. While accumulating lake sediment, Ampasambazimba had also accumulated thousands of bones, including those of no fewer than fourteen species of lemurs.

Although animal bones had attracted the attention of earlier scholars, we searched the same sediments for fossils of microscopic size. We found charred grass fragments and the pollen of many plants more typical of open environments than of closed forest. There was tree pollen, but generally not from the types of trees that would have covered the landscape with forest. Instead, most of the tree pollen was from species that grow mainly in swamp forests or along streams. The surrounding uplands apparently supported grasses, shrubs, and light-loving trees typical of open woodlands and wooded grasslands. These findings directly contradicted the prevailing theory of a totally forested Madagascar.

Sediment cores removed from lakes and bogs in other parts of the island substantiated this data, making certain conclusions increasingly unavoidable. The fossil charcoal particles in the sediments indicate that there were fires in Madagascar dating back at least 36,000 years (the age of the oldest sediments collected so far). The amount of burning varied from century to century and site to site, but all prehistoric sediments examined contained some charcoal. Although most sites show an increase in charcoal about the time of human arrival, the highest levels of charcoal measured so far are from Lake Tririvakely, a crater lake in the south-central part of the island, for the period about 11,000 to 4,000 years ago.

About three-fourths of the charred material recovered was from grass leaves, not wood. Pollen from the cores taken in the central region of Madagascar, which is today dominated by grassland, also shows that open habitats predated human arrival. The vegetation in the vicinity of Lake Tririvakely 11,000 years ago, for instance, was dominated by heath shrubs, grasses, and herbs. The amount of tree pollen was comparable to that in pollen samples from the site today, when the nearest extensive forest is about forty
miles away. About 9,000 years ago, the heath shrub community seems to have declined, and for the next 5,000 years, grass was dominant. Only small amounts of pollen from trees are found for this time period, mostly of types that grow along streams and in open country today.

There was, however, a trend toward greater forestation sometime before human colonization. At Lake Tritrivakely, for example, charcoal, previously plentiful, declined drastically about 4,000 years ago. For the next two millennia, fires were apparently less frequent, and an increase in the pollen of several types of trees and shrubs shows that woody vegetation became more common. Grass pollen persisted as well, suggesting a mosaic, or patchy, environment. These alterations may have reflected local changes in topography or in the flow of streams, but climatic change is more likely.

Whatever the cause, this increase in woodlands at Lake Tritrivakely lasted less than 3,000 years. At a level in the lake's sediment that was radiocarbon dated to 1,240 years ago (sometime after human colonization), charcoal increases dramatically. However, the increase did not reach the concentration recorded at the same site between 11,000 and 4,000 years ago. The pollen of woody vegetation declines over the next few centuries, as grass and herb pollen increase.

Another lake, Kavitaha, which lies 100 miles north of Lake Tritrivakely near the

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**Malagasy Roots**

by Robert E. Dewar

The origins of the Malagasy people and the date and manner of their ancestors' arrival in Madagascar have long been debated. Physically, the Malagasy are diverse: some would melt into a roomful of Indonesians; others look like East Africans. Genetic research on the distribution of blood groups on the island suggests that some Malagasy regional populations have predominantly Indonesian ancestry and others primarily African, but that all have some forebears on both the eastern and western sides of the Indian Ocean. Although the Malagasy language is of Indonesian origin, the people's agricultural and pastoral economies are based upon techniques that have both Asian and African roots. And various architectural forms, burial customs, political institutions, and aspects of everyday life all point to a fusion of cultures from places separated by thousands of miles.

Despite Madagascar's attractively large size and proximity to Africa, there is no evidence it was inhabited in Stone Age times. The only stone tools found on the island are net sinkers, weights, and (since the seventeenth century) gunflints. Decades of prospecting by amateur and professional archaeologists have failed to yield any sites left by Stone Age peoples, in marked contrast to findings in comparably sized areas of Africa or Southeast Asia. So far, every indication is that Madagascar's first settlers used tools of iron. Iron Age sites on the nearby East African coast are known from the first century A.D.; the Southeast Asian early Iron Age was established about 500 B.C. Therefore, regardless of whether the initial Iron Age immigrants came from Africa or Southeast Asia, they probably arrived less than 2,500 years ago. Linguists who have compared Malagasy with its most closely related languages in Indonesia estimate that Malagasy has been evolving as a distinct language for between 2,000 and 1,600 years.

Most scholars assume that Indonesians penetrated the western Indian Ocean for the purpose of long-distance trade. As there is no evidence for an early presence of Indonesians on the islands of the central Indian Ocean, such as Diego Garcia, Mauritius, or the Seychelles, the initial route was probably via the Middle East. Roman geographies tell of Arab trade and travel between East Africa and the Middle East by the first century A.D., and maritime commerce seems to have been similarly well established on the eastern margins of the Indian Ocean, with goods moving from Indonesia to India and the Middle East.

Since an uninhabited island would have been an unlikely terminus for traders, Indonesian traders probably first landed in Africa, and the fusion of African and Asian traditions began there. How soon this was followed by colonization of Madagascar is not known. The earliest reliable radiocarbon date for an archeological site on the island is from Lakaton'i Anja, a rock-shelter in the extreme north that we discovered and tested in 1986. This site contains pottery, iron blades, and stone weights (probably from nets used to snare birds). There are also animal bones, including some of marine animals with cut marks. The lowest occupation level dates to about A.D. 700.

Trading sites along the East African coast from Mozambique to the Persian Gulf are well known archeologically for the seventh to ninth centuries A.D. By the tenth century, food vessels carved of soapstonelike rock, apparently manufactured on the northeast coast of Madagascar, are commonly encountered at these sites. Irodo, a site on the island not far from the source of the stone food vessels, may have been occupied in the ninth century, while agricultural villages and cattle-herding settlements were present in south and southeastern Madagascar by the eleventh century. And archeological sites in the north have yielded pieces of Middle Eastern ceramics and glassware and even fragments of late Song Dynasty Chinese ceramics, all of which, based on their styles, can be dated to the eleventh and twelfth centuries A.D. Thus, the first definite traces of human settlement in the seventh century are followed fairly quickly by evidence that the island was widely populated and well integrated into the network of the East African coastal trade.

**Robert E. Dewar** is an associate professor of anthropology at the University of Connecticut.
Ampasambazimba fossil site, shows these recent trends in greater detail. The lake’s deep water and fast rate of sedimentation have created a record of events on a scale of centuries, perhaps even decades. According to the pollen evidence, a mosaic of woodland and grassland existed about 1,500 years ago, the beginning of the sedimentary record. Between 1,500 and 900 years ago, the sediments indicate a nearly twentyfold increase in the amount of charcoal, with a transition over this same period from pollen of both woodland and grassland to pollen of almost exclusively grassland plants. Then, in the last few centuries, charcoal declines again to levels similar to those of 1,500 years ago, while pollen of woody vegetation increases.

Even though natural fires occurred in Madagascar’s prehuman period, the evidence suggests that human-introduced fires may have helped change the vegetation. Perhaps human-set fires were more frequent than those ignited by natural causes. Studies in areas as diverse as Florida and Australia have shown that burning on a three-year cycle, for instance, may produce radically different plant communities from those in an adjacent area on a thirty-year cycle. More frequent fires retard plant succession, promoting the growth of grass and restraining the growth of woody plants.

But new fire patterns may have been only one factor introduced by human colonization. As fire opened up the landscape, people may have hunted the animals more effectively. Likewise, cats and dogs may have been more destructive of unhabituated prey than were the native carnivores. And the cows, goats, and pigs people brought with them may have been in direct competition with the possibly less efficient native herbivores. Sorting out these causes could depend heavily on the findings of Robert Dewar, the archeologist on our team, who is trying to find out how long humans and large native animals coexisted in Madagascar. He has recently found direct evidence of their coexistence in far northern Madagascar, at sites where pottery shards and other human refuse are mixed with the bones of extinct animals. A few months ago, MacPhee rediscovered, in the French National Museum of Natural History, some leg bones of Madagascar’s pygmy hippo that were collected nearly a century ago by the renowned French naturalist Guillaume Grandidier. These bones bear numerous cut marks that, as Grandidier recognized, can only be interpreted as signs of butchery.

One possible scenario that might be applicable to Madagascar is the “blitzkrieg” hypothesis developed by Paul Martin and James Mosimann. In this rapid type of “overkill,” major extinctions follow when prehistoric hunters first colonize a continent or island. The larger animals in particular, according to this theory, fall easy prey to a well-organized, well-armed new carnivore. Human groups respond to the new-found wealth of easy protein with a population explosion and rapid spread over the available land. Martin and Mosimann used a computer model to simulate the “wave” of human hunters spreading over the virgin landscape of the Americas and laying waste the great, unsuspecting Pleistocene herds. As Donald K. Grayson and other critics often point out (see “Death by Natural Causes,” Natural History, May 1987), proving or disproving blitzkrieg is difficult, since such a sudden event is apt to be missed in the coarse-grained fossil record.

Currently, we are not sure of either the timing of first human entry into Madagascar or the date of the last of the prehistoric extinctions. While the island may have been colonized as late as 1,500 years ago, preliminary radiocarbon dating of Grandidier’s hippo bones raises the possibility that settlement took place considerably earlier. Furthermore, we do not know precisely when the various species died out. Some species may have persisted until the first European explorers arrived in the early sixteenth century. Old Malagasy stories recorded in the seventeenth century tell of large fantastic creatures living in the interior.

Explanations for the extinctions that emphasize climatic change and play down the role of humans are also worth considering. Early investigators in the arid southwest of the island found many completely dried-up ponds containing abundant bones of the water-loving pygmy hippo, as well as some bones of the presumably tree-adapted giant lemur. Today these sites are waterless thorn forests or bushlands of spiny succulent plants. For our part, we found many bones of small native insectivores in dry caves and sinkholes of southwestern Madagascar, far from the wetter areas they occupy today.

Some researchers working on the late Pleistocene extinctions of Australia and the Americas feel that during the last
10,000 or 12,000 years the climates have become generally more intensely seasonal, with hotter summers and colder winters, than otherwise comparable climates going back possibly for several hundred thousand years. If Madagascar’s climate became more seasonal in recent millennia, this could have placed stress on many types of vegetation and the animals adapted to them. The effects the large grazers and browsers themselves may have had on their stressed environments is another factor that must be considered. All this, in turn, could have made both plants and animals more vulnerable to the new effects of arriving humans.

Neil Wells, the group’s geologist, has found a useful clue in Madagascar’s riddled interior. The great gullies, regardless of origin or age, are all found in a peculiar type of soil that is hard on the surface and soft beneath, sometimes to great depth. Although human deforestation might produce such an erosion pattern, so too might climatic and other changes in the environment. A decrease in rainfall or a shift from equable precipitation (rainfall distributed throughout the year) to extreme wet-and-dry seasonality could perhaps have been responsible for vegetation changes and accelerated erosion.

A more remote hypothesis that could not even have been anticipated a few years ago is that a climatic catastrophe contributed to causing some of the extinctions. The only well-known (but still little-understood) phenomenon of this type is related to the southern oscillation, or El Niño. During an El Niño, which occurs roughly twice per decade but with extremely variable intensity, complex interactions of ocean currents, atmosphere, and shifting precipitation belts produce droughts and other meteorological anomalies throughout the world for several months or even much longer. Climatologist Hermann Flohn theorizes that peculiar combinations of factors working over time scales from days to millennia could produce far worse “singular extreme events” of climate than ordinary El Niños.

We cannot predict at this point what theory, if any, will take the place of Perrier and Humbert’s hypothesis. Despite the application of new scientific techniques to a problem of the past, we find ourselves far from any explanation. We have learned, however, that in the complete absence of humans in Madagascar, fire and fire-adapted plants were present, and that catastrophic extinctions, like most natural phenomena, can be a complex business. Perhaps Madagascar, and indeed most islands and continents, have lost their large animals to a multiplicity of causes, some of which have yet to be discovered.
The arid southern and southwestern parts of the island support communities of succulent plants, including the bizarre members of the Didiereaceae family. Fossil pollen and animal bones collected at some sites in these regions show that, just a few thousand years ago, this landscape was also able to support plant and animal species that required a wetter habitat.
Lemurs Lost and Found

Three species of these primates are discovered alive and well and living on bamboo

by Patricia C. Wright

As far as I knew, there were two species of bamboo-eating lemurs in Madagascar: the gray gentle lemur, which weighed less than two pounds and ranged throughout the eastern rain forests, and the much larger greater bamboo lemur, which was dark gray with dramatic white ear tufts. Although the fossilized remains of the latter had been found throughout eastern, central, and northern Madagascar, only a single group was known, and these lived in barely forty acres of bamboo forest surrounded by a coffee plantation. Bernhard Meier and I had come on separate expeditions to see whether the greater bamboo lemur still survived in the southeastern rain forest, unlike the dozen or more Madagascar lemurs that went extinct between five hundred and a thousand years ago.

From 1900 to 1964, the greater bamboo lemur was thought to be extinct. Then André Peyrieras, a French naturalist, rescued one from the cookpot by buying it in a market near Vondrozo, west of Farafangana. Although he had it boxed, the animal escaped, and Peyrieras, an entomologist by profession, spent much of the next eight years desperately searching southeastern Madagascar for the lost lemur. In 1972, with Jean-Jacques Petter, he at last found a group living on the coffee plantation near Kianjavato. They captured two of them, and these lived in the National Zoo in Antananarivo for several years and produced two offspring before all four died. Corinne Dague, a student of Petter, had spotted an unidentified species of lemur in the southeast and this prompted Meier’s expedition.

As a behavioral ecologist, I was hoping to see one of the “fossil” lemurs alive. I would never see the gorilla-sized Megaladapis, which had once roamed the central plateau browsing on vegetation, or the slothlike Palaeopropithecus, hanging from trees and pulling branches to their mouths in order to eat leaves. Why would a species as widespread as the greater bamboo lemur disappear from so many areas? Maybe we would understand more about the mechanisms that caused all the giant lemurs to go extinct if we knew more about the ecology of this one, which appeared to be lost so recently.

My search began in the southeastern rain forest in 1986 with expedition coordinator Patrick Daniels. The flight over the central plateau north of Antananarivo was depressing. Less than a thousand years ago this bare moonscape was covered with woodlands and meadows and was the habitat of the greater bamboo lemur. Today, yawning, eroded chasms pit the barren, rolling hills, which are too infertile to feed even cattle.

The landscape on the road from Antananarivo to Fianarantsoa was also dry, with few native trees. (The central plateau is burned of vegetation each year during the dry season, and the burning hillsides are particularly dramatic at sunset.) Clusters of two-story adobe houses dotted the landscape, and barefoot men, women, and children walked along the road carrying firewood or baskets on their heads.

On the third morning of our drive we began to see forest. From Fianarantsoa a road went straight east to the Indian Ocean. The road followed the Namorona River, lazy at its source in the central plateau, but plunging into white-water rapids as we passed over the escarpment. As we traveled down the escarpment, the vegetation became lush. The rain forest mountains came as a great relief after the harsh, brown habitat of the deforested high plateau. Just outside the town of Ranomafana we sighted giant bamboo gracing the slopes along the white-water river. This looked like the kind of place where the greater bamboo lemur might still live.

We pitched our tents at the top of one of the mountains and began the search. Rain began to fall and continued for five days. With the help of our guides, Rajeriarison Emile and Loret Rasabo, we carefully searched up and down each of the steep, slippery, bamboo-covered slopes. We spotted other lemurs in the trees: a group of seven red-fronted lemurs huddling in the cold and a pair of rare red-bellied lemurs munching on fruits. We even glimpsed a small gray gentle lemur as it ate the leaf bases of a vining species of bamboo. Although there were traces of giant bamboo having been eaten by a bigger animal, the lemur that ate them remained elusive.

Week after week we searched the forested slopes near the Namorona River for the greater bamboo lemurs. I had just about given up hope when early one cold, misty morning, I caught a glimpse of a lemur clinging to a trunk, making loud tonking calls, and twirling its long, red tail.
in a circle, like a windmill. It was a golden red color with a short muzzle and short, furred ears that reminded me of the gray gentle lemur, but it was twice the size of that animal. I could hardly contain my excitement. Could this be the greater bamboo lemur? But then the animal disappeared, and despite our daily searches, we didn’t see it again. We decided to postpone further search in this area, get on with our general survey, and come back when the weather improved.

On the road to the coast we traveled through many forests, but along the coast, half of the green areas shown on our map, which were forested in the 1960s, were now bare, brown hills. The forests and giant bamboo around Vondrozo, where Peyrieras had bought the greater bamboo lemur in the market, were severely cut. In a four-mile-wide strip of forest remaining in the steep mountain nearby, we found only the gray gentle lemur. In Kianjavato, on the coffee plantation where the French scientists had captured the two greater bamboo lemurs in 1972, the plantation manager mentioned that he still saw lemurs in the forests. When we investigated, we found a large group of red-fronted lemurs jumping through the trees, making their guttural grunting alarm caw and a loud “yip, yip, yawww.” And then, just as it was getting dark, we heard another sound, a purring call ending in a long, cawlike crescendo. The large, gray animal that was making it was not up in the branches like the red-fronted lemurs, but was peeking out from behind the trunk of a small tree and showing its large, white ear tufts. Full of excitement, we counted eleven more of these animals, but because we didn’t have permission to do research at the coffee plantation, we had to postpone studying this group.

When we returned to Ranomafana, Meier had arrived from Germany and we discussed our plans to do behavioral studies on the bamboo lemurs. Meier was particularly interested in mapping bamboo patches and exploring regions where other groups of the rarely seen golden red bamboo lemur might live. I settled down to the long process of getting the shy group of four—a pair of adults, a juvenile about two years old, and a six-month-old—at the main study site to tolerate an observer. It took two months of careful following. After I returned to Duke University to teach, Meier continued the study.

The group moved about 400 to 1,000 yards each day, within a territory of about 100 acres of forest. They slept together in bamboo clumps above streams, in large tree ferns near ridgetops, in vine tangles, and in the crowns of palm trees. They ate bamboo, particularly the giant bamboo, almost exclusively. On the steep banks of the Namorona River, giant bamboo flourishes, growing up to forty feet high. Most months of the year the golden lemurs ate the tender young growing tips of this bamboo. They would chew off the end of this large asparaguslike treat and carry it to a nearby branch—a treasure to be shared and slowly relished. But in the cold, dry months of July and August when there were no new sprouts, this group ate the tough bamboo leaves. Only the basal half of the leaf was eaten and the remainder discarded. A trail of discarded leaves made it much easier to follow the group. The female led the way, with the juvenile and adult male about ten yards behind her. The youngest often trailed by as much as forty yards. The forest is dense and group members keep track of one another with a cawlike caw.

The golden bamboo lemurs begin browsing at dawn. They sometimes come to the ground to find a new sprout, but
The dense tropical forests, left, of eastern Madagascar provide cover and food for lemurs. The trees are often sixty or more feet high, and the lemurs make their way through the jungle by leaping from one narrow trunk to the next, rarely traveling more than three feet off the ground. When they feed and sleep, they move higher into the trees. Farmers clear-cut the forests, below, for cultivating hill rice, but the land remains fertile for only three years. It is then abandoned and begins to erode.

David Burney

most often they search high in the canopy where the quickly growing shoots arch above the steep mountain slope. Meier and I were surprised at how limited this group’s diet was. At midday the lemurs traveled up to the top of the canopy to nap in places where the giant bamboo made a lattice of branches. When the sun shone golden through the bamboo, the golden lemur’s all but disappeared. After two in the afternoon, the group began to browse and travel again. When they wanted to travel quickly, they leaped from trunk to trunk, landing feet first—an especially efficient means of locomotion in a forest with a great many tree trunks less than ten inches in diameter. If the lemurs wanted to be stealthy, they could move up into the canopy and hide or sneak away as slowly as slow lorises.

One day in July, while Martine Randriamanantena of the University of Madagascar and I were searching the forested mountains for new groups of bamboo lemurs, we discovered a site ten yards square where the ground was covered with foot-long strips of giant bamboo. The trunks of many stalks had been ripped apart and the inner pith eaten. The area looked like a spaghetti factory run amok or a streamer-filled Times Square. The pounds and pounds of fibrous green feces, intermingled with the shredded bamboo, was evidence that many bamboo lemurs had been here and stayed a long time. Yet, even though we had been following them day after day, I had never seen golden bamboo lemurs eat the trunks or thick stalks of bamboo. I rationalized that this behavior must occur at night, but I was still puzzled.

Meanwhile, Meier traveled back to Kianjavato to follow a group of charcoal gray lemurs with white ear tufts that we assumed were a color variation of the golden Ranomafana lemur. (The black-and-white ruffed lemur, for example, contrasts dramatically with its subspecies found on the Masoala Peninsula, the red-ruffed lemur.) The Ranomafana lemur was a rich red-gold with bright yellow-gold fur framing the face and throughout the underparts. The face was almost black, as was the tip of the tail. The back, forehead, and ears were a bronzer gold. Ears were close to the head and not obvious. In contrast, the Kianjavato animal was charcoal gray with a black face and conspicuous white ear tufts.

But Meier and I noticed other differences. Instead of a monogamous pair and offspring, seven to twelve of the large gray lemurs formed a single group. Two or three individuals huddled together when resting, but the social structure contrasted sharply with the group we had seen at the higher altitudes. The diet of the charcoal gray lemur was not entirely bamboo. They ate the bright blue flowers of the traveler’s palm, an endemic palm with leaves spread like a Chinese fan, as well as mangoes, figs, several understory palms, ginger leaf, forest cover grass, and hill rice crops. All the giant bamboo had long since disappeared from this nearly deforested lowland, and we wondered whether these other foods made up the gray’s natural diet or whether this diet simply kept the animals alive. Meier also confirmed a difference in calls that I’d noticed between the gray and our golden Ranomafana type. The golden’s purring was quite distinct, and the prolonged, raucous call that punctuated our Ranomafana evenings was never heard in Kianjavato. By the fall, we were convinced the two were separate species. But which one was the greater bamboo lemur? And what was the other?

Chromosomal analysis by Yves Rumper confirmed that these bamboo-eating lemurs were very different. The small group of Ranomafana lemurs that we had been studying was a new species altogether: the golden bamboo lemur. The Kianjavato group was the long lost greater bamboo lemur. But in Ranomafana, where we had been studying the new golden lemur, there was another surprise. David Haring, one of the Duke University field assistants, came across seven large, charcoal gray lemurs munching on wild grass near the trail. They jumped to the trunk of a nearby tree, emitted a scolding, whirring sound, and then settled back to feed. Each had large white ear tufts. During the ten months that Meier and I, along with our guides and field assistants, had been searching the two-square-mile study site, we had never come across these greater bamboo lemurs.

With Haring’s discovery we now had three species of bamboo-eating lemurs sharing this small territory: the greater bamboo, the golden bamboo, and the gray gentle. How were they all able to use the same food resource? Then I recalled that the site we’d found littered with shredded bamboo was very near where Haring had
While the gray gentle lemur eats the bamboo leaves, and the greater bamboo lemur tears at the trunk to feed on the pith, the recently discovered golden bamboo lemur, below, eats the tips of the new shoots. The two pounds of shoots that it eats each day contain enough cyanide to kill a human.

Bernard Meier; BIOS

found the greater bamboo lemurs. These animals were eating the bamboo trunks, while the goldens ate the young bamboo shoots and the gray gentle lemurs ate the leaves. Kenneth Glander of Duke University and David Seigler of the University of Illinois analyzed the different parts of the bamboo eaten by the different species, as well as species of bamboo not eaten by either.

Many species of bamboo are found only in Madagascar and some nine species of bamboo grow in this region alone. David Edelman, a bamboo expert from the Smithsonian who had joined our group, found that one bamboo had a unique flowering pattern. While others flowered all at once and then died, this species flowered at different times in different parts of this forest. This would make life easier for the bamboo lemurs that relied on this species. Glander and Seigler also had a surprise for us. The bamboo leaves that the gray gentle lemur ate were high in silica, a far different composition from the pith of the fibrous inner trunks on which the greater bamboo lemurs fed. The new shoots and growing tips on which the new species, the golden bamboo lemur, fed had little fiber and much protein but contained a level of cyanide that, in the amounts the lemur consumed, would kill a human. Neither the charcoal gray greater bamboo lemur nor the gray gentle lemur ever ate those ever-growing tips of the giant bamboo, and now we knew why. The three species of bamboo lemur, the only primates in the world known to live on bamboo, had evolved differences in physiology in order to share their main resource.

The large, charcoal gray lemur with the white ear tufts appears to be the same animal whose fossilized remains have been found among other extinct lemurs in the caves of the far northern areas of Madagascar and the central plateau. As far as we know, no museum has the skulls or skeletons of the new species in its collection. The southeastern rain forest is the only place where either of these species has been seen in this century. A change of habitat may have caused the extinction of this lemur in the north and on the central plateau where the fossils were found, but that cannot account for its absence in the remaining northern rain forest. Although bamboo lemurs are trapped or killed with slingshots in many areas, including Kianjavato where they raid rice fields, this has not resulted in their extinction. So another alternative may be that in some of the remote northern forests, other groups of greater bamboo lemurs survive. We just haven't found them yet. And if we can discover new species of lemurs in Madagascar, might not remnant populations of other fossil lemurs still exist?

Editor's Note: A new lemur may soon be named. Seen in northern Madagascar in 1979 by Ian Tattersall of the American Museum, this lemur, which was identified as a form of Propithecus diadema, may turn out to be yet another new species.

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Enter the Dragon

In recent years, China has become the new frontier of vertebrate paleontology. Fossil finds of dinosaurs, mammal-like reptiles, and early mammals rival or surpass those made anywhere on earth in number and importance. Although discoveries of “dragon bones” have been noted in the Chinese historical record for some 1,700 years, resources for excavation and research have until now been very limited. Finds made in China since the 1950s are comparable to those made in North America about the turn of the century, when the first complete, well-preserved fossil skeletons of extinct vertebrates were being found.

The most extensive collection of Chinese fossils ever seen in the Western world will be shown in “From the Land of Dragons,” an exhibition cosponsored by the Institute of Vertebrate Paleontology in Beijing and the American Museum of Natural History. Many fossils never before seen outside of China will be brought together with others found throughout the world in a comprehensive exhibition of more than seventy specimens, dating from the Permian (235-286 million years ago) to the Oligocene (25-38 million years ago). Eugene Gaffney, curator of vertebrate paleontology at the American Museum, notes that since “the Asian record is still only sparsely sampled compared with Europe and North America, all other exhibitions of Chinese fossils have been either just dinosaurs or casts or just a few skeletons.” Nearly all the main groups of amniotes, organisms whose embryo develops in a sac of fluid, will be represented. Extinct amniotes, the ancient relatives of modern land animals, include dinosaurs, lizards, snakes, birds, and mammals.

Synapsids, or mammal-like reptiles, first evolved during the Permian, before the rise of the dinosaurs, and ranged in stature from the size of a mouse to that of an ox. Synapsids reveal the evolutionary sequence in which our own mammalian lineage split off from other tetrapods 200 to 300 million years ago. “These animals are our closest extinct relatives,” says Timothy Rowe of the University of Texas, “and by looking at them we can learn about what our ancestors went through. They are the evidence of our history.”

The most notable characteristic of the synapsids was an opening in the rear of the skull, which all mammals, including humans, have retained. Therapsids, which arose during the late Permian, were synapsids named for the “beast arch” characterizing their more advanced jaw. One group of therapsids, the dicynodonts

Lystrosaurus
Illustrations from AMNH
From the Land of the Totem Poles

The Northwest Coast Indian Art Collection at the American Museum of Natural History
by Aldona Jonaitis

Less than a century ago, the Indian tribes living along the Northwest Coast of North America were under great pressure to forsake their cultural heritage. At stake were their religious practices, their mythology and customs, and their ancient way of life.

Franz Boas, a young curator at the American Museum of Natural History, later to become known as the "Father of American Anthropology," determined that this culture must survive, if not in daily practice, then within the protective walls of a great museum. In 1897, he launched what is still the biggest, most ambitious, and most important expedition in the history of American anthropology and gave impetus to the creation of the greatest collection of Northwest Coast art in the world.

Now, for the very first time, this extraordinary collection and the adventures behind its formation are available to you in a stunningly illustrated hardcover book, From the Land of the Totem Poles. Many of the specially commissioned color photographs are of objects of great magic and meaning—stunning works of art never before seen by the public. This outstanding book is enriched by rare archival photographs, many never previously published, of life among the Northwest Coast Indians as seen through the eyes of the nineteenth-century expeditioners. The rich and complex story of the expeditions, the art, and the Indians themselves is deftly woven by Dr. Aldona Jonaitis, one of the world's foremost authorities on Northwest Coast Indian art.

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Lotosaurus adentus

Lufengosaurus

(two dog teeth), had a pair of tusks covered by a horny beak. The dicynodonts, which will be prominently featured in the exhibition, were probably early vegetarians that developed dentition suitable for grinding plants and thus digesting cellulose. By exploiting a wide range of vegetation, these terrestrial herbivores were able to adapt into a broad spectrum of under-filled ecological niches. The two-tuskers were among the most successful of lineages, thriving for about sixty million years through the late Permian and Triassic before being displaced by dinosaurs.

One dicynodont, *Lystrosaurus*, is a subject of paleontological controversy. Its beak extended over its entire face and into the roof of its foreshortened skull. Some scientists have inferred from this and other features that the animal had a semi-aquatic life style, browsing for floating plant matter. Rowe believes, however, that *Lystrosaurus's* deep snout possibly evolved to withstand cranial collisions: "It may have used its skull in head-butting competitions for mates, much as mountain sheep use their horns."

The most spectacular find is a twenty-four-foot-long, twelve-ton slab containing the skeletons of nine dicynodont specimens. This and other dicynodont mass burials have suggested to some the possibility of group social behavior, but multiple trackways, usually associated with herding, have not been found.

This is the first time that dicynodont remains found on all continents, including Antarctica, will be displayed together. The close relationships among these widely scattered bone demonstrate that pre-Jurassic animals roamed a single supercontinent.

Archosaurs, the group of erect-postured vertebrates that includes dinosaurs and birds, will be represented by skeletons of some of the oldest species. *Lufengosaurus*...
saurus, a long-necked, long-tailed, heavy-limbed prosauropod, looks like a smaller forerunner of the brontosaurus. Datasaurus will be shown for the first time. "Only fragments of the skull have been described," says Gaffney, "and those are very ambiguous. It is a primitive sauropod, and it's a titanosaur or a diplodocid or whatever is still not really well known." Lotosaurus admentus has never been seen outside Asia. This mysterious archosaur was apparently beaked but toothless and had a dorsal ridge whose function is unknown.

Early mammals will also be on display; among them is Juxia, a primitive rhinoceros that is related to Indricotherium, the largest land mammal ever discovered. Sinoconodon, a tiny, shrewlike creature, is one of the oldest known mammals. According to Gaffney, "Sinoconodon is related to all mammals; it's very primitive." Says Rowe, "This represents a bottleneck in our own history. The first mammals were very tiny in size."

"From the Land of Dragons" will be in the American Museum's Gallery 1 from July 22, 1988, through January 1, 1989. In 1989, it will travel to Boston, Massachusetts, and Los Angeles, California.

Thomas R. Miller

At The American Museum

Pre-Columbian Art

Since the opening of the American Museum's Mesoamerican Hall in 1970, the collection of Ernest Erickson (1893–1983) has formed the core of the Museum's collection of pre-Columbian art. Born in Finland, Erickson spent more than forty years collecting and enriched the American Museum during his lifetime with some of the finest artifacts of their kind displayed anywhere. One hundred fifty of these objects will be shown in a special exhibition, Pre-Columbian Art from the Ernest Erickson Collection. The exhibition incorporates works from much of Mexico and Central America, some from as early as 800 B.C. Many of the pieces depict the human face and form in effigy vessels, painted ceramics, and stone sculptures. On display will be jade carvings from the Olmec, Mesoamerica's oldest known civilization; village models, animal sculptures, and human figures from western Mexico; stone replicas of Native American ball game equipment from Veracruz; Maya painted vases and Jaina figurines; and objects of wood and gold from the Mixtec and Aztec, including the Aztec teponaztli, an idiophonic log drum.

Pre-Columbian Art from the Ernest Erickson Collection will be on view in the Hall of Mexico and Central America from Wednesday, June 15, through Monday, August 15.

At The Planetarium

Science fiction has long captivated the popular imagination with tales of visitors from outer space. Today, scientists are using powerful signal transmitters, ultrasensitive receiving devices, robot spacecraft, and high-speed computers in a quest for contact with alien beings. Encounter: The Search for Extraterrestrial Life, a new Sky Show premiering June 29 at the Hayden Planetarium, examines the past and present pursuit of interplanetary communication and considers what an actual "close encounter" might be like. For more information call (212) 769-5920.

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Tracking the Tiger

by Ronald L. Tilson

I encountered my first wild tiger in Assam, a remote northeastern state of India, while searching for a field site to study primates native to the area. Early one day, while walking along a stream that sliced through Holongapar forest reserve, I discovered the imprint of a large, catlike paw in the mud. Water was beginning to seep into the paw's depression, just as it was seeping, I noted with some trepidation, into the tracks that I myself had just made. From its size I knew that a tiger had passed my way and was in all likelihood still dangerously close. I never saw the tiger, but from the surge of adrenalin I experienced, I may as well have. Since then I have tramped through other forests in Thailand, Malaysia, and Indonesia where tigers live, but I never did see one.

My experiences are not too unusual. Tigers are scarce and elusive animals; only a handful of biologists have had the good fortune to study them in the wild. Fewer still have had the opportunity to come to know tigers as individuals. In their book *Tiger Moon*, Fiona and Mel Sunquist give an account of their two-year study of tigers in the Royal Chitwan National Park of Nepal, which has as its backdrop the lofty, snow-capped peaks of the Himalayas. Although the book is an informed investigation of the social behavior and life history of wild tigers, it is also a personal account, as seen through the eyes of Fiona Sunquist and recorded in her diary. *Tiger Moon* is the story of what it is like to live and work in Nepal—not only the adventure and excitement but also the day-to-day grind of getting up, going out, and coming back without much to show for your efforts. For the most part, the Sunquists do a good job, and I only wish that more field biologists would similarly take the time and effort to document their experiences. Through time, such accounts become significant historical descriptions of an area's natural history, providing the baseline information that often does not get published in traditional journals.

*Tiger Moon* is full of unusual anecdotes: what it is like to be eye-to-eye with a short-sighted, one-horned rhinoceros; how it feels to have dangerously unpredictable sloth bears shuffle by, leopards prowl the campsite's perimeter, scores of brilliant birds flit overhead, and camp elephants reveal their personalities. Sounds punctuate the book: deer barking real or imagined predators, elephants trumpeting, parakeets shrieking, tigers roaring. It is the roaring that captures one's attention, for the tiger more than any other predator is a symbol of power, strength, and untamed wilderness.

Tigers are difficult animals to study in the wild. They are shy, secretive, and solitary. They move mostly at night across vast areas of thick jungle or tall grasslands. The Sunquists' study is based on data gathered from radio tracking tigers fitted with transmitters strapped around their necks. Each night the tigers' movements are plotted on field maps, and over the course of many nights, the tigers' approximate ranges emerge. Analysis of prey remains and prey hair found in scats adds to the knowledge of what the tigers are killing and eating. Following the trail of a tiger provides additional information about its social habits. And then there is the occasional roaring when tigers are fighting, courting, or just lamenting their solitary existence. Each piece of biological information is like a piece of a jigsaw puzzle that gradually takes form as more pieces are added. But it is a long and tedious process, and the most critical pieces are, of course, the most difficult to find. Thanks to the Sunquists we now have a clearer picture of wild tigers.

Tiger spatial organization is much like that of other cats. Females establish and

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Tiger Moon, by Fiona Sunquist and Mel Sunquist. *University of Chicago Press; $24.95; 183 pp., illus.*
A large male tiger basks in the sun.
Photographs by Fiona Sunquist.
maintain relatively small, exclusive home ranges of six to eight square miles, in which they hunt and raise their cubs. Males occupy ranges two to seven times larger than those of females, overlapping several female ranges but not ranges of neighboring males. Compared with tigers in other areas of their broad geographic range, the tigers of Chitwan live at extraordinarily high densities. In the Soviet Far East, for example, territories of females are as large as 160 square miles and widely overlapping, with males ranging over areas as large as 400 square miles.

The tigers maintain their territorial arrangements with a combination of visual signals, scent marks, and vocalizations. Both males and females deposit scent marks throughout their range at all times of the year by raking the ground with their hind feet, leaving feces in prominent places along roads and trails, and spraying urine onto vegetation. Just exactly what these signals convey to other tigers is unknown, but there is some understanding that these olfactory signals help convey information about individual identity, sex, and reproductive condition.

Male tigers have more turf to cover than females. Their objectives are to exclude other males and to insure that they are near any females in estrus. Both sexes accomplish this in part by long-distance vocalizations. Tigers reach sexual maturity at about three years of age. When females start cycling, they are receptive to males for only a short period. This window of opportunity is about five to seven days for courting and two to three days for copulating. If the female does not conceive, she will recycle every three weeks until she does. Once pregnant the female has a gestation of just over 100 days. Generally two cubs are born.

The demands of motherhood are clearly reflected in the increased need for food. The Sunquists noted that one particular tigress usually made a large kill once every eight days but was forced to make one kill every five or six days when she had two six-month-old cubs to provide for. Interestingly, although tiger numbers in Chitwan remained fairly constant during the Sunquists' study, three of the four prey species (sambal, hog deer, and barking deer) remained about the same, while one (chital) increased markedly. The numbers suggest that tiger predation is not limiting prey populations, a fact often overlooked by government wildlife officials whenever large carnivores are in conflict with national park policy.

At 416 square miles, Chitwan is the second-largest tiger reserve in the Indian subcontinent (the other is in the Sundarbans of Bangladesh). There are an estimated 150 to 200 tigers in the park and the surrounding forest, more than in most of the reserves in Asia. The Sunquists suggest that unless disease sweeps through the population or there is some dramatic ecological catastrophe, the tigers' long-term survival seems assured. I wish I could share their optimism, but I do not. There are two mutually exclusive perspectives that must be resolved in formulating a tiger conservation strategy. One is a numbers game; the other a political game. When avenues of dispersal are cut off, tiger populations become isolated and the deleterious effects of inbreeding—such as reduced female fertility and increased cub mortality—are increasingly likely to show themselves. The Sunquists write that the only way to get around the inbreeding dilemma is to transfer tigers from one reserve to another, thereby introducing new bloodlines into isolated populations. They suggest, however, that such introductions or removals of breeding males (or resident females) in order to increase genetic variance is undesirable because it would disrupt the animals' social system. I agree, but there are other options, which were not addressed, that would effect genetic exchange. Instead, I fear we are left with a blueprint for extinction.

Guidelines emerging from conservation
biology theory suggest that for a species like *Panthera tigris* a population must contain a minimum of several hundred breeding adults to guarantee long-term survival. These numbers are derived from genetic models in which every adult in the population breeds with a different mate each year, as in a captive situation. In the wild only adults with territories breed, often with the same mate several years in a row, so even greater numbers would be necessary to insure their evolutionary stability. The smaller the population, the faster genetic diversity is lost through random genetic drift. This means we must be prepared to provide periodic recolonization of habitat vacated by local extinction, as well as an exchange of genetic material between locally decimated populations. This will require the development of strategies for interactive management of the fragmented wild populations and use of captive populations for backup and support. Unfortunately, these problems of small numbers are not unique to the tigers of Chitwan. Tigers, with a global distribution extending from India across China to the Soviet Far East, and south through peninsular Malaysia to Indonesia, are steadily declining in every part of their range with only a few exceptions. Three of the originally recognized eight subspecies are now extinct; a fourth is near extinction. The remaining tiger populations, with the possible exception of the Sundarbans population in Bangladesh, are all too fragmented and too small for long-term survival.

In India there are now sixteen designated tiger reserves that serve to protect about 4,000 tigers, a vastly improved situation from what tigers faced barely twenty years ago, when their numbers were less than half what they are now. Project Tiger arose out of genuine national and international concern for the dramatic decrease in the Bengali tiger's numbers. It was formulated along an ecosystem approach that protected sizable populations of tigers in conservation areas of biological importance. Central to the concept was the realization that tigers and humans come into conflict when they share the same space or resources. The idea was to create a core area that would be used exclusively by tigers, surrounded by a buffer zone that would be more multipurpose, both for tigers and for humans. In the buffer zone, young adults, especially males, could hang out and wait for openings to appear in the core area. Older tigers, displaced from core areas, would have a place to retire. Finally, as the reserve becomes surrounded by villages and increasingly isolated, buffer zones become critical because they help reduce the probability of tigers coming into contact with villagers or their livestock. Once a tiger starts killing either humans or livestock, promoting a conservation ethic in the local community becomes extremely difficult. It becomes a political game.

The situation in Nepal, specifically in the Chitwan National Park, illustrates the problem at its most acute. In one of the world's most magnificent, yet poorest, countries lives an expanding population of some 16 million human beings. In their struggle to survive, these people have been steadily reducing their forests, and because so much of Nepal is vertical, the soil is easily washed away. Despite the almost overwhelming problem of preserving potentially prime agricultural areas for wildlife in the midst of a land crisis, Nepal is ardently committed to saving the tiger, because the tiger and the environment it occupies have become one and the same, a national heritage and a symbol of what is at stake. *Tiger Moon* is a chronicle of this symbolism, told passionately and accurately.

Ronald L. Tilson is the director of biological programs at the Minnesota Zoo. He is also an adjunct professor in the Department of Wildlife and Fisheries at the University of Minnesota, a co-coordinator of the Species Survival Plan for Siberian tigers, and coeditor of Tigers of the World (Noyes Publications).
How Soon the Moon?

by Thomas D. Nicholson

The U. S. Naval Observatory invites cooperation in a project designed to solve an old astronomical question: how soon after new moon can the very slender crescent moon be seen? Interested sky watchers can send their sighting reports to the observatory in Washington, D.C.

The question is not an idle one. Even today, the sighting of the new crescent moon marks the beginning of the month in some Islamic countries. Astronomical tradition suggests that the crescent can be seen under good conditions as soon as eighteen hours after the moon and the sun come in line, but this piece of received wisdom has not been well tested. It isn't even clear that a one-day-old moon (twenty-four hours after new) can be seen. By inviting sky watchers to make observations after the new moon of July 13 this year, the observatory hopes to shed light on the matter. It could help those calendar makers who use the ancient rule of beginning the month when the moon can be seen to predict lunar visibility.

July was chosen for the undertaking because the thin crescent moon is in an exceptionally favorable position that month for early sighting by Northern Hemisphere viewers; an opportunity that comes about every nineteen years. The moon is nearly at its most northerly position in the twenty-four hours immediately following new moon in July. This July is especially good because the tilt of the moon's orbit relative to that of the earth takes the moon practically as far into the northern sky as it ever gets, as much as 28°5 above the earth's equatorial plane (see "Celestial Events," July 1987).

The key date is July 14; the time is about half an hour after sunset; the direction is toward the sunset glow, low in the sky. There is no chance of seeing the moon on July 13 anywhere in Europe or North America; it is only a few degrees from the sun and sets while the westerly sky is simply too bright for viewers to see the slim crescent. But by sunset on the 14th, the moon is another 13° away from the sun, and nearly that much more above the horizon, setting forty minutes or more after the sun. The darker sky and thicker lunar crescent make it easier to see.

Observations can be made on the 14th from about twenty-one hours after new moon in eastern Europe to twenty-three hours in England, twenty-eight hours along the eastern United States, thirty-one hours in western North America, and thirty-three hours in Hawaii. Viewers should give the observatory the time (specifying whether standard or daylight-saving) and place of observation.

Reports can be sent directly to Looking for the Moon, U. S. Naval Observatory, Washington, D.C. 20392-5199, or to Celestial Events, Natural History.

Events in the calendar below are given in local time unless otherwise indicated.

July 1: The moon, three days past full, rises in Capricornus after 9:00 p.m. but is too bright to allow the constellation's dim stars to be seen.

July 2: Perigee moon (nearest the earth) is still in Capricornus.

July 4: Venus resumes its easterly motion after its retrograde motion took it to the sun's right. It is a morning star, low in

Following new moon at 4:53 p.m., EST, on July 13, the crescent (a) for East Coast observers is barely east of the sun and well below the horizon a half-hour after sundown. A half-hour after sunset on the 14th, the slender moon (b) is about 7° higher and possibly visible. (It is even higher in California—about 7:00 p.m., PST.) The wider crescent moon on the 15th (c) is about twice as high as on the 14th and easily visible. At comparable phases ten years ago (a', b', and c'), when the moon's path was more southerly, early evening viewing was more difficult.
Celestial Events

the east-northeast before sunrise. Ruddy Mars rises shortly after the moon before midnight. It is a morning star, like Venus, but is becoming more prominent in the evening hours as well.

July 5: Earth is at aphelion, its greatest distance from the sun.

July 6: Last-quarter moon, rising about midnight, occurs at 6:36 a.m., EST, in Pisces. Mercury, in the morning sky with Venus, is at greatest westerly elongation but poorly placed for viewing.

July 7–8: Bright Jupiter and Venus are visible in the east below the late crescent moon before daybreak.

July 9–11: The moon highlights Jupiter and Venus nicely in the dusk sky. It is above Jupiter on the 9th, between Jupiter and Venus on the 10th, to the left of Venus on the 11th, and in Taurus all three mornings. The 11th may be the last morning on which to see the waning crescent.

July 13: New moon, at 4:53 p.m., EST, is in Gemini.

July 14–15: The moon will probably be visible on the 14th, and certainly on the 15th, as a slender crescent in the sunset glow.

July 16–18: The crescent moon passes close to Regulus, Leo’s bright star, on the 16th, occulting it at about 9:00 p.m., EST, in twilight, just before moonset for East Coast observers. The moon moves left from Regulus on the 17th, when apogee moon (farthest from the earth) occurs.

July 19–22: Passing through Virgo, the rapidly growing gibbous moon shifts from Spica’s right on the 21st to its left on the 22d, when it becomes a first-quarter moon at 9:14 p.m. Venus is at greatest brilliance in the morning sky on the 19th, even though it has been moving away from the earth since becoming a morning star in mid-June. Its waxing phase accounts for the brightening.

July 24: The moon is just below Scorpius’ reddish star Antares. The distance between them closes slowly until about
midnight, EST, when the moon occults the star over the Southern Hemisphere. The bright object to their left is Saturn.

July 25–26: The moon is well south of Saturn as it moves from the planet’s right to its left while passing through Sagittarius. Approaching full, it appears rather low in the south these evenings.

July 28: In Capricornus again, full moon is at 10:25 P.M., EST, spoiling chances for the southern Delta Aquarid meteors to be seen. The peak rate is about fifteen to twenty meteors per hour and they are usually not very bright.

July 30: The month’s second perigee moon comes about twenty-nine hours after full moon, causing the full-moon spring (maximum) tide to lag a day or so.

July 31: The wandering gibbous moon brightens the sky from 9:00 P.M., EST, to dawn, overpowering the dim stars of Pisces and Aquarius. Mars, noticeably brighter than it was at the beginning of the month, adds its luster to this part of the sky after it rises about 10:00 P.M., EST.

The summer Sky Map identifies constellations and stars for the months of July, August, and September from 40° north latitude at the hours given below. To use the map, hold it vertically in front of you with south (S) at the bottom and match the lower half with the stars you see facing south. As you face in other directions, turn the map to bring the corresponding compass direction to the bottom. The stars move westward continuously during the night. By morning (before dawn), those on the western half of the map will have set, those on the eastern half will have moved into the west, and new stars (those of the fall evenings) will have risen in the east. The map represents the sky at about 1:30 A.M. on July 1; 12:30 A.M. on July 15; 11:30 P.M. on August 1; 10:30 P.M. on August 15; 9:30 P.M. on September 1; 8:30 P.M. on September 15; and 7:30 P.M. on September 30. Add one hour for daylight time. The map can also be used for an hour or more before and after the times given.
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Measure for Measure

Only in America do we measure dry ingredients with a cup

by Raymond Sokolov

Of all the things that identify us as Americans and set us off from other peoples, the least ambiguous—and most seldom noticed—is the measuring cup.

The Dominicans and even the Japanese play baseball seriously. French designers make the sexiest blue jeans, and Russians wear them. Yet nowhere else but in these United States does an entire nation habitually and almost exclusively measure dry ingredients with a cup.

In the cookbooks of other twentieth-century nations, when an author wants to specify how much flour to use for a cake, that author will give the amount by weight. Most countries use the metric system and cooks are accustomed to weigh out so many grams of flour on a kitchen scale. In Britain, ounces and pounds coexist with grams, but modern books virtually all assume some kind of scale will be used for measuring flour, as well as sugar and many other ingredients that we on this side of the Atlantic persist in doing out by volume instead of weight.

I say we persist, because measuring by volume—by the cupful and by half and quarter and third of a cup—is old-fashioned and inaccurate and clumsy, notably so for flour. The scale is the ideal, scientific way to measure flour. It allows you to repeat a recipe with virtually the identical amount of flour the author used. One hundred grams of flour is 100 grams of flour. But a cup of flour may vary in weight by wide margins from one kitchen to another or from one day to another. Flour settles in the bag or canister, so that more weight takes up less space. That is why we Americans sift flour, attempting to undo the effect of gravity and to create a uniform lightness that will match the lightness of an equal volume of sifted flour as measured by the cookbook author.

All of us who have spent lifetimes with cups in hand know that the system fundamentally works. We would probably be getting more predictable results with bread and cakes if we switched to scales, but we get by all right with cups. The question is, how did we get to be cupmen and cupwomen in the first place?

Before I looked at the historical record, I had always supposed that there were two possible answers. One was that cups were a vestige of antique British and European practice that survived here long after the Old World had latched on to the scale. In much the same way that pockets of obsolete British dialect still flourished in remote parts of this country, the cup, I reasoned, might have lingered here. After all, our system of weights and measures itself preserves eighteenth-century British practice and remains unaffected by 200 years of metrological reform.

The metric system was introduced in France in 1790. That was the year the U.S. Constitution was ratified, granting Congress the right to "fix the standard of weights and measures." Congress had already broken from the English monetary chaos of shillings and pounds and substituted a decimal currency. George Washington was eager to make similar progress in redefining weights and measures. He asked his secretary of state, Thomas Jefferson, to devise a plan, and Jefferson came up with two, which he submitted to the House of Representatives on July 4, 1790. The first plan proposed taking weights and measures then in use and standardizing their definitions throughout the country. The second plan opted for a decimal system but not the metric system (which was based on fundamental mea-
A Matter of Taste

surements then practicable only in Europe; also the United States had not been included in the diplomatic ceremonies heralding the adoption of the metric system in France).

Congress, as it would so often in the future, vacillated. Twenty-five years passed. In 1816, President Madison urged Congress to act and called upon the secretary of state, John Quincy Adams, to prepare a report. After due consideration, Congress established uniform standards of weights and measures in 1836. Basically, after nearly fifty years of dithering, the country had settled on a scientifically uniform version of a British system that Britain itself had abandoned in 1824.

In that year, the British Parliament, hoping to escape from the chaos of a medieval system with many separate standards of capacity, voted to establish a single, "imperial" gallon consisting of "10 imperial pounds weight of distilled water weighed in air against brass weights with the water and the air at a temperature of 62 degrees of Fahrenheit's thermometer and with the barometer at 30 inches." This reform also unified British measures of capacity: a dry measure ounce in the imperial system has a volume of one fluid ounce. As a result, liquid and dry measure terminology became conveniently interchangeable.

Back in the United States, we kept the old gallon, which weighed 8½ pounds, or 133⅓ avoirdupois ounces, but was also equal to four 32-ounce quarts, which is to say, 128 fluid ounces. Because of this fundamental incompatibility with the imperial gallon system, we drifted irrevocably apart from England in the way we measured food.

In Britain, the imperial pint has 20 ounces (there are 10 pounds, or 160 ounces, in an imperial gallon, remember, and, as always, 8 pints per gallon). But a pound in Britain has remained 16 avoirdupois ounces. This means that in Britain, a cook who tried to use a measuring cup would have to keep two proportional systems in mind at all times, one based on fractions of 16, for weight measurements, the other based on fractions of 20, for volume measurements. We can use both weight and cup measurements without strain because, for us, both are based on a "scale" of 16. Which explains, in some measure, why we use cups in the first place.

For us, the old saw "a pint's a pound the world around" is, in a technical sense, true. Our liquid and solid measuring systems converge almost magically at the same number. Obviously, this does not mean that a pound of lead weighs the same as a pint of lead. But a pint of butter actually does weigh a pound. A pound of all-purpose flour, according to Julia Child's table of weight-volume equivalencies in Mastering the Art of French Cooking, is roughly 4½ cups, an easy measurement with a single, graduated cup, and quite close to scale accuracy, especially in a log cabin on the frontier, where no scale was available. Similarly, sugar works out to a relatively convenient 2½ cups per pound. And since eggs come in easily counted quanta (better to weigh them, too, but who does that anywhere outside professional kitchens?), the pioneer housewife with a single measuring cup was in a good position to measure all the main ingredients for a cake or for bread with more than passable accuracy.

This was my second theory, the Cone-toga theory of cup measurement. It asserts that pioneers and homesteaders heading west did not bother lugging heavy metal scales with their weights. They measured with cups, any old cups, not necessarily measuring cups. You could get by with a teacup after a little experimenta-
tion. A full cup was a workable volumetric module, whatever its actual capacity.

The Conestoga theory is a nice little theory, and it has the authority of food historian Karen Hess behind it. In the notes to her scholarly facsimile edition of Mary Randolph's *The Virginia Housewife* (1824), she endorses the theory while sneering at the inaccuracy that measuring cup measurements would produce with flour. But there is no direct evidence that I can find that supports the Conestoga theory. Logic is behind it, but the written evidence of early American cookbooks does not depict a nation without scales.

Amelia Simmons in *American Cookery* (Hartford, 1796), the first cookbook published by an American in the United States, usually gives quantities for flour and sugar by weight. Perhaps she reflects frontier practice when she calls for Indian (corn) meal by the pint. But the bulk of her recipes imply a scale.

Almost thirty years later, Mary Randolph sometimes calls for flour by the pound, sometimes by the quart. The same vacillation between cup and scale is also a feature of Lydia Maria Child's *The American Frugal Housewife* (1828). She, too, seems to prefer volume measurement for her more obviously indigenous baking recipes: Indian cake, doughnuts, shortcake. You could argue that this split in method implies an ultimate European source for the scale-based recipes and an American source for the ones that measure by volume. Indeed, it would be tempting to posit an early nineteenth-century America in which the cup was displacing the scale in northeastern cities such as Hartford, in a kind of backwash from the backwoods.

It's impossible to say it didn't happen that way, and appealing to think that it did. But volume measurement didn't start in this country. The most important cookbook in England in the eighteenth century, Hannah Glasse's *The Art of Cookery Made Plain and Easy* (1747) called for "three quarts of fine flour" in a gingerbread recipe. And more than a century later Mrs. Beeton gave quantities for the main ingredients of a Christmas cake for her British readers in teacups.

Clearly, cooks in America and even in Britain vacillated between measuring by volume or by weight well into the nineteenth century. Volume measurement was, on the not entirely persuasive evidence of cookbooks, of growing importance in this country, and of small significance in Britain. But our mission is not to gauge the degree to which the scale had lost ground in one part of America or another, at one time or another—even if the evidence for such a task exists.

We have something much more dramatic and improbable to ponder and, perhaps, to explain. We want to know why volumetric measurement, based on an 8-ounce (half-pint) cup has come to dominate American cookery almost completely. Recipes developed with cups on the frontier could easily have been converted to weight equivalents back in Hartford or at the Boston Cooking School. And the woman who had to make do without her scales could have ordered a set as soon as she set her new house in order. Real frontier conditions didn't last that long for most people. Scales were not rarities in nineteenth-century America. We ought, moreover, to have expected that the scale would reassert itself everywhere as civilization crept westward across the land.

But it didn't. In 1896, Fannie Farmer's *Boston Cooking-School Cook Book* completed the cup revolution. The scale had all but vanished, swept away by the peculiar conviction that cup measurement was the way of modern science. In the prefatory section, "How to Measure," Mrs. Farmer wrote: "Correct measurements
are absolutely necessary to insure the best results… Tin measuring cups, divided in quarters or thirds, holding one half-pint, and tea and table spoons of regulation sizes—which may be bought at any store where kitchen furnishings are sold—and a case knife, are essentials for correct measurement.” But where did Mrs. Farmer learn to love the cup? And why didn’t she choose the far more scientific scale?

The rise of the manufactured, graduated half-pint measuring cup can be traced as far back as 1846. (I owe the documentation that follows to Lynne Belluscio.) In Miss Beecher’s Domestic Receipt Book, Catherine Beecher, the first evangelist of home economics, recommended converting weighed recipes to measured recipes, for convenience sake: “It saves much trouble to have your receipt book so arranged that you measure instead of weighing. This can be done by weighing the first time, and then having a small measure cup, and fill it with each ingredient you have weighed. Then note it down in your receipt book, and ever after use the same measure cup.” It seems clear that Miss Beecher was using an ordinary cup as a module, but her influential example seems to have created the need for a standard “measure cup” with internal graduations for greater accuracy.

By 1880, the most famous cooking teacher in America, Maria Parloa of Boston, was writing recipes with measured quantities, and she advised readers of her New Cookbook and Marketing Guide that “the quart measure for milk is the best for common measuring. Being divided into half pints, the one vessel answers for all quantities.” An engraving of such a quart measure is inset into the paragraph. No doubt, Miss Parloa had found these quart measures already in existence for use in commercial dairies and had adapted them to the new fashion of measuring in domestic kitchens.

Before the decade was out, equipment manufacturers had realized the need for a smaller cup and had begun making one. In her recent study of cooking at the turn of the century, Perfection Salad (Henry Holt and Co.), Laura Shapiro quotes Sarah Tyson Rorer, the influential Philadelphia food journalist writing in 1887: “…a small tin kitchen cup that has recently made its appearance in our market. They are sold in pairs at various prices… one of the pair is divided into quarters, and the other into thirds.” Although Rorer doesn’t specify the capacity of these cups, the division into thirds is an innovation and would make no sense except for the relatively small quantities measured in half-pint cups. And so, at long last, the true measuring cup, the emblem of Beecherite convenience and domestic science, took its place in our kitchens.

But even Fannie Farmer, a committed acolyte of Beecher and Parloa’s vision of the kitchen as labor-saving laboratory, did not abandon weight completely in the first edition of her famous book. The cup holds sway almost everywhere in that cheerless tome, except when Farmer sets down her recipe for the ne plus ultra of avoidipus cookery, pound cake. Like dozens before her, Mrs. Farmer calls for a pound each of butter, sugar, and flour. The recipe itself is misleading and vague. I much prefer a modern one, worked out in cups. Those equal weights in the original Fannie Farmer are suspiciously symmetrical.

Raymond Sokolov is a writer whose special interests are the history and preparation of food.

<table>
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<tr>
<th>Fannie Farmer’s Pound Cake</th>
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<tr>
<td>1 pound butter</td>
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<tr>
<td>1 pound sugar</td>
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<tr>
<td>Yolks 10 eggs</td>
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<tr>
<td>Whites 10 eggs</td>
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<tr>
<td>1 pound flour</td>
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<tr>
<td>½ teaspoon mace</td>
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<tr>
<td>2 tablespoons brandy</td>
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Cream the butter, add sugar gradually, and continue beating; then add yolk of eggs beaten until thick and lemon colored, whites of eggs beaten until stiff and dry, flour, mace, and brandy. Beat vigorously five minutes. Bake in a deep pan one and one-fourth hours in a slow oven...

<table>
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<tr>
<th>Pound Cake</th>
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<td>(From The Fannie Farmer Cookbook, 12th edition, revised by Marion Cunningham with Jeri Laber, Alfred A. Knopf, 1979)</td>
</tr>
<tr>
<td>½ pound (225 g) butter</td>
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<tr>
<td>1⅛ cups (325 g) sugar</td>
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<tr>
<td>5 eggs</td>
</tr>
<tr>
<td>2 cups (280 g) cake flour</td>
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<tr>
<td>1 teaspoon salt</td>
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<tr>
<td>1 teaspoon vanilla or ½ teaspoon mace</td>
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Preheat the oven to 325° F (165° C). Butter and lightly flour a 9-by-5-inch loaf pan. Cream the butter, slowly add the sugar, and beat until light. Add the eggs, one at a time, beating each in well. Stir in the flour, salt, and vanilla or mace and combine well. Spoon into the pan and bake for 1½ to 2 hours, or until a toothpick comes out clean. Cool in the pan for 5 minutes before turning out onto a rack. Serve very thin slices.

Yield: 1 loaf

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A perch had to get up pretty early in the Eocene to make a go of it in what was clearly a fish-eat-fish world. The Rocky Mountain basins of the western United States, now bone dry, were jungles then. Tropical fish shared palm-shaded lakes with crocodiles, alligators, and stingrays. Over a three-to-four-thousand-year period some fifty million years ago, animals that died and fell to the bottom of lakes were layered in a combination of sediments that, as they dried, preserved the bones in limestone. A perch, *Mioplosus*, and a herring, *Knightia*, are two of the most common fossil fish found in the Green River formations of Colorado, Utah, and south-western Wyoming. The ancient perch were evidently as voracious as their descendants. When this perch fry tried to swallow whole a herring far too big for it to handle, the results should have been obvious. But one theory suggests that young fish sometimes have poorly developed nervous systems: they may have big fish appetites and big fish ambitions before they’re big fish. In this case the comeuppance was fatal. A fossil with a moral? Or just a tale that’s hard to swallow.—B.D.S.

Photograph
by John Cancalosi
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Authors

H. Jane Brockmann (page 32) is an associate professor of zoology at the University of Florida in Gainesville, where she teaches animal behavior and evolution. Brockmann studied the burrowing behavior of digger wasps for her doctoral work from the University of Wisconsin, but it was her postdoctoral work with Richard Dawkins at Oxford University that, she says, “really got me thinking about alternative mating strategies and other questions of behavioral ecology.” Having watched pipe-organ mud-dauber wasps for years, she knew that the males guarded the nests and that the species had interesting nesting and provisioning behavior. So when she wanted to study a species in which reproductive success could be measured, she turned naturally to mud daubers, which are both conspicuous and common in the South. Much of her work on mud daubers has been done in collaboration with biologist-mathematician Alan Grafen of Oxford. When not studying hymenopterans, Brockmann enjoys bird watching and archaeology. For those who want to learn more about wasps, she recommends Wasps, by Howard E. Evans and Mary J. West Eberhard (Ann Arbor: University of Michigan Press, 1970), and Insect Behavior, by Robert W. Matthews and Janice R. Matthews (New York: John Wiley & Sons Inc., 1978).

Patience is the first requirement of a nature photographer, and John Cancalosi (page 84) says he waited in a blind for forty million years to get just the right shot of a fossil fish for this month’s “Natural Moment.” In the meantime, he worked on his master’s degree in zoology at Colorado State University and began “Vida,” a series of education films on wildlife that is shown in schools in Colorado, Wyoming, and his home state of Arizona. He is pictured here giving Arizona schoolchildren a demonstration of how to handle a boa constrictor. Cancalosi lives in Tucson but spends much time traveling, especially to Australia, where he does a great deal of wildlife photography. The fossil was a specimen held by Green River Geological Laboratories; Cancalosi photographed it with a Nikon FE2 fitted with a 55-mm micro/Nikor lens.
“When I was growing up in Texas,” says Don B. Wilmeth (page 38), “the circus was one of the few forms of entertainment available on an annual basis. Ringling Brothers had a lasting effect on me.” Wilmeth (above) is a professor of theater arts and English at Brown University in Providence, Rhode Island. For those who share his enthusiasm for the circus, he suggests reading The American Circus, by Wilton Eckley (Boston: Twayne Publishers, 1984), or A History of the Circus, by G. Speight (San Diego: A. S. Barnes & Co. Inc., 1980). Edwin Martin (below) began to take pictures seriously in 1980, after spending twelve years in the philosophy department at the University of Indiana. In 1987, he earned his master’s degree in journalism and now teaches both philosophy and journalism. From 1983 to 1986, Martin traveled around the United States photographing circuses.

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After working with rare plants and animals in North Carolina and studying cheetahs in Kenya, zoologist David A. Burney (page 46) became curious about the many creatures that became extinct in geologically recent times. He hopes that by learning more about the human and environmental factors that caused extinctions, scientists will be able to help save endangered species. In this issue, Burney (left), along with Ross D. E. MacPhee, a paleontologist and mammalogist (right), reports the results of a multidisciplinary effort to understand prehistoric events in Madagascar. A research associate in Duke University’s Department of Anatomy, Burney contributed to the identification of the island’s fossil pollen and analyzed satellite imagery to map vegetation. MacPhee, an associate professor in the same department, collected and studied animal remains. For additional reading, they recommend “Extinctions in Madagascar: The Loss of the Subfossil Fauna,” by Robert E. Dewar, in Quaternary Extinctions: A Prehistoric Revolution, edited by Paul S. Martin and Richard G. Klein (Tucson: University of Arizona Press, 1984); and “Environment, Extinction, and Holocene Vertebrate Localities in Southern Madagascar,” by R. D. E. MacPhee (National Geographic Research, vol. 2, 1986, pp. 441–55).

When Pat Wright (page 56) felt that her pet night monkey was in need of a mate, she scoured the pet shops, without success, and then went to the Amazon to find one. She “fell in love with the rain forest” and has since worked in the Philippines, Borneo, and Madagascar. Her work on night monkeys led her to study Madagascar’s gray gentle lemurs, a species that leads a life similar to that of the Amazon monkeys. Her studies led the Malagasy government to make the rain forests surrounding Ranomafana a national park to preserve the three species of bamboo-eating lemurs that live there; surveys will begin this summer. Wright says her only work outside of lemurs, conservation, and teaching primate anthropology at Duke University is raising her daughter, Amanda. For further reading on Madagascar, there is Alison Jolly’s A World Like Our Own: Man and Nature in Madagascar (New Haven: Yale University Press, 1980) and The Primates of Madagascar, by Ian Tattersall (New York: Columbia University Press, 1982).
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Letters

Postscripts

Olympics B.C. Judith Swaddling

Although the official prizes were only crowns of olive, the ancient Olympics were popular—and profitable—extravaganzas.

This View of Life Stephen Jay Gould

In a Jumbled Drawer

This Land Robert H. Mohlenbrock

Indian Creek, Missouri

Reviews Erin Younger

Hopi Village Views

Nature's Infinite Book Jared M. Diamond

The Last First Contacts

Feeding on the Fly J. Christopher Haney

Marine life and seabirds gather and feed along narrow ocean fronts. Unfortunately, pollutants concentrate there, too.

Of Time and the Forest

The 16.8-million-acre Tongass National Forest in southeastern Alaska is the last great primeval rain forest in North America. Because much of it is remote and economically worthless scrub, the preserve has been ignored by the lumber industry—and scientists. But time and Congressional acts have changed that. This special report highlights the recent natural history research at a moment when Congress is again considering the fate of the 10,000-year-old forest.

Silent Music Matthew D. Kirchhoff

Endless Battles, Verdant Survivors Paul Alaback

Little Deer in the Big Woods John W. Schoen and Matthew D. Kirchhoff

Fish among the Trees Stan Gregory

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Making and Breaking the Tongass

Celestial Events Thomas D. Nicholson

August Showers

At the American Museum

A Matter of Taste Raymond Sokolov

The Glasnost Gourmet

The Natural Moment Photograph by Nancy Sefton

Goosefeathers

Authors

Cover: The bald eagle soars at the top of the complex food chain in the immense rain forest along North America's northwest coast. The last virgin stands of this great forest are found in Alaska's Tongass National Forest. A special report begins on page 40. Photograph by Erwin and Peggy Bauer.
The world-renowned tropical bird artist Etienne Demonte creates his first works in porcelain—portraying six exotic birds in brilliant hand-painted porcelain.

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Head-bashing Gulls

I was both amused and delighted by gull researcher Larry Spear’s experiences with the recognition capabilities of western gulls on Southeast Farallon Island (“The Halloween Mask Episode,” June 1988). But one sentence of his article especially captured my attention. Describing the well-known swoop-and-bomb maneuvers of colony residents, Spear notes that “once, presumably through miscalculation, a gull struck the back of my head” (emphasis mine). Spear is either very lucky or western gulls exhibit consider-
ably more restraint than the ring-billed, California, and glaucous-winged gulls I study. Human head bashing, I am convinced, occurs through no miscalculation on the part of these feisty critters. I have been hit so many times by fistful feet that a hard hat is now a standard accessory to my motley colony toggery. Rarely, I have been hit by the belly of a swooping bird, presumably (and here I agree with Spear) through miscalculation.

JAMES L. HAYWARD
Berrien Springs, Michigan

Frost’s Walls

In his June 1988 column, Stephen Jay Gould repeats a common confusion regarding Robert Frost’s poem “Mending Wall.” Gould states that “as a New Yorker now resident in New England, I tend to side with Frost on the correlation between good fences and good neighbors.” If Professor Gould does in fact believe “good fences make good neighbors,” he finds himself on the side of Frost’s neighbor, whose unexamined clichés about neighborly relations Frost challenges in his famous poem. The poem’s narrator, whom we presume is Frost, asks of fences, “Why do they make good neighbors?” and states:

Before I built a wall I’d ask to know
What I was walling in or walling out,
And to whom I was like to give offense.

The narrator’s neighbor is apparently capable of none of these questions, and the narrator comes to see him as one who dwells in the darkness of his own ignorance:

... like an old-stone savage armed.
He moves in darkness as it seems to me,
Not of woods only and the shade of trees.

The neighbor indeed is made to seem much like our cliché of the Neanderthal, who lives by prejudice and superstition and cannot use consciousness to inform his condition. By contrast, it is Frost who demands that we examine our clichés, particularly as they determine our social relations. As his narrator repeats, “Something there is that doesn’t love a wall, that wants it down.”

Perhaps Gould, who has always seemed an opponent of the unexamined life, will reread his Frost and review his notions of good fences and good neighbors.

DAN DORRITIE
Davis, California

Possible Climates

In “Caterpillars on Ice” (January 1988), the author makes the following claim about the Alexandra Fiord lowlands on Ellesmere Island: “The glacial ice, acting as a parabolic reflector, focuses the sun’s rays on the lowland, melting the snow and uncovering the plants beneath.” From that description, and from the one photograph of the terrain she is describing, I think it quite unlikely that any such “parabolic reflector” existed. Even if it did, it would not account for any increased melting of snow in “the bowl-shaped lowlands.”

In the first place, parabolic shapes are not the result of typical natural forces acting on terrain: exfoliating material from mountains under the pull of gravity, accumulation of ice on such talus, drifting snow, blowing sand, etc. In the unlikely event that such a parabolic shape were to be formed on the surface of the earth, the cover of glacial ice described by the author would produce diffuse reflection rather than the spectacular reflection necessary to produce focusing. Even if these two conditions could be satisfied, a third factor would make impossible the effect claimed by the author: the focus of any such parabolic surface would be in the air high above it. At that point, the heat would be reradiated away from the earth and the lowlands that are the supposed beneficiaries of this thermal bath.

Later there is another questionable statement: “Eventually the heat radiates upward, preventing cloud formation and consequently minimizing local precipitation.”

On the contrary, the conditions the author describes would be ideal for local cloud formation: The heated earth would evaporate the surface water that it stores is present. The moisture-laden heated air would rise. Cooling as it rises, water vapor would precipitate. Presto chango, clouds!

RICHARD G. GOULD
Washington, D.C.

Editor’s Note: According to Claude Labine of Campbell Scientific Canada and an authority on the Alexandra Fiord lowland microclimate, Mr. Gould’s observations are quite valid. While reflections from the nearby glacier and sea ice do increase radiation to the lowland, the reflection is not focused or concentrated by a parabolic surface. The many clear days are not a product of upward-radiating heat, but are more probably an effect of the region’s nearness to the semipermanent Greenland high pressure area. However, on cloudy days, when there is a break in the clouds, surface heating will lead to increased convection and may help to clean the cloud deck.
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Natural History 8/88
Baby Boom

The seesaw fortunes of the highly endangered black-footed ferret unexpectedly swerved upward this year as the captive animals more than doubled their numbers. These weasel-like mammals native to the Great Plains were thought to be extinct until a group was discovered near Meeteetse, Wyoming, in 1981. Their numbers had hit a high of 128 when most of the Meeteetse population was lost; plague decimated their prairie dog prey, and canine distemper ravaged the ferrets themselves (Natural History, February 1986). Wildlife officials then caught the few remaining ferrets for captive breeding. The last known wild ferret, a male, arrived at the Sybille Research Center near Laramie, Wyoming, on March 1, 1987 (Natural History, May 1987). Since then, the population has grown from eighteen to fifty-five after two successful breeding seasons. Seven surviving young, from two litters, were produced in May and June of 1987, and the five females in that group joined ten older females that bred this April. Thirteen of the fifteen females that bred this year bore litters of from one to five kits after the forty-two-day gestation period. One artificially inseminated female and a ten-month-old from last year's group did not give birth. The total for this season was forty-four young; thirty-eight survive. A wild-caught female named Becky has produced the largest litter so far—six kits in 1987; she came through with three this year.

Although biologists use a “preferred pairing” program to match up ferret mates that have the best chance of producing genetically healthy offspring, timing and ferret disposition are critical. A female may suddenly go out of heat or a male may be disinclined to mate with his designated partner. But except for the one artificial insemination, all the matings at Sybille were natural, and most ferret pairings were within the top two choices of mates selected by the biologists.

The births this summer mean that some of the animals can be moved to a separate breeding site. This will insure survival of some ferrets should an epidemic strike at one facility (ferrets are highly susceptible to some human viruses, as well as mammal-borne diseases such as distemper). The field of candidates for the second site has now been narrowed to three zoos, and a decision will be made this summer. No ferrets will be put on exhibit.

Wyoming state wildlife veterinarian Tom Thorne, the coordinator of the captive breeding program, believes that three to five captive breeding sites and a total of 200 to 250 breeding animals are essential before the ferrets can be reintroduced into the wild.

Another requisite is an abundance of prairie dogs, the carnivorous ferrets’ main prey. A healthy prairie dog town ranging over seven to eight thousand acres would support a base population of fifty wild ferrets. The long-range goal of the program is a total of fifteen hundred free-ranging ferrets in at least ten populations of fifty or more members.

Captive-born ferrets may need some coaching before they enter the wild. They must be able to find and excavate prairie dog burrows and kill the prey, which can outweigh a ferret. Small, enclosed prairie dog towns are to be set up at the captive breeding sites to allow young ferrets to practice their predatory skills, thus giving them a better chance to survive when they are released.

The search for other wild ferrets, which could contribute to the limited genetic pool, also goes on.

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Olympics B.C.

Far more than a love of sport spurred the ancient athletes

by Judith Swaddling

The 1988 Olympics will again provoke comparison between the simplicity and idealism of the original Olympics and the lavish, high-security spectacle of the modern games. But even before the influence of the Romans, with their love of grandiose public entertainment, the ancient Greek contests were a big event, drawing tens of thousands of spectators and turning top athletes into living legends. Moreover, in addition to the meets at Olympia, held every four years, Greek sports fans flocked to three other festivals: the Pythian games at Delphi, the Isthmian games at Corinth, and the Nemean games. Together with the Olympics, these formed the periodos, or "circuit," arranged so that there was one major sports event every year. Other Greek localities sponsored smaller meets, and by Roman times hundreds of sports festivals throughout the classical world had been granted "Olympic" status, their events and programs modeled closely on the original.

At the circuit festivals, the only prizes were symbolic honors, crowns of olive at Olympia, laurel at Delphi, fresh parsley and later pine at Corinth, and dried parsley at Nemea. The victors' home states, however, provided ample cash rewards, along with such civic honors as free board and lodging and theater seats, not to mention, by the third and second centuries B.C., extravagant homecomings and celebratory processions.

Sometimes, states would erect statues of their victors where they won or in their home towns. This was no mean reward, for a life-size statue in bronze or marble by the average craftsman could cost the equivalent of ten years' wages. One man, Dikon, had fifteen statues, equal to his number of Olympic wins. Famous poets, most notably Pindar, the great Greek lyricist, were paid large sums to write verses in the victors' honor. Wins were recorded with pride on the athletes' epitaphs and in stone inscriptions that hailed them as benefactors of the state. The names of the winners in the Olympic footrace were even used as a dating system made up of four-year periods (Olympiads), by tradition going back to 776 B.C.

The main reason athletes were so honored was that these games were bound up with religion. The circuit games were held at the chief religious sanctuaries of Greece, where each was performed in honor of a god: Zeus at Olympia and Nemea, Apollo at Delphi, and Poseidon at Corinth. The Greeks believed athletes received their prowess from the gods, and therefore it was to the gods that athletes prayed for victory and gave gifts, both to curry favor and in thanks. As early as the fourth century B.C., however, the inscriptions on the stone bases of the victors' statues tell us that the athletes themselves and their city-states were receiving primary recognition.

States would sometimes pay for an athlete's training, and there are even instances of top athletes being "bought" by city-states that hoped to benefit from athletic or equestrian triumphs. The wealthy Greek colonies of southern Italy and Sicily had a very strong penchant for sports, in which they invested heavily, particularly by recruiting athletes from other cities. In the early fifth century B.C., Astylos of Croton (in southern Italy), victor in the long-distance race and in the race in armor, mysteriously changed his national allegiance to Syracuse (in Sicily) between one Olympics and the next, while in the fourth century, a Syracusan tyrant tried to bribe the father of a winner in the boys' boxing contest to have the boy proclaimed a Syracusan. Similarly, the city of Ephesus in Asia Minor succeeded in acquiring a Cretan long-distance runner after his second Olympic victory.

The national sanctuaries were cultural and religious centers that provided arenas not only for sporting events but also for music, dance, drama, and public debate. In the fifth century B.C., the sports complex at Olympia included both indoor and outdoor facilities for field and track events, a swimming pool, a bathhouse, accommodations for athletes, a stadium, and a racecourse. On the other hand, because of the vast crowds, accommodations for spectators were makeshift; the majority slept in tents or under the open sky. When Plato attended the Olympic games he shared a tent with strangers, who did not realize who he was until he later entertained them at Athens.

Olympia was crammed with temples and altars to the gods and treasury buildings where city-states and colonies could display their wealth. To impress visitors, states erected monuments to their deities, athletes, statesmen, heroes, and military triumphs. There were also some monuments reflecting unsportsmanlike behavior. Right from the beginning, only victory in the games counted (the word athlete literally meant "prize seeker"); simple participation and effort were insignificant. On some occasions a state had to foot the bill when its overeager contestants were fined for breaking the rules; the proceeds were used to pay for bronze statues of Zeus set up at Olympia, so that the transgressions would be a permanent warning to potential offenders. The Athenians were required to set up six statues after the Athenian Kallippos bribed his opponents in the pentathlon.

The ancient world was full of internal strife, so a truce from hostilities was instituted to safeguard competitors and spectators traveling to and from the Olympic games. This "sacred truce"—one existed for the Nemean games as well—eventually lasted as long as three months to pro-
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tect participants coming from as far afield as southern Spain and the eastern coast of the Black Sea. As a result of the truce, countries openly at war could compete against one another with no apparent intention of resolving their more fundamental differences.

The original function of physical education in ancient Greece, as training for warfare, was apparent in events such as the race in armor. The pyrrhic, or war, dance was also staged at some festivals. This is one reason that women rarely participated in sports, except in Sparta, where their physical toughness was believed to enable them to produce fine warrior sons. In Sparta, physical education was specially designed to promote endurance, and Sparta's athletes achieved a substantial number of Olympic victories in track and combat events.

Although the Eleans, in whose territory the sanctuary of Olympia was situated, were of minor political significance, they inevitably became embroiled in hostilities as a result of their role in the festival. This was particularly so when, siding with the Athenians during the Peloponnesian War, they banned the Spartans several times from competing in the games or worshiping at the Temple of Zeus. On one such occasion, a Spartan named Lichas wanted to enter his horse in the chariot race, and so he registered his chariot in the name of the Theban people. His team won, and he decked the charioteer with the victory ribbons, without waiting for them to be presented by the judges. When the judges discovered that Lichas was a Spartan, they had him publicly whipped as a punishment. In retaliation, the Spartans invaded Olympia.

Whereas in Sparta tough physical training was part of the regimen forced on all boys from the age of seven, in Athens it was part of general education at schools, which were probably nearly all privately run for the sons of the well-to-do. For the rest of the populace, sports were a leisure activity in which both the rich and the poor participated.

Nearly all Greek towns had a gymnasium, a kind of clubhouse with accommodations for various sporting activities, where professional trainers could be hired for instruction, massage, and dietary advice. There were also palaistrai, facilities often amounting to little more than open sports grounds, which even villages usually possessed. Watching men and boys train and compete against one another was a popular pastime: artists and sculptors found many of their models this way and used wrestling, in particular, as a means of depicting mythical battles between gods and heroes. At the sporting grounds, too, older men readily chose lovers from among the young boys. Athletes themselves had sexual favorites: in the entrance tunnel to the stadium at Nemea, where the competitors waited to be summoned for their events, one of them scrawled "Akrotatos is beautiful"; another athlete added words to the effect, "Well, his father thinks so, anyway."

Gymnasiasts and sports meets were also natural locations for discussing current affairs. Athletes occasionally served as political envoys or took up politics after their retirement. Such was the case of Theogenes of Thasos, a boxer and wrestler who ventured into public affairs after a stunning sports career spanning more than twenty years, with twenty-three victories in the circuit games and more than a thousand at lesser festivals. Unfortunately, his successes, if not the rigors of his sport, seem to have gone to his head, for he also began to proclaim himself the son of the superman Herakles.

While the expense of maintaining horses and equipping a team meant that only the wealthy could compete in chariot races, a young athlete from the lower classes could probably work his way up to the top in other athletic events. The first known Olympic victor, Koroibos, is recorded as a cook, while other early victors included a cowherd and a goatherd. There were no regulations prohibiting professional athletes from competing at the ancient games, as there are now; a successful athlete could have probably earned his living simply by traveling around from one athletic meet to another. While cash prizes were not given at the Olympics themselves, elsewhere a single sprint race could earn the winner a prize large enough to buy a luxury house. Celebrity sportsmen were occasionally paid huge fees by entrepreneurs to appear at local festivals: in one case as much as five talents, the equivalent of nearly sixty pounds of silver.

At the Panathenaic festival in Athens, held every four years in honor of Athena, patron goddess of the city, vast quantities of olive oil were presented as prizes. The olive oil was contained in amphorae decorated with the goddess Athena on one side, and the contest for which the prize was won on the other. The oil was used for lighting, heating, and cooking and for cleansing and lubricating the body. The vessels, with or without oil, were occasionally sold, often to buyers in Italy. Athletes were apparently allowed to export vessels without paying the usual duty. Each vessel was worth a minimum of twelve days' wages, and the biggest prize, for the sprint, was one hundred amphorae.

In addition to material rewards, ancient athletes enjoyed the adulation of the crowds, which at times was oddly expressed. The Rhodians had the restrained habit of applauding a performance by smacking their lips, while the people of Tarsus used a strange kind of snort. But a scene with spectators of a kind more familiar to us is described by the orator Dio Chrysostom, writing in the first century A.D. and speaking of athletic festivals at Alexandria:

When they enter the stadium, they behave as if under the influence of drugs; they forget everything they have ever learned, and say and do the first thing that comes into their heads. . . . Who could describe the yelling and uproar, the frenzy, the change of color and look on [their] faces, not to mention the foul language.

*Judith Swaddling is a curator in the Department of Greek and Roman Antiquities, British Museum.*

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In a Jumbled Drawer

"Old, bad arguments never die (they don’t fade away either)"

by Stephen Jay Gould

As my son grows, I have monitored the changing fashions in kiddie culture for words expressing deep admiration—what I called “cool” in my day, and my father designated “swell.” The half-life seems to be about six months, as “excellent” (with curious lingering emphasis on the first syllable) gave way to “bad” (extended, like a sheep bleat, long enough to turn into its opposite), to “wicked,” to “rad” (short for radical). The latest incumbent—“awesome”—possesses more staying power, and has been reigning for at least two years. My only objection, from the fuddy-duddy’s corner, lies in kiddie criteria for discernment. Ethan’s buddies require such a tiny extension beyond the ordinary to proclaim something “awesome”—just a little bit bigger, brighter, and especially, louder will do. This or that is proclaimed awesome every second sentence—and we have lost a wonderful English word.

Now let me tell you about awesome—the real thing, when adults still held possession of the concept. I collected fossils all my youthful life, or at least on those rare occasions of departure from the asphalt of New York City. I had amassed, by the end of college, five cartonfuls, all ordered and labeled—and I was pretty proud of both quantity and quality. Then I got my present job as curator of fossil invertebrates at Harvard’s Museum of Comparative Zoology. I came to Cambridge with my five cartons and discovered that my new stewardship extended to 15,000 drawers of fossils, including some of the world’s finest and oldest specimens, brought from Europe by Louis Agassiz more than a century ago. I put the cartons in a back corner of my office twenty years ago this month. I have never opened them. Me with my five cartons facing those 15,000 drawers—that is awe.

But when awe subsides, ecstasy creeps in. For I had 15,000 drawers to open, each harboring a potential discovery or insight. Raise to the nth power any simile you ever heard for “as happy as”—a boy in a candy store, a pig in . . . well, you know what. I spent two weeks pulling out every last drawer, and I found a cornucopia of disparate objects that have fueled my aesthetic and intellectual pleasure ever since.

The fossils were sublime, but I found as much fascination in the odd paraphernalia of culture that, for various reasons, ends up in museum drawers. Late eighteenth century apothecary boxes, thread cases from the mills of Lawrence, Victorian cigar boxes of gaudy Cuban design—all the better to house fossils. Tickets to Lowell Institute lecture series by Gray, Agassiz, and Lyell, invitations to a ball honoring Napoleon III, merchants’ calling cards from Victorian Cincinnati—all the better (on their blank obverses) to label fossils. Pages from the Sears catalog for 1903, snippets of nineteenth-century newspapers—all the better to wrap fossils. The most interesting news item, a headline from a Cincinnati paper for July 11, 1881, read, “Garfield’s Grit” and announced that the president, though severely wounded in the recent assassination attempt, “is now on the sunny side of life again,” and would almost surely recover—the flip side to a happy Harry Truman holding that 1948 Chicago Tribune headline announcing Dewey’s victory.

For my most interesting discovery, I opened a drawer late one night and found only a jumble of specimens inside. Someone had obviously overturned the drawer and dumped the contents. But the thick layer of dust identified the disordered pile as a very old jumble. Inside, I found the following note:

This incident was the result of the carelessness of the janitor Eli Grant who managed to overturn about half a dozen drawers of specimens by undertaking to move certain trays which he was not authorized to touch. The accident happened during my absence but I judge that it arose from an excess of zeal rather than from any recklessness. I have deemed it best to leave the specimens exactly as I found them awaiting an opportunity to have them arranged by Mr. Hartt.

I developed an immediate dislike for this pusillanimous assistant—fingerling the janitor, distorting himself even further from responsibility by assuring the boss that he hadn’t been there at the time, then feeling a bit guilty for placing Mr. Grant’s job in jeopardy and praising him for zeal through the back door. I then looked at the date and signature—Cambridge, April 26, 1869, N. S. Shaler.

David lamented over Saul: “How are the mighty fallen.” But one might look the other way in ontology and observe, “How meek are the mighty when young and subservient.” Nathaniel Southgate Shaler became one of the greatest and most popular teachers in the history of Harvard University. He was a giant among late nineteenth century American naturalists. But in 1869, Shaler was just a junior professor without tenure, and his superior was the most powerful and imperious biologist in America—none other than Louis Agassiz himself. Obviously, Shaler had written that note in mortal fear of Agassiz’s celebrated wrath. Equally obviously, Agassiz had never found out—for Shaler became professor of paleontology later that year, while a century of undisturbed dust still lies atop the jumbled specimens.

N. S. Shaler reapèd the rewards of his unflinching loyalty to Agassiz. The path of devotion was not smooth. Agassiz was a transplanted European with an Old World sense of professorial authority. He told students what they would study, awarded degrees by oral examination and direct assessment of competence, and insisted upon personal approval for any publica-
Tim GETS A PET

Wanta help me name my new turtle?

Sure, how about "Native Dancer"?

Nah, I was thinking about something simple, like Kate.

Mmm, Do you think he's sleeping?

We'll see—HEY!!

The name's Tim, and it's a new turtleneck from Lands' End.

I'm wearing one, too.

Well, they're sure worth whatever you shelled out for them.

Oh, brother.

Hi there. Nice shirt you're wearing, Buster.

Heh, heh.

But seriously, folks...

That's silly.

...Lands' End makes great turtlenecks for kids. I wish they made kid-necks for turtles.

We could name him "Lands' End."

See ya later.

Maybe he should remain anonymous.

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tion based on material at his museum. He never failed in encouragement, warmth, and enthusiasm—and he was a beloved teacher. But he never relinquished one iota of authority. These attitudes might only have yielded a tightly run ship in times of intellectual quiescence, but Agassiz was captain on the most troubled waters of biological history. Agassiz opened his museum in 1859, the same year that Darwin published *The Origin of Species*. He gathered around himself the most promising, and therefore most independently minded, group of young zoologists in America, Shaler included. Inevitably, evolution became the chief subject of discussion. With equal inevitability, students flocked eagerly to this beacon of intellectual excitement and became enthusiastic converts. But Agassiz had built both a career and a coherent philosophy upon the creationist premise that species are ideas in God's mind, made incarnate by his hand in a world of material objects. Sooner shall a camel pass through the eye of a needle than the old lion and young wolf cubs shall dwell in harmony amidst such disagreement.

And so, inevitably once more, Agassiz's students revolted—against both his overweening authority and his old-fashioned ideas. In 1863, they formed what they called, in half-jest, a committee for the protection of American students from foreign-born professors. Agassiz, however, held all the cards in a hierarchical world, and he chucked the rebels out, much to the benefit of American science, as they formed departments and centers at other great universities. Agassiz then staffed his museum with older and uncontroversial professionals, bringing peace and mediocrity once again to Harvard.

Of his truly excellent students, only Shaler remained loyal. And Shaler reaped his earthly reward. He received his bachelor of science in geology, *summa cum laude*, in July 1862. After a spell of service in the Civil War, fighting for the Union from his native Kentucky, Shaler returned to Harvard in 1864. Agassiz, describing Shaler as "the one of my American students whom I love the best," appointed him assistant in paleontology at the Museum of Comparative Zoology. In 1869, soon after he penned the guilty note that would lie unread for exactly 100 years (I found it in 1969), Shaler received his lifelong appointment as professor of geology, succeeding Agassiz (who continued to lecture in zoology until he died in 1873). There Shaler remained until his death in 1906, writing numerous treatises on everything from the geology of Martha's Vineyard to the nature of morality and immortality. He also became, by far, Harvard's most popular professor. His classes overflowed, and his students poured forth praise for his enthusiasm, his articulateness, and the comfort, optimism, and basic conventionality of his words, spoken to the elite at the height of America's gilded age. On the day of his funeral, flags in city buildings and student fraternities flew at half-mast, and many shops closed. Thirty years later, at the Harvard tercentenary of 1936, Shaler was named twelfth among the fifty people most important to the history of Harvard. To this day, his bust rests, with only fourteen others, including Franklin's, Longfellow's, and of course, Agassiz's in the faculty room of Bullfinch's University Hall.

Shaler's loyalty to Agassiz, and to comfortable convention in general, held as strongly in ideology as in practice. Shaler wrote these words of condolence to Agassiz's widow, Elizabeth Cary, founder of Radcliffe College, when Louis died in 1873: "He never was a greater teacher than now. He never was more truly at his chosen work ... . While he lived I always felt myself a boy beside him." (See David N. Livingstone, *Nathaniel Southgate Shaler and the Culture of American Science*, University of Alabama Press, 1987, for the source of this quotation and an excellent account of Shaler's intellectual life.)

I don't think that Shaler, in his eulogy to Elizabeth, either erred or exaggerated in his chosen metaphor of subservience to Agassiz's vision. While Shaler remained subordinate, he followed Agassiz's intellectual lead, often with the epigone's style of exaggerating his master's voice. Shaler's very first publication provides an interesting example ("Lateral Symmetry in Brachiopoda," 1861, *Proceedings of the Boston Society of Natural History*, vol. 8, pp. 274–79). Here Shaler supports both Agassiz's creationism and his zoological classification. Brachiopods, once a dominant group in the fossil record of marine invertebrates, are now a minor component of oceanic faunas. With their bi-valved shells, they look superficially like clams, but their soft anatomy is entirely distinct, and they are now classified as a separate phylum. But Georges Cuvier, Agassiz's great mentor, had placed brachiopods with clams and snails in his phylum Mollusca—and Agassiz, whose loyalty to Cuvier matched any devotion of Shaler's, wished both to uphold Cuvier's classification and to use his concept of Mollusca as an argument against Darwin.
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Shaler obliged in his first public performance. He affirmed Cuvier and Agassiz’s inclusion of brachiopods in the Mollusca by demonstrating a bilateral symmetry of soft parts similar enough to the symmetry of such “standard” forms as clams and squids to justify a conclusion of common plan in design. But he then took a swipe at Darwin’s reason for including separate groups in a single phylum by arguing that no evolutionary transition could possibly link adult brachiopod and clam. (Shaler was quite right about this, but not for his stated reason. You cannot transform a brachiopod into a clam, but then nature never did because brachiopods aren’t mollusks and the two groups are entirely separate—contrary to Shaler’s first conclusion.) The planes of bilateral symmetry are different for the two groups, Shaler argued correctly, and no transition could occur because any smooth intermediate would have to pass through a nonbilateral stage entirely inconsistent with molluscan design. Shaler wrote:

Such a transition would require a series of forms, each of which must present a negation of that very principle of bilateral symmetry which we have found of so much importance. And must we not, therefore, conclude that the series which united these two orders is a series of thought, which is itself connected, though manifested by two structures which have no genetic relations.

Now if you’re holding a nineteenth-century scorecard, and therefore know the players, only one man could be lurking behind this statement. Only one real Platonist of this ilk operated in America, only one leading biologist still willing to designate species as thoughts of a Creator, and taxonomic relationships as the interconnections within His mind—Louis Agassiz. Shaler, with the true zeal of the acolyte, even out-Agassized Agassiz in referring to the central character of bilateral symmetry as “the fundamental thought of the type” and then designating animal taxonomy as “a study of personified thought.”

Even Agassiz was not so explicit in specifying the attributes of His God.

When the winds of inevitability blew strongly enough, and when Shaler’s own position became secure in the late 1860s, he finally embraced evolution, but ever so gently, and in a manner that would cause minimal offense to Agassiz and to any Brahmin member of the old Boston order. After Agassiz’s death, Shaler continued to espouse a version of evolution with maximal loyalty to Agassiz’s larger vision of natural harmony, and marked aversion to all Darwinian ideas of chanciness, contingency, unpredictability, opportunism, and quirkiness. He led the American Neo-Lamarckian school—a powerful group of anti-Darwinian evolutionists who held out for order, purpose, and progress in nature through the principle of inheritance for features acquired by the effort of organisms. Progress in mentality might be predictably ordained if some organisms strove for such improvement during their lives and passed their achievements to their offspring. No waiting for the Darwinian chanciness of favorable environments and fortuitous variations.

Shaler’s loyalty to Agassiz persisted right through this fundamental change from creationism to evolution. For example, though he could scarcely deny the common origin of all humans in the light of evolutionary theory, Shaler still advocated Agassiz’s distinctive view (representing the “polygenist” school of pre-Darwinian anthropology) that human races are separate species, properly and necessarily kept apart both on public conveyances and in bedrooms. Shaler argued for an evolutionary separation of races so long ago that accumulated differences had become, for all practical purposes, permanent.

Practical purposes, in the genteel racism of patrician Boston, abetted by a slaveholding Kentucky ancestry, meant “using biology as an accomplice” (in Condorcet’s words) to advocate a “nativist” social policy (where “natives” are not the truly indigenous American Indians, but the earliest immigrants from Protestant western and northern Europe). Shaler reserved his lowest opinion for black Americans, but invested his social energies in the Immigration Restriction League and its attempts to prevent dilution of American whites (read WASPs) by the great Catholic and Jewish unwashed of southern and eastern Europe.

One can hardly fathom the psychological and sociological complexities of racism, but the forced intellectual rationales are always intriguing and more accessible. Shaler’s own defense merged his two chief interests in geography and zoology. He argued that we live in a world of sensible and optimal pattern, devoid of quirk or caprice. People differ because they have adapted by Lamarckian means to their local environments; our capacities are a map of our dwelling places—and we really oughtn’t be elsewhere (hence the biological rectitude of restricting immigration). The languid tropics cannot inspire genius, and you cannot contemplate the Pythagorean absolute while trying to keep body and soul together in an igloo. Hence the tough, but tractable, lands of northern Europe yielded the best of humanity. Shaler wrote:
Our continents and seas cannot be considered as physical accidents in which, and on which, organic beings have found an ever-perilous resting place, but as great engines operating in a determined way to secure the advance of life.

Shaler then applied this cardinal belief in overarching order (against the Darwinian specter of unpredictable contingency) to the largest question of all—the meaning of human life as a proof of God’s existence and benevolence. In so doing, he completed the evolutionary version of Agassiz’s dearest principle—the infusion of sensible, progressive, divine order into the cosmos, with the elevation of “man” (and I think they really meant only half of us) to the pinnacle of God’s intent. Shaler could not deny his generation’s proof of evolution, and had departed from his master in this conviction, but he had been faithful in constructing a vision of evolution so mild that it left all cosmic comfort intact, thereby affirming the deepest principle of Agassiz’s natural theology.

Shaler rooted his argument in a simple claim about probability. (Shaler often repeated this line of reasoning. My quotations come from his latest and most widely read book—The Individual: A Study of Life and Death, New York: D. Appleton and Company, 1901.) Human life is the end result of an evolutionary sequence stretching back into the immensity of time and including thousands of steps, each necessary as a link in the rising sequence:

The possibility of man’s development has rested on the successive institution of species in linked order. ... If, in this succession of tens of thousands of species, living through a series of millions of years, any of these links of the human chain had been broken; if any one of the species had failed to give birth to its successor, the chance of the development of man would have been lost.

Human evolution, Shaler holds, would have been “unattainable without the guidance of a controlling power intent on the end.” If this sequence alone could have engendered us, and if the world be ruled by Darwinian caprice and contingency, our appearance would have been “essentially impossible.” For surely, one link would have failed, one step in ten thousand aborted, thus ending forever the ascent toward consciousness. Only divine watchfulness and intent could have produced the human mind (not a direct finger in the pot, perhaps, but at least an intelligent construction of nature’s laws with a desired end in view):

The facts connected with the organic approach to man afford what is perhaps the strongest argument, or at least the most condensed, in favor of the opinion that there is an intelligent principle in control of the universe.

Nathaniel Southgate Shaler was one of the most influential American intellectuals of his time. Today, he is unknown. I doubt that one in a thousand readers of this essay (geologists and Harvardians excepted) has ever heard of him. His biography rates thirteen lines in the Encyclopaedia Britannica, more than half devoted to a listing of book titles. Why has he faded, and what does his eclipse teach us about the power and permanence of human thought? We can, perhaps, best approach this question by considering one of Shaler’s best friends, a man also influenced by Agassiz, but in a different way—William James. In their day, Shaler and James were peas in a pod of Harvard fame. Now Shaler is a memory for a few professionals, and James is one of America’s great gifts to the history of human thought. Why the difference?

William James also came under Agassiz’s spell as an undergraduate. Agassiz decided to take six undergraduates along on his famous Thayer Expedition to...
Brazil (1866). They would help the trained scientists in collecting specimens and, in return, hear lectures from Agassiz on all aspects of natural history. William James, among the lucky six, certainly appreciated the value of Agassiz's formidable intellect and pedagogical skill. He wrote to his father: "I am getting a pretty valuable training from the Prof. who pitches into me right and left and makes me [own] up to a great many of my imperfections. This morning he said I was 'totally uneducated.'"

But James maintained his critical perspective, while Shaler became an acolyte and then an epigone. James wrote:

I have profited a great deal by hearing Agassiz talk, not so much by what he says, for never did a man utter a greater amount of humbug, but by learning the way of feeling of such a vast practical engine as he is... I delight to be with him. I only saw his defects at first, but now his wonderful qualities throw them quite in the background. ... I never saw a man work so hard.

Was James "smarter" than Shaler? Does their differential in renown today reflect some basic disparity in amount of intellectual power? This is a senseless question for many reasons. Intelligence is too complex and multifaceted a thing to reduce to any single dimension. What can we say? Both men had certain brilliance, but they used their skills differently. Shaler was content to follow Agassiz throughout his career, happy to employ his formidable intellect in constructing an elaborate rationale for contemporary preferences, never challenging the conservative truths of his class and culture. James questioned Agassiz from day one. James probed and wondered, reached and struggled every day of his life. Shaler built pretty buildings to house comfortable furniture. Intelligence or temperament; brains or guts? I don't know. But I do know that oblivion was one man's reward, enduring study and respect the other's.

As a dramatic illustration of the difference, consider James's critique of Shaler's "probability argument" for God's benevolence from the fact of human evolution. James read Shaler's The Individual, and wrote a very warm, though critical, letter to his dear friend. He praised "the gravity and dignity and peacefulness" of Shaler's thoughts, but singled out the probability argument for special rebuttal.

James points out that the actual result of evolution is the only sample we have. We cannot compute a "probability" or even speak in these terms. Any result in a sample of one would appear equally miraculous when you consider alternative possibilities. But something had to hap-
We may only talk of odds if we could return to stage 1, list a million possible outcomes, and then lay cold cash upon one possibility alone:

We never know what ends may have been kept from realization, for the dead tell no tales. The surviving witness would in any case, and whatever he were, draw the conclusion that the universe was planned to make him and the like of him succeed, for it actually did so. But your argument that it is millions to one that it didn’t do so by chance doesn’t apply. It would apply if the witness had preexisted in an independent form and framed his scheme, and then the world had realized it. Such a coincidence would prove the world to have a kindred mind to his. But there has been no such coincidence. The world has come but once, the witness is there after the fact and simply approves. . . . Where only one fact is in question, there is no relation of “probability” at all. [James’s letter is reprinted, in full, in The Autobiography of Nathaniel Southgate Shaler, Boston: Houghton Mifflin, 1909.]

Old, bad arguments never die (they don’t fade away either), particularly if they match our hopes. Shaler’s false probability argument is still a favorite among those who yearn to find a cosmic rationale for human importance. And James’s report is as brilliant and as valid now as when he first presented it to Shaler. We could save ourselves from a lot of nonsense today if every devotee of the anthropic principle (strong version), every fan of Teilhard’s noosphere, simply read and understood James’s letter to Shaler.

James then continues with the ultimate Darwinian riposte to Shaler’s doctrine of cosmic hope and importance. Human intellect is a thing of beauty—truly awesome. But its evolution need not record any more than a Darwinian concatenation of improbabilities:

I think, therefore, that the excellence we have reached and now approve may be due to no general design, but merely to a succession of the short designs we actually know of, taking advantage of opportunity, and adding themselves together from point to point.

Which brings us back to Mr. Eli Grant. (I do hope, compassionate reader, that you have been worrying about this poor man’s fate while I temporized in higher philosophical realms.) The young Shaler tried to cover his ass by exposing Grant’s. Obviously, he succeeded, but what happened to the poor janitor, left to take the rap?

This story has a happy ending, based on two sources of evidence: one inferential; the other direct. Since Agassiz never found out, never saw the note, and since Mr. Hartt, like Godot, never arrived, we may assume that Grant’s zealous accident eluded Agassiz’s watchful eye. More directly, I am delighted to report that I found (in yet another drawer) a record book for the Department of Invertebrate Paleontology in 1887. Mr. Eli Grant was still listed as janitor.

Was Mr. Grant meant to survive because he did? Does his tenure on the job indicate the workings of a benevolent and controlling mind? (Why not, for I can envisage 100 other scenarios, all plausible but less happy.) Or was Mr. Grant too small to fall under God’s direct providence? But if so, by what hubris do we consider ourselves any bigger in a universe of such vastness? Such unprofitable, such unanswerable questions. Let us simply rejoice in the happy ending of a small tale, and give the last word to William James, still trying to set his friend Shaler straight:

What if we did come where we are by chance, or by mere fact, with no one general design? What is gained, is gained, all the same. As to what may have been lost, who knows of it, in any case?

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.

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Indian Creek, Missouri

by Robert H. Mohlenbrock

The most vivid memories of my boyhood trips to the Missouri Ozarks, across the Mississippi River from my southern Illinois home, are of the crystal clear rivers and streams that flowed in rocky beds. Illinois terrain is often covered by thick layers of windblown soil, called loess, which slips into that region's streams, muddying the waters and forming a silty sediment. In contrast, erosion along an Ozark stream causes pebbles and boulders to tumble in, with only a minimum of soil. One such sparkling stream in a perfect hideaway is Indian Creek, which originates near the community of Willow Springs in south-central Missouri and meanders southwestward before entering the North Fork of the White River. The creek flows through private property and public forestland within the boundaries of Mark Twain National Forest.

Through countless centuries following the uplift of the Ozark Mountains 400 million years ago, Indian Creek has carved a twisting, narrow defile through layers of sandstone and dolomite, leaving 200-foot cliffs on either side. From the northern bluff tops, down across the creek, and up to the summits of the south bluffs, one can pass through nine plant communities in less than 600 feet.

The tops of the north cliffs are exposed to intense sunlight throughout the year. As a result, the soil is dry, and only a scrub forest occupies this desertlike habitat. The trees that are able to survive here—blackjack oak, post oak, and red cedar—are often gnarled and usually short-statured, although they may be more than 100 years old. The two oaks have a heavy waxy coating, or cuticle, on their leaves that prevents excessive moisture loss, and their roots penetrate deeply into the crevices in the cliff. The leaves of the red cedar are tiny needles and scales that expose a minuscule surface to the sun. The only shrub here is the farkleberry, which has waxy, leathery leaves. Ground-level herbs are sparsely scattered, and there are many patches of bare rock.

Here and there on the north bluff tops are areas apparently too dry for any trees—even oaks and cedars. These glades, or barrens, contain prairie plants. Little bluestem and the six-foot-tall gama grass are common, as are pale coneflower and round-headed bush clover. The grasses depend on extensive root systems to survive, while the coneflower and bush clover have hairy leaves that inhibit excessive moisture loss.

From the north bluff tops, the hike down the south-facing slope toward Indian Creek takes one through a dry, upland forest. The angle of the slope moderates the impact of the summer sun's rays, but the plants still struggle to obtain

*White camass is one of the flowering plants that grow along the south side of Indian Creek.*
Indian Creek

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enough moisture. Black hickories and chinkapin oaks are the dominant trees, and they grow taller and straighter than the oaks on the bluff top. Pink azaleas and fragrant sumacs share the shrub layer, while the understory plants, less scattered than those on the bluff top, include butterfly pea and an assortment of asters and goldenrods. The greater concentration of vegetation on the slope results in a swifter buildup of soil, as leaves fall and plants eventually die.

Toward the bottom of the slope, the intermittent shade cast by the opposing cliff allows a more moist woods to prevail. Red maples, Ohio buckeyes, basswoods, and bitternut hickories are able to grow here, sometimes more than fifty feet tall. Their crowns touch completely, closing the canopy and shading the understory. Spicebushes, bladdernuts, and pawpaws in the shrub layer add more shade. The abundant wildflowers beneath generally have thin leaves that permit each chlorophyll-bearing cell to receive enough of the minimal sunlight.

Most of the south-facing slopes flatten out into a terrace a few feet wide as they approach the creek. Here, sycamores, box elders, and hackberries grow, trees that tolerate annual flooding in permeable soil that does not remain wet for long periods. The terrace floor is colored yellow and white in early spring by the blossoms of common butterweed and white bulbless cress. During summer, dense colonies of touch-me-nots grow shoulder high.

The stream bed itself is filled with gravel, cobbles, and boulders. In some places, the stream flows through narrow channels; in others, over wide, level beds of rock. Woody plants that often grow in the creek bottom, where they are continuously washed by the flowing stream, are the Ozark witch hazel, Ward's willow, smooth alder, and ninebark. Biologist Max Hutchison has observed damage on the trunks of many of these plants, where boulders slammed against them during torrential rains.

In many places, the cliff face on the south side of Indian Creek abuts the water's edge. The limestone rock immediately above the stream is concealed by overlapping layers of mosses and liverworts, while occasional delicate-leaved ferns, such as the southern maidenhair, gracefully arch over the water. In this zone grow some of the rarest flowering plants of the southern Missouri Ozarks—sullivantia, grass-of-parnassus, white camass (of the lily family), barren strawberry, and lady-slipper orchid.

Elsewhere the slope on the south side of the creek is less precipitous. Since this slope is never exposed to the unrelenting rays of the afternoon sun, moisture is abundant in the moderately deep soil. White oaks, slippery elms, and persimmons are the common trees, over a midlevel of flowering dogwoods and black haws. Scattered herbs include May apple, Indian physic, and bottlebrush grass.

Finally, at the summits of the south bluffs are areas that are open to the sunlight and therefore dry, with poor soils. Shortleaf pines, black and red oaks, and black gums are common, as is sassafras. Somewhat of a surprise, because of the seemingly hostile environment, are three small kinds of fragile-looking orchids that grow in the rocky, acidic soil beneath the pines and oaks: the rattlesnake plantain orchid, small adder's mouth orchid, and twayblade orchid.

"This Land" highlights the biological phenomena of the 154 U.S. national forests. Robert H. Mohlenbrock is Distinguished Professor of Botany at Southern Illinois University at Carbondale.
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Kate Cory was born in Waukegan, Illinois in 1861, the daughter of a newspaper editor who was a “crusading Abolitionist” and a personal friend of Abraham Lincoln. She was an artist who studied at Cooper Union and the Art Students’ League in New York City. In 1904, she met painter Louis Akin at a gathering of the Pen and Brush Club in New York. Akin had recently returned from a year spent living and painting among the Hopi Indians of northeastern Arizona. He spoke enthusiastically about developing an artists’ colony on the remote and arid mesas where the Hopi lived. He apparently spun such an intriguing tale that Cory set off by train the following year, never to return to the East Coast. In traveling to Arizona, she joined an illustrious list of artists, scientists, tourists, and fellow adventurers who had been lured west around the turn of the century.

The Hopi Photographs reproduces 68 of the 642 negatives that remain of those Cory made during the seven years she lived in the Hopi villages of Walpi and Oraibi. She was one of a small number of outsiders to observe the full ceremonial calendar of the Hopi and recorded many sequences of their preparations and performances between 1905 and 1912. Some of these images have survived as rare documents of ceremonies no longer performed. Cory also came to know many of the Hopi as friends and photographed them as they went about their daily lives.
Three brief essays introduce this book. The first, “Kate Cory: Artist of Arizona,” was written by Marnie Gaede. Another was written by her husband, photographer Marc Gaede, who describes the methods he used in reprinting the Cory negatives. Barton Wright contributed “A Hopi Essay,” a review of nearly a thousand years of Hopi history. Wright also wrote the photo captions and culled statements from the vast literature published about the Hopi to amplify and further describe the scenes depicted. Although readers are told that the photographs have been arranged according to the Hopi ceremonial calendar, they are interspersed with portraits and village scenes.

As early as the 1850s, the Hopi posed for the cameras of government surveyors who were charting the hitherto unknown frontier. Anthropologists, traders, and missionaries came next: the first to study and record Hopi practices before they disappeared; the last named to hasten the change to, and promote the acceptance of, Christian values. With the completion of

THE HOPI PHOTOGRAPHS: KATE CORY 1905–1912, by Barton Wright, Marnie Gaede, and Marc Gaede. The University of New Mexico Press, $35.00 hardcover, $19.95 paperback; unpaged, illus.

the Sante Fe railroad through New Mexico and Arizona in the 1880s, settlers and tourists began to arrive in the Southwest in growing numbers. Although the Hopi mesas were a good sixty miles of rutted dirt road away from the nearest train station, stories of the late summer Snake Dance drew thousands by 1900. Some of these visitors returned year after year, and others, like Cory, stayed for extended periods of time.

Many of the visitors to the Hopi mesas carried cameras. Their photographs, along with their notes and published articles, have helped to create the large

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repository of historical information we have about the Hopi today. Thousands of these images and negatives have been preserved in museums and historical society collections and a number of recent books and articles have added greatly to our understanding of this pivotal time in Hopi history. Kate Cory appears to have been one of the few unmarried non-Indian women to live and work among the Hopi during this period. The publication of her photographs thus comes as a welcome addition to the inventory of documented Hopi collections.

Many questions remain about Cory and the circumstances surrounding her residence in the Hopi villages. With whom did she live and how did she fill her time? We know that she took photographs, but how did she integrate herself into the community? We are told that she “preferred to be close to the Indians,” rather than “live in the style of the few whites who had settled in the area” but learn little else of what that meant. A number of details are provided about Cory’s life after she left the mesas. She eventually settled in Prescott, Arizona, and became something of a recluse. She apparently gave up photography, although she continued to paint. A collection of her paintings is held by the Smoki Museum in Prescott and several more reside at the Smithsonian Institution. She lived alone until moving to a retirement home where she died in 1958 at the age of 97.

While many of the questions about Cory may never be answered, Gaede tells us that she kept a diary between 1907 and 1908 and that she published a number of articles in The Border, a magazine no longer in print. The existence of these materials is tantalizing, and we can only wish that their contents had been cited directly. The introductory essay is further flawed by a number of erroneous assertions about the history of photography among the Hopi, particularly the swift dismissal of most other contemporaneous photographers as “lacking the sensitivity and eye for composition that make Cory’s images special.” Certainly there are some very fine photographs reproduced here, but other photographers, such as Frederick Monsen, Ben Whittick, Sumner Mattheson, and George Wharton James, also framed images that have withstood the test of time.

Finally, it is unfortunate that the authors did not enlist Hopi discussion before publishing the book, writing instead that they hoped the photographs would prove of value and use to the Hopi. Photographs are known to be valuable tools in conducting ethnographic research. They are also of poignant interest to the people who have been photographed. One wonders what Hopis today would say about Cory’s photographs, and what, indeed, they might say about her.

The content and meaning of historic photographs are rarely self-evident. Photographers are influenced by personal, situational, and technical circumstances, as well as by the clarity of their artistic or documentary eye. Those who went among the Hopi around the turn of the century created a comprehensive photographic record that focused on individuals and the environment, as well as on Hopi religion, life style, and material culture. This record not only reflects the way things were at a pivotal time in Hopi history but also contains the subtle reflection of the photographers’ own era. Some photographers were driven by documentary zeal to “record the vanishing Indian”; others carried a more romantic, picturesque vision, hoping to re-create a view of how things were before non-Indians arrived. Some approached the Hopi with an entrepreneurial eye, looking for scenes that would promote tourism and translate into postcard images, while others photographed what they could, paying money to stand in line to take snapshots that would fill family scrapbooks.

The presence of so many visitors on the Hopi mesas was congestive at best and disruptive at worst. In 1901, Indian agent Leo Crane proposed increasing the tribe’s revenue by charging each visitor one dollar for a photographic permit. By 1902, signs began to appear asking visitors to stay away from certain areas of the village and to refrain from making noise around the kivas—the Hopi ceremonial cham-
Enn Younger currently lives in Seattle, Washington, where she is visual arts coordinator for the King County Art Commission. She has previously lived in Arizona and worked as museum curator and Native American art consultant. In 1993, the country photographer Erin Press published her work, "Hopi: Photographs of the Hopi People," which was well-received for its detailed portrayal of the Hopi way of life. The book was accompanied by a CD-ROM that included audio and video clips.

With hindsight, it can be seen that the danger to the Hopi way of life feared by the nineteenth-century anthropologists has been realized. The Hopi people have become isolated and their traditional way of life has been substantially altered.

Some time after the turn of the century, Hopi began taking photographs of themselves. Today, the majority of photographs are taken with permission. More photographs were negotiated individually and portraits were recorded, and the majority of Hopis were willing to have their pictures taken. Some photographs taken on the reservation were not taken with permission. More photographs were taken of Hopi people by Hopis, and the majority of portraits were recorded. Few photographs were negotiated individually and portraits were recorded, and the majority of Hopis were willing to have their pictures taken.

With the advent of photography by outsiders, the nature of the photographs changed. Few photographs were negotiated individually and portraits were recorded, and the majority of Hopis were willing to have their pictures taken. Some photographs taken on the reservation were not taken with permission. More photographs were taken of Hopi people by Hopis, and the majority of portraits were recorded. Few photographs were negotiated individually and portraits were recorded, and the majority of Hopis were willing to have their pictures taken.

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The Last First Contacts

Within our generation, the last experiment by humans to construct a society without knowledge of other societies will have ended.

by Jared M. Diamond

Fifty years ago, on August 4, 1938, an expedition from the American Museum of Natural History made a discovery that virtually ended a long phase of human history. On that date, the advance patrol of the Third Archbold Expedition (named after its leader, Richard Archbold) became the first outsiders to enter the Grand Valley of the Balim River, in the supposedly uninhabited interior of western New Guinea. To everyone’s astonishment, the Grand Valley proved to be densely populated—by 50,000 previously unknown Papuans, living in the Stone Age and themselves unaware of the existence of others. In search of undiscovered birds and mammals, Archbold had found an undiscovered human society.

To appreciate the significance of Archbold’s finding, we need to understand the phenomenon of “first contact.” Throughout several million years of human evolution, each human group was ignorant of the world beyond its own lands and those of its immediate neighbors. Only in recent millennia did changes in political organization and transportation permit some people to routinely travel afar and encounter distant peoples. This process accelerated with Columbus’s voyage of 1492, until today there remain only a few tribes in New Guinea and South America still awaiting first contact with remote outsiders. The Archbold Expedition’s entry into the Grand Valley will be remembered as one of the last first contacts of a large human population.

How could such a populous people remain unknown to outsiders until 1938? How could the people in turn remain unaware of the outside world? How did first contact change human societies? This world before first contact—a world that is finally ending within our own generation—holds a key to the origins of human cultural diversity.

To anyone who has not been to New Guinea, the long concealment of 50,000 people there seems incomprehensible. After all, the Grand Valley lies only 115 miles from either New Guinea’s north or south coast. Europeans discovered New Guinea in 1526, Dutch missionaries took up residence in 1852, and European colonial governments were established in 1884. Why did it take another fifty-four years to find the Grand Valley?

The answers—terrain, food, and porters—become obvious as soon as one sets foot in New Guinea and tries to walk away from an established trail. Swamps in the lowlands, endless series of knife-edge ridges in the mountains, and jungle covering everything reduce one’s progress to a few miles per day under the best conditions. On my 1983 expedition into the Kumawa Mountains, it took me and a team of twelve New Guineans two weeks to penetrate seven miles inland.

Compounding these terrain problems is the impossibility of living off the land because of New Guinea’s lack of big game animals. In lowland jungle, the staple of New Guineans is a tree called the sago palm, whose pith yields a substance with the consistency of rubber and the flavor of vomit. However, not even New Guineans can find enough wild foods to survive in the mountains. This problem was illustrated by a horrible sight on which the British explorer Alexander Wollaston stumbled while descending a New Guinea jungle trail: the bodies of thirty recently dead New Guineans and two dying children, who had starved while returning from the lowlands to their mountain gardens without carrying enough provisions.

The paucity of wild foods in the jungle forces explorers going through uninhabited areas, or unable to count on obtaining food from native gardens, to bring their own rations. A porter can carry forty pounds, the weight of the food to feed himself for about fourteen days. Thus, until the advent of planes made airdrops possible, all New Guinea expeditions that penetrated more than a seven-day walk from the coast (fourteen days round trip) did so by having teams of porters going back and forth, building up food depots inland. The expedition that came closest to discovering the Grand Valley before Archbold, the 1921–22 Kremer Expedition, used 800 porters and 200 tons of food and took more than six months of relaying to get four explorers inland to just beyond the Grand Valley. Unfortunately for Kremer, his route happened to pass a few miles west of the valley, whose exis-
Dani on a grassy ridge await a party from the 1938 Archbold Expedition.

Photographs from AMNH Archives

Expedition members, watched by valley residents, take a break near the Balim River.

tence he did not suspect because of intervening ridges and jungle.

Apart from these physical difficulties, the interior of New Guinea seemed to hold no attractions for missionaries or colonial governments because it was believed to be virtually uninhabited. European explorers starting from the coast or from rivers discovered many tribes in the lowlands living off sago and fish but few people eking out an existence in the steep foothills. From either the north or south coast, the snow-capped central cordillera that forms New Guinea's backbone presents steep faces. What remained invisible from the coasts were broad intermontane valleys, hidden behind those faces and suitable for agriculture.

For eastern New Guinea, the myth of an empty interior was shattered on May 26, 1930, when two Australian miners,
Michael Leahy and Michael Dwyer, scaled the crest of the Bismarck Mountains in search of gold, looked down at night on the valley beyond, and were alarmed to see countless dots of light: the cooking fires of thousands of people. For western New Guinea, the myth ended with Archbold's second survey flight on June 23, 1938. After hours of flying over jungle with few signs of humans, Archbold spotted the Grand Valley, looking like Holland: a cleared landscape devoid of jungle, neatly divided into small fields outlined by irrigation ditches, and with scattered hamlets. It took six weeks before Archbold could establish camps at the nearest lake or river where his seaplane could land and before patrols from those camps could reach the Grand Valley to make first contact with its inhabitants.

That's why the outside world didn't know of the Grand Valley until 1938. But why didn't the valley's inhabitants, now referred to as the Dani people, know of the outside world?

At this point we have to remind ourselves of a modern perspective that we take for granted. The whole globe is now divided into political states, whose citizens enjoy more or less freedom to travel within the boundaries of their state and to visit other states. As a result, people, information, and goods have diffused around the globe. I recall with embarrassment my visit to a Pacific island called Rennell, whose inaccessibility had preserved its Polynesian culture unchanged until recently. Setting out at dawn from the coast, I plodded through jungle with not a trace of humans. When in the late afternoon I finally heard a woman's voice ahead and glimpsed a small hut, my head whirled with fantasies of the beautiful, unspoiled, grass-skirted, bare-breasted Polynesian maiden who awaited me at this remote site on this remote island. It was bad enough that the lady proved to be fat and accompanied by her husband. What humiliated my self-image as intrepid explorer was the University of Wisconsin sweat shirt that she wore.

In contrast, for all but the last 10,000 years of human history, travel was impossible, and diffusion of ideas and of sweat shirts was limited. Each village or band constituted a political unit, living in a perpetually shifting state of wars, truces, and alliances with neighboring groups. Hence New Guinea highlanders spent their entire lives within twenty miles of their birthplace. They might occasionally enter lands bordering their village lands by stealth during a war raid or by permission during a truce, but they had no social framework for travel beyond immediately neighboring lands.

The notion of tolerating unrelated strangers was as unthinkable as the notion that any such stranger would dare appear. Many precontact peoples thought they were the only humans in existence. Perhaps the smoke of fires on the horizon or an empty canoe floating past down a river did prove other people existed. But to venture out of one's territory to meet those people, even if they lived only a few miles away, was equivalent to suicide.

Thus, first contact patrols had a traumatic effect. They revolutionized the highlanders' material culture by bringing steel axes and matches, whose superiority over stone axes and fire drills was immediately obvious. The missionaries who followed the patrols suppressed ingrained cultural practices such as cannibalism, polygyny, and homosexuality. Other practices were discarded spontaneously by tribespeople themselves, in favor of new practices that they saw. But there was also a more profoundly unsettling revolution in the highlanders' view of what made up the universe. They and their neighbors were no longer the sole humans, with the sole way of life.

A recent book by Bob Connolly and Robin Anderson, entitled First Contact, poignantly relates that moment in the eastern highlands, as recalled recently in their old age by New Guineans and whites who met there as young adults or children in the 1930s. Terrified highlanders took the whites for returning ghosts, until the New Guineans dug up and scrutinized the whites' buried feces, sent terrified young girls to have sex with the intruders, and thus discovered that whites defecated and were men like themselves. Leahy wrote in his diary that highlanders smelled bad, while at the same time the highlanders were finding the whites' smell strange and frightening. Leahy's obsession with gold was as bizarre to the highlanders as their obsession with cowrie shells was to him. For the survivors of those Grand Valley Dani and Archbold Expedition members who met in 1938, such an account of first contact has yet to be written.

I said at the outset that Archbold's entry into the Grand Valley was not only a watershed for the Dani, but also part of a watershed in human history. What difference did it make that all human groups used to live in relative isolation, awaiting first contact, while only a few such groups remain today? We can infer the answer by comparing areas where isolation ended long ago with areas where it persisted into modern times. We can also study the rapid changes that followed historical first contacts. These comparisons suggest that contact between distant peoples gradually obliterated much of the human cultural diversity that had arisen during millennia of isolation.

Take artistic diversity as one obvious example. Styles of sculpture, music, and dance used to vary greatly from village to village within New Guinea. Some villages along the Sepik River and in the Asmat swamps produced carvings that are now world famous because of their quality. But New Guinea villagers have been increasingly coerced or seduced into abandoning their artistic traditions. When I visited an isolated tribelet of 578 people at Bomai in 1965, the missionary controlling the only store had just manipulated the people into burning all their art. Centuries of culture ('heathen artifacts,' as the missionary put it) had thus been destroyed in one morning. On my first visit to remote New Guinea villages in 1964, I heard log drums and traditional songs; on
my most recent visit in April of this year, I heard guitars and rock music. Anyone who has seen the Asmat carvings at the Metropolitan Museum of Art or heard log drums played in antiphonal duet at breathtaking speed can appreciate the tragedy of postcontact loss of art.

There has been massive loss of languages as well. For example, Europe has only about fifty languages; most belong to a single language family (Indo-European). In contrast, New Guinea, with less than one-tenth of Europe's area and less than one-hundredth of its population, has about a thousand languages, many of them unrelated to any other known language in New Guinea or elsewhere. The average New Guinea language is spoken by a few thousand people living within a radius of ten miles. When I traveled the sixty miles between Okapa and Karimui in the eastern highlands of New Guinea, I passed through six languages.

New Guinea shows linguists what the world used to be like, with each isolated tribe having its own language, until agriculture's rise permitted a few groups to expand and spread their tongue over large areas. It was only about 6,000 years ago that the Indo-European expansion began, leading to the extermination of all prior western European languages except Basque. In the New World alone, more than two hundred Indian languages have become extinct in recent centuries.

Isn't language loss a good thing, because fewer languages mean easier communication among the world's people? Perhaps, but it's a bad thing in other respects. Languages differ in structure and vocabulary, in how they express causation and feelings and personal responsibility, hence in how they permit us to think. There is no single-purpose "best" language: instead, different languages are better suited for different purposes. For instance, it wasn't an accident that Plato and Aristotle wrote in Greek, Kant in German. The grammatical particles of those two languages, plus their ease in forming compound words, helped make them the preeminent languages of Western philosophy. Another example, familiar to all of us who studied Latin, is that highly inflected languages (ones in which word endings suffice to indicate sentence structure) can use variations of word order to convey nuances impossible with English. Our English word order is severely constrained by having to serve as the main clue to sentence structure. If English becomes a world language, it won't be because it is necessarily the best one for diplomacy.

The range of cultural practices in New Guinea also eclipses that within equiva-

lent areas elsewhere in the modern world, because isolated tribes were able to live out social experiments that others would find utterly unacceptable. Forms of self-mutilation and cannibalism varied from tribe to tribe. At the time of first contact, some tribes went naked, others modestly concealed their genitals, and still others (including the Dani) flagrantly advertised the penis and testes with various props. Child-rearing practices ranged from extreme permissiveness (including freedom for babies to grab hot objects and burn themselves), through punishment of misbehavior by rubbing a child's face with stinging nettles, to extreme repression resulting in child suicide. Barua men pursued institutionalized bisexuality by living in a large, communal, homosexual house with the young boys, while each man had a separate, small, heterosexual house for his wife, daughters, and infant sons.

We wouldn't mourn the shrinking cultural diversity of the modern world if it only meant the end of self-mutilation and child suicide. But the societies whose cultural practices have now become dominant were selected just for economic and military success. Those qualities aren't necessarily the ones that foster happiness or promote long-term human survival. Our consumerism and our environmental exploitation serve us well at present but bode ill for the future. Features of American society that already rate as disasters in anyone's book include our treatment of the aged, adolescent turmoil, abuse of psychotropic chemicals, and gross inequality. For each of these problem areas, there are (or were before first contact) many New Guinea societies that found far better solutions to the same issue.

Unfortunately, alternative models of human society are rapidly disappearing, and the time is almost past when humans could try out new models in isolation. Surely there are no remaining uncontacted populations as large as the one encountered by Archbold's patrol of fifty years ago. When I worked on New Guinea's Rouffaer River in 1979, missionaries nearby had just found a band of a few dozen nomads, who reported another uncontacted band five days' travel upstream. Small bands have also been turning up in remote parts of Peru and Brazil. But at some point within the coming decade, we can expect the last first contact and the end of the last separate experiment at designing human society.

Jared M. Diamond teaches biophysics, physiology, and ecology at the School of Medicine of the University of California at Los Angeles.
Wilson's storm-petrels feed where upwelling waters bring nutrients to the ocean surface.

Frank W. Mantik
Feeding on the Fly

Ocean fronts gather plankton, fish, seabirds, and pollution

by J. Christopher Haney

Cape Canaveral and the Kennedy Space Center lay fifty miles behind our research vessel, the Cape Hatteras. We steamed east over the edge of the continental shelf, five hundred feet below, on a sultry October day with almost no wind. For several hours the lack of marine life in the coastal waters off eastern Florida, coupled with intense heat and glare, made it difficult to concentrate on the glassy horizon. A few hundred feet ahead, the oil-smooth waters became unexpectedly choppy. As we neared this boundary, the deep greens of the shelf water were replaced by the turquoise and violet blues of the Gulf Stream. Cory's shearwaters and bridled terns appeared, flying over mats of sargassum, a floating pelagic cousin of the kelps. Apple-sized jellyfish dotted the surface, attracting loggerhead and rarer leatherback turtles. Then, after we had traveled only a few hundred yards, the activity trailed off behind and we were once again cruising through barren waters.

Encounters with water mass boundaries, or ocean fronts, are often dramatic. When crossing the western edge of the Gulf Stream, I always anticipate a changing seascape. Like atmospheric, or weather, fronts, ocean fronts separate dissimilar physical entities, in this case water instead of air masses. Ocean fronts move at varying speeds, and may form, disappear, and then re-form at other locations. Sea surface temperatures can be 15° to 20° F warmer or colder across fronts. Sometimes the temperature differences create fog banks over the cooler water.

Fronts are also inherently unstable, frequently marking such steep contrasts in current velocity and sea state that the meeting of two masses resembles the breaking of waves in shallow water. Thor Heyerdahl's Kon-Tiki expedition through the South Pacific crossed a midocean front so rough that the crew mistook it for a reef. Their error was compounded because a fifty-year-old nautical chart had also recorded a "shoal" at their position, 600 miles southeast of the Galápagos Islands where the ocean was at least 2,400 feet deep.

A front is attractive habitat for many marine animals, a kind of oasis in the sea.
To locate schools of tuna and swordfish, fishermen off the eastern seaboard of the United States receive up-to-date positions of fronts through radio broadcasts or from satellite fixes transmitted through onboard telemetries. Before the advent of electronics, fishermen located fronts by looking for feeding seabirds.

On trips across the Gulf Stream front I have seen seabird species from all over the Atlantic Ocean congregating to feed. Cory’s shearwater, with a wingspan of three to four feet and a weight of well over two pounds, is the largest species. Band-rumped storm-petrels visit the frontal boundary of the Gulf Stream in summer and early fall. Wilson’s storm-petrels, thought by some to be the most abundant bird species in the world, arrive from South Atlantic and subantarctic islands on their way to “winter” in the Northern Hemisphere’s summer and feed on the rich waters of New England’s Georges Bank. Black-capped petrels, along with bridled terns, come out of the Caribbean. None of these species nest on the nearby coast of the southeastern United States, and they are only seen near land when storms or sickness brings them to seek temporary shelter in protected bays. Black-capped petrels breed in burrows on steep, forested mountainsides in the Dominican Republic, Haiti, and Cuba. Cory’s shearwaters nest on isolated islands of the eastern Atlantic off Africa and Europe, and the young then migrate to the western Atlantic Ocean, where some immature birds stay for up to four years before returning to their natal homes to breed. Band-rumped storm-petrels also breed in the eastern Atlantic.

The concentration of prey is what attracts these disparate seabird species to fronts. Animals, both predators and prey, move with the Gulf Stream front as it meanders back and forth. Water sweeping in and then sinking at one or both sides of a front can herd marine prey that normally swim or float at the surface. At the same time, fish that must stay at constant depths will swim upward to keep from being pulled down by water flowing outward from the front. Concentrated by the currents they, too, end up in large ag-
When the Gulf Stream meanders on its way north, the movement sometimes draws deeper, cooler water to the surface. As shown in the drawing at left, the rising water swirls counterclockwise, forming an eddy on the Gulf Stream's western front. Two such eddies can be seen in the satellite thermal image, below, of the Gulf Stream as it passes the northeast coast of Florida, Georgia, and the Carolinas. Warmer than the surrounding Atlantic, the Gulf Stream is red and yellow in the thermal image; water warmed by the Gulf Stream is green. Filaments of warm water wrap around the cold (blue) cores of the eddies. Over a period of weeks the eddies gather plankton, sargassum, and small fish and eventually attract seabirds on their ocean migrations.
gregations, along with deeper-dwelling fish and squid that, although they swim faster than the currents, are pulled in as they feed. Since many fish and invertebrates are sensitive to temperature changes, the temperature differences across fronts limit their movements.

When these aggregations of fish are forced to the surface by feeding schools of tuna, mackerel, and dolphin, the birds come to feed. Cory’s shearwaters settle on the water in such large, boisterous flocks that mariners have confused them with dry land. The diversity at these fronts could be seen from ships, but what brought that diversity about was better viewed from the air.

In the mid-1970s, researchers from the University of Miami began using infrared satellite images to describe the Gulf Stream from an altitude of 500 miles. They found that between North Carolina and Florida the Gulf Stream current winds much like a water hose under high pressure. Occasionally, these meanders break, forming a fingerlike projection of warm water that stretches west, then wraps around a colder elliptical or circular core. Deep, nutrient-rich cold water is drawn up into the core and the entire sys-
Drifting sargassum, left, buoyed by tiny, gas-filled bladders along its fronds, is gathered by the currents at the frontal eddies into mats of an acre or more. These mats serve as a kind of offshore coral reef where pelagic fish and birds come to feed. Where ocean currents meet, such as at fronts or at an ocean rip, below, calm seas can quickly turn turbulent.

Frank W. Mantik

Satellite sensors pick up the thermal signatures of these cold core eddies. Their tracks reveal that frontal eddies are typically six to thirty miles wide and thirty to one hundred miles long. They have lifetimes of only two to fourteen days, and move north attached to the main current at speeds of twenty-five miles per day. (Knowledge of these eddies dates back at least to Colonial times. In a 1786 letter, Benjamin Franklin noted that ships could minimize their sailing times by using the eddy side of the Gulf Stream when traveling south and west.) The cyclonic, upwardly spiraling cold cores of frontal eddies bring up deeper waters, where decaying organisms create a nutrient-rich layer. When these nutrients reach the sunlit depths where phytoplankton drift, the microscopic plant life blossoms, along with the populations of zooplankton that feed on it.

As water rises in the middle of the eddy, water along the warm outer filament sinks, creating a kind of giant ocean drain that swirls, accumulates, and traps floating organisms (and debris), including sargassum. This drifting seaweed, buoyed by the gas-filled bladder floats along each frond, can gather into a mat that covers up to two and a half acres of ocean, where as though it were a midocean coral reef, it supports a complex animal community. Some fifty species of fish spend some of their lives on the sargassum, along with crabs and shrimp that live on the algae growing among the weeds. Barracuda and dolphin forage the dark underside of the sargassum mat.

By comparing several years of cruise tracks to eddy positions mapped from satellite images, I found that there were from seven to fifteen times the number of seabirds at eddies than at locations a few miles distant. At Gulf Stream fronts where I had seen no birds, there were no eddies and no upwelling.

Each seabird species focuses on a specific portion of the eddy when feeding. Bridled terns do most of their fishing in the warm outer waters, swooping down from eight or ten feet and plucking the fish from the surface. They feed on juvenile filefish, small spine-backed fish that stick close to the sargassum, feeding on algae before returning to bottom reefs as adults. Shearwaters, petrels, and storm-petrels hunt in the upwelling water at the cold core of the eddy. Storm-petrels may feed on larval fish and other zooplankton. With wings outstretched, feet touching the water, and sometimes hydroplaning with the wind, the storm-petrels seem to walk on the water, giving them their common name of Saint Peter’s birds (the genus name for most storm-petrels, Oceanodroma, means “ocean runner”). The petrels feed on squid and the shearwaters on pelagic fish, like menhaden and bluefish, that spawn at the eddies before returning to coastal waters.

Because eddies last only a few weeks at most, I wondered how the fish, squid, and carnivorous zooplankton upon which the birds feed could become so abundant so
cause they resemble jellyfish, a principal component of the turtles’ diets.

Oil spills are not dispersed as readily by wave and wind action at frontal zones, increasing the risks of exposure for seabirds feeding on the ocean surface. Bird plumage loses its water repellency when coated with oil. Birds also ingest oil during preening. Heavy metals, polychlorinated biphenyls (PCBs), and other contaminants that have been washed from rivers do not disperse evenly throughout the ocean. Their concentrations at fronts have been measured at one thousand to ten thousand times higher than background levels. Such substances accumulate in the tissues and organs of seabirds that repeatedly feed on contaminated prey.

These birds have nowhere else to feed. After studying hundreds of maps showing locations of the Gulf Stream edge and frontal eddies, along with surveys of birds, I concluded that some seabirds were entirely dependent on the frontal eddies for food. Off the southern coast of the United States, where the Gulf Stream and the continental shelf meet, the frontal eddies are the major sources of biological productivity. (Where the Gulf Stream veers offshore, different forces are at work.) If these eddies didn’t exist, the outer continental shelf from Florida to North Carolina would be nearly devoid of life.
Known as Saint Peter's birds because they seem to walk on water as they feed, Wilson's storm-petrels, like the one at left, hunt in the cold core of the eddies for larval fish and other marine life. Cory's shearwaters, below, with three-foot wingspans, are the largest birds to flock at the Gulf Stream eddies.

R.A. Rowlett
Of Time and the Forest

The vast Tongass National Forest, shrouded in the rains and mists of southeastern Alaska, is the last primeval rain forest of North America. In the dim light that filters through the canopy of towering spruce and hemlock, the forest seems unchanging and timeless to us. For we have no clock to measure the biological time that shapes it and its creatures. Instead, we deal with the forest in political time (satisfying the short-term wishes of constituents and winning votes) or in economic time (lumbering for short-term profits). Unwittingly, in a few years we will have hacked away the heart of a forest that took millennia to grow.

After years of fieldwork, a few scientists have barely begun to understand the 10,000-year natural history of the Tongass. They present pieces of the complex puzzle in the following pages.

In 1909, when the conservationist president Theodore Roosevelt signed the bill creating the Tongass forest, he thought the great rain forest had been saved for future generations of Americans. Time is proving T. R. wrong.
Silent Music

by Matthew D. Kirchhoff

The first time I heard the expression, it caught me by surprise. "Found some nice music out there today," the man said, as we hiked toward camp on the muddy spur road. The remark seemed somehow out of character, and my puzzled look brought a grin to the logger's face. He explained. He'd been felling trees that morning on a flat near the mouth of a small, unnamed stream. Not your run-of-the-mill old-growth forest, this was a two-acre stand of Sitka spruce—perhaps a dozen big trees in all. Buttressed against the wind by thick roots that spread out from the base of each tree, the trunks quickly tapered to diameters of three to five feet and then, without tapering further, rose skyward, smooth barked and free of limbs for another eighty feet. These "select-grade" Sitka spruce saw logs, the finest wood available anywhere, would yield thousands of board feet of knot-free lumber. Sitka spruce's light weight, superior strength, and close, even grain make it ideally suited for guitars and piano sounding boards. As the logger explained, such trees brought top dollar from the makers of musical instruments.

The story illustrates how inadequately the generic term old growth describes these ancient forests. As this logger clearly recognized, all old growth was not created equal. The Forest Service defines old growth as any stand of trees more than 150 years old. By this standard, the average old-growth stand on the Tongass is scrub timber, where individual trees are indeed old but stunted by poor growing conditions.

Forest quality varies from site to site in any old-growth forest, but these differences are exaggerated in southeastern Alaska. Here, the land is still young. The forces of erosion and gravity have just begun their work on the jagged mountains that, a short 10,000 years ago, were scraped bare of soil by glaciers. Nearly 40 percent of the Tongass is not forest at all, but rock, ice, and muskeg. Most of the remaining forested land is only marginally productive. Significantly, only a small fraction of the Tongass, perhaps half of one percent, harbors the "music" of this old-growth forest.

Today, the finest old-growth stands from the Pacific Northwest through Alaska are gone. The value of the remaining big trees is tied to their scarcity and to the important role they play in old-growth ecosystems—a role biologists are just beginning to discover. As politicians struggle with the difficult question of how to allocate the Tongass's remaining old growth, they would be wise to recall the words of Aldo Leopold, who forty years ago said: "To keep every cog and wheel is the first precaution of intelligent tinkering." With newly found appreciation for the diversity of old growth, we are beginning to understand. An old-growth forest, absent the music, would be a very quiet place indeed.
Lowland Sitka spruce in southeastern Alaska
Endless Battles, Verdant Survivors

by Paul Alaback

In ancient folklore, trees talk to each other and whole forests move across the land, sometimes engaging in great battles. Raised in a scientific age, we may view such tales as pure foolishness and fancy—unless we think of forests as dynamic organisms, changing not in seasons, years, or even centuries, but over thousands of years. If we collapse time, then the tales become meaningful metaphors of forest dynamism and changeability—as I have begun to understand over the course of my studies of the Tongass National Forest.

The battleground I have come to know formed more than 10,000 years ago when the last continental glacier retreated, leaving behind thousands of rocky islands, deep, steep-walled bays, and rugged hills and valleys, some still containing glacial remnants, that make up the coast of southeastern Alaska. The glaciers often pressed back against the forest during little ice ages, and only 200 years ago, during a cold period, they surged down the valleys and the bays danced with glacial ice. Even today some glaciers continue to expand, tearing at the edges of the forest. My goal has been to understand the ancient chronology and the natural history of the rain forest that has taken over this wild, ever-changing landscape.

But as I step from the U. S. Forest Service boat, slosh through wet tidal meadowland, and gingerly cross a peat bog, my first concern is to find a dry tent site for the night. Crashing through a dense thicket of dripping blueberry shrubs and six-foot crabapple trees, I finally enter the dark, silent hemlock forest that has grown up since the hillside was clear-cut fifty years ago. An old corduroy road of four-inch logs leads through the dense, dreary stand of uniform hemlocks. The floor is brownish and almost devoid of undergrowth, except for the mosses.

A few hundred feet down the trail, past the old clear-cut section, the forest changes dramatically into a verdant primeval rain forest dominated by hemlocks of many ages, from seedlings and juveniles, some more than fifty years old, to towering five-century-old giants. In a clearing where an old Sitka spruce blew down five years ago, the white bells of blueberry flowers pepper a carpet of fast-growing seedlings of hemlock, blueberry, and bunchberry. As I look at the two contrasting sections of forest, familiar questions arise: Is that first, monotonous patch, with only a few scattered clumps of herbs and small shrubs, the ultimate and typical response of the northern rain forest to human-caused disturbance? And why does it contrast so drastically with the luxuriance of forests subject to small natural disturbances such as this single fallen tree? The question is not
an idle one, since the conversion of primeval forests to secondary growth through logging, ranching, or other human activities has many unknown implications for wildlife, soils, biological diversity, and fisheries.

I have spent six long summers in damp tents pitched on remote beaches and in Sitka spruce groves in forests of nearly every age in the 17-million-acre Tongass National Forest. At sixty-four study sites, I carefully described all trees, herbs, shrubs, and mosses, measuring and recording their mass and growth. In each forest, from Prince of Wales Island in the south to Admiralty Island and Juneau in the north, and from Misty Fjords National Monument along the rugged mainland to the stormy outer coast near Sitka, I found a clear pattern of forest development.

Twenty to thirty years after a mature forest is cleared away, a nearly impenetrable thicket of trees and shrubs develops. For the next 100 to 150 years a dense secondary hemlock forest rises above a dark, barren floor almost devoid of plant life.

The oldest sites, dominated by trees 200 or more years old, were of two types: forests with trees of the same age that arose after a catastrophic disturbance and forests with trees of all ages that evolved with continual small-scale disturbances of windthrows—individual trees that blew over. The even-aged forest had a less diverse understory (the plants on the forest floor and under the canopy) and a more homogeneous upper canopy.

In the even-aged forests, thick mats of hemlock and spruce seedlings regenerate quickly. Their dense growth smothers smaller plants by absorbing 99 percent or more of the available sunlight in a place where the sun's appearance through terrestrial clouds is a noteworthy event. Even after two centuries of development, when more light comes through the 100- to 200-foot canopy, even-aged and uneven-aged forests are still visibly different.

If I studied a few plants that thrive in the Tongass, I might find clues to the role of wind disturbance and how the rain forest ecosystem might have evolved. A leading candidate was western hemlock, a prominent conifer found from the fog-drenched redwood forest in northwest California to the edges of ice sheets near the Kenai Peninsula in south-central Alaska.

Unlike most timber-producing trees, hemlocks do not grow well on exposed mineral soil. They prefer to take root in the thick organic layers on the forest floor, where their fine roots form symbiotic relations with a variety of fungi. The trees grow fastest where nutrients are readily available: in sediments on alluvial terraces along major river valleys or on fresh soils of steep, actively eroding mountain slopes.

The major evolutionary strategy of western hemlock is to produce billions of seedlings each year, thus exploiting any new opportunities for nutrients now or in the future. A single tree typically produces a half million seeds each year. A few fortunate seedlings may grow fast enough to eventually reach the upper canopy. Their chances are particularly good if the upper canopy opens up. And along the coast of Alaska, high winds frequently create such opportunities.

The floor of an old-growth rain forest in southeastern Alaska resembles a huge, lumpy sponge. If you walk across it, sooner or later you will step on a rotten lump camouflaged by a thick carpet of mosses and stumble into a hole. These holes form as fungi slowly swallow up the decomposing wood of logs or stumps from decade- or century-old wind-thrown trees.

The upturned roots and soil of windthrows form root mounds that are colonized by haircap mosses, which absorb water and nutrients with rootlike hairs that penetrate deep into the soil layer. These deep rhizoids also hold the moss in place when the soil sloughs off the unstable root wad, thus stabilizing the mound for other plant species. Within fifty years, these mosses are usually overgrown by the expanding wefts of epiphytic feather mosses.

With their well-drained mixture of nutrients from deep in the soil, surface organic litter, and decomposing roots, windthrow mounds support some of the largest trees in the forest. These fertile mounds contrast sharply with nearby pits created when the roots of falling trees rip out the soil mat. There, poor drainage produces a slimy layer of decaying vegetation in which the nutrients, locked in insoluble organic compounds, are unavailable to most tree seedlings. Skunk cabbage, which often grows in these windthrow pits, is one of the few plants capable of
extracting these nutrients from the waterlogged habitat.

Several ecologists have proposed that windthrow mounds influence tree growth and soil development, and probably are essential for the sustained fertility of the rain forest. Without these upheavals of the soil, the leaching by heavy rainfall and the slow decomposition of leaves, wood, and other vegetation could lead to a buildup of infertile litter, a rapid deterioration of soils, and possibly, the formation of a water-impermeable layer. By impounding water, such a layer could acidify or waterlog the soil, ultimately creating an open, poorly drained forest or a peat bog. The ecologists believe that windfalls and other disturbances, by churning up the soils, may keep many northern rain forests from turning into bogs. The shallow roots of hemlock and spruce (usually no more than a foot deep) predispose rain forest trees to windthrow.

In the northern limits of the rain forest, heavier precipitation, cooler temperatures, and a shorter growing season combine to reduce forest areas and expand the bogs and alpine meadows; finally, the only place the forest can maintain its balance over bogs is on steep mountain slopes where soil is constantly mixing, forming, and eroding. In regions that are only marginal for the forest, one plant, the blueberry, often prospers.

The Alaska blueberry grows successfully high in the Cascade Range of Oregon, in the rain forests of Washington’s Olympic Peninsula, and all over southeastern Alaska, from Sitka spruce forests at the ocean’s edge to the mostly snowbound subalpine mountain hemlock forests. All these places are cold and wet and all have highly acidic soils. Most other shrubs could not survive in such harsh growing conditions.

In forests where less than one percent of sunlight reaches the floor, most blueberry seeds germinate and produce seedlings that persist—at barely an eighth of an inch high—for more than a year. Most seedlings, however, die within a few years. Even a tiny hemlock needle glued to the top of the blueberry seedling by perennial raindrops can spell demise. Fungi, animals, and sloughing of snow from the forest canopy all seem to work against the seedlings. But when a windthrow creates an opening, they grow rapidly and are more likely to survive to maturity.

The mature blueberry shrubs constantly change shape and reallocate their scarce energy reserves among roots, leaves, and stems, depending on how much sunlight is available, how heavily animals browse their stems and leaves, and how many other plants are competing for light and nutrients.

In dense old-growth forests, where light is scarce, blueberry plants put out a broad and open canopy of leaves to capture as much light as possible. These leaves have few or no chemical compounds to discourage animal browsing. When light is abundant, as in a new clearing created by a windthrow, the plant allocates most food energy into growing tall stems that rise above surrounding plants and into the manufacture of distasteful tannins and other chemicals that discourage browsing animals.

The blueberry plant may also adjust the size and density of stems on each plant. When growing conditions are excellent, the plant invests in a few old, large stems—costly to nourish and maintain, but capable of high starch and fruit production. But when light diminishes as trees close the overhead canopy, the large shrub stems usually die back and new, smaller stems form.

When a sudden windstorm hit the mature forest above the old corduroy road four years ago, trees in a one-acre patch fell over like dominoes. Three big spruce trees knocked over some smaller hemlocks, which in turn bent over others. The result was a long, narrow swath of cleared forest and a gartered mess of tree stems, leaves, and branches. The blowdown ruined some study plots, but it provided an opportunity to watch the response of hemlock and blueberry to natural disturbance.

With the flood of light through the open canopy, hemlock seedlings produced more buds, which led to more branches the following year. The trees gained significant weight and height within months of the windthrow. Elderberries, whose seeds had been dormant deep in the soil, germinated, especially on the fresh windthrow mounds. Despite cool, cloudy weather, blueberry seedlings and other understory plants, burned by the sudden increase in light, turned yellow or even white. By the next growing season, the blueberries’ leaves were green, but their growth was slow. They did produce small, creeping evergreen sprays with tiny toothed leaves less than a half inch across.
For years this diminutive, slow-growing, evergreen phase of the blueberry confused fieldworkers and it was often considered a separate species. Most understory plants in dense patches of rainforest are evergreen (shedding their leaves only every two or three years), probably to conserve precious food-energy reserves in the low-light environment. In openings, these same species usually have deciduous leaves.

Just last year, a great turnabout took place: three years after the blowdown, blueberry and elderberry seedlings burst forth, producing two- to three-foot fresh green shoots of adult deciduous leaves that overtopped the young hemlocks. This contrast in strategies—immediate growth of the hemlock seedlings and the delayed development of the shrubs—may be why the rain forest responds so differently to small-scale, natural disturbances and to human-caused, catastrophic disturbances.

In the rain forest's erratic environment, most plants are perennials and rely heavily on asexual reproduction. In order to resprout after stems are senescent, eaten, or otherwise damaged, shrubs build up food reserves in their roots. This probably explains why shrubs show less visible response to newly open environments than do herbs and why evergreen herbs such as bunchberry and trailing bramble can often colonize and even preempt shrubs in newly created habitats.

An herb can quickly skirt across the forest floor (sometimes several years a year) and flourish in a small windthrow area, even if the site lasts only a few years before the canopy closes again. Since herbs do not invest energy in woody rhizomes or tall stems, they can "gamble" by sending out long shoots in different directions.

My studies, and those of others, suggest a consistent pattern in rain forest renewal. Frequent windthrows toss up the soil and create small forest openings. There, evergreen herbs grow rapidly and produce fruits before being shaded out again by the trees. Larger openings are at first colonized by herbs but will eventually be dominated by shrubs that seed or resprout. Hemlock seedlings in turn will overtake the shrubs, unless the forest canopy closes in before the hemlocks grow large enough to survive. All types of disturbance, from the fall of a single tree to the destruction of whole swaths of forest, overlap in space and time and create a rich mosaic of plant species and wildlife.

In contrast, large-scale disturbances, such as clear-cutting, create huge, uniform openings that only slowly, if ever, return to the complex primeval forest. The woody plants best able to exploit these catastrophic events capture most of the light by growing dense and tall. Such growth creates a stark and barren forest floor.

But these intermediate outcomes, which may take a few centuries to evolve, are only short-term developments in a forest where many trees were old before Columbus was born and have lived through little ice ages. What is the forest's fate in the endless battle against the elements, accidents, and other plants?

Will some even-aged stands produce a hard pan in the soil, become waterlogged, and revert to bogs? How will wildlife fare when second-growth forest replaces the rich mosaic of an old-growth forest? Can we preserve diversity if we modify logging and let some trees remain rather than completely clear-cut? What will happen when clear-cut forests are cut again? How resilient will the forest be to the inevitable climate change?

I've tried to work out scenarios, but speculation at the longer time scales soon gets fuzzy. I've also kept copious research notes, and perhaps many human generations from now another scientist will use them to help answer these questions.
Alaskan blueberries
The terrain on Baranof Island is typical of much of the Tongass: a steep rise from lush forests at sea level to stark rock and snowfields above.
Little Deer in the Big Woods
by John W. Schoen and Matthew D. Kirchhoff

With the flick of an ear, a black-tailed doe suddenly appears, half hidden behind the trunk of an ancient spruce. Then, with gliding steps, she is gone, melting from view into the lichen-shrouded forest. She had been watching us as we followed her zigzagging tracks from tree to tree, skirting tangles of devil's club and blueberry shrubs. Burdened by steamy rain gear, we steadily work our way up the steepening slope. Everywhere in small clearings, dense patches of melting snow are littered with lichens and tips of conifer branches, knocked from the canopy in recent storms. Deer consumed those bits of food only weeks before, but now ignore them as the succulent new growth of spring once more abounds.

We are tracking a young Sitka black-tailed deer through an ancient rain forest on 1,700-square-mile Admiralty Island, one of the largest of the thousand islands within the Tongass National Forest in southeastern Alaska's Alexander Archipelago. This small subspecies of mule deer is found only along the rain-swept Pacific Coast from northern British Columbia through southeastern Alaska. Here, at the northern extent of their natural range, these deer have persisted in a precarious balance with their winter habitat since the last ice sheet retreated more than 10,000 years ago. Unlike most deer in North America, which thrive in clear-cut areas and in open brushlands, the Sitka blacktail prefers old-growth, or virgin, forest over other habitats, particularly in winter, when it depends on the massive forest canopy for protection from periodic deep snows.

Our research, begun in 1976, has enabled us to put together a picture of a year in the life of a Sitka blacktail. During summer, the doe we were tracking would, like most of the archipelago's blacktails, migrate to the lush alpine ridges that form the backbone of the major islands. Here, above tree line, she feeds belly deep in meadows of succulent wildflowers and green plants, particularly deer cabbage—a summer favorite. At this time of year the high country, at least on Admiralty, Baranof, and Chichagof islands, is relatively safe; the only predators are grizzlies, and most of them move down to salmon streams far below during summer and early fall. (In the southern portions of the archipelago, the deer have to contend with wolves and black bears.) The doe is able to concentrate on eating, putting on the fat she needs to carry her through the long winter.

As alpine meadows yellow from the killing frosts of autumn,
the doe begins to descend. At first, she moves just far enough to reenter the forest, where the vegetation—nutritious low-growing, broad-leaved plants such as bunchberry and trailing bramble—remains green and palatable. Later, as the first snows begin to accumulate, she and other deer move farther down the steep mountainsides into the heart of the rain forest.

With the end of the fall rut, or breeding season, in late November and early December, many bucks begin to lose their antlers. The yearling doe bred for the first time this year and has now descended to her winter range, the same area she wintered in last year and one that overlaps her mother’s home range. Consisting of about 200 forested acres on a southwest-facing slope overlooking the frigid waters of Chatham Strait, the winter range extends from 500 feet above sea level down to the shoreline and is a complex mosaic of habitats. More than half of the range is composed of scrubby trees and dense blueberry shrubs growing on poorly drained soils. These trees, many of them 200 to 500 years old, technically qualify as old growth, but they are short and sparse, providing little protection from the elements. Snow falls unimpeded through openings in the forest canopy, burying most vegetation on the forest floor and making every step a struggle for the deer. Interspersed throughout the forest are patches of open muskeg overgrown with sedges, Labrador tea, scattered shore pines, and stunted mountain hemlocks. Less than 10 percent of the winter range contains the big trees most people think of as old growth. In these groves the deep crowns and broad, spreading limbs of the dominant western hemlock intercept up to 80 percent of the falling snow. The old trees also bear the brunt of the frequent gales and driving rains. During the severest winter months, the doe spends nearly two-thirds of her time in these relatively rare stands.

By January, more than two feet of snow has piled up in the scrub forest and muskegs. Even under the old-growth canopy, the deer is faced with nearly a foot of snow. In response, she moves several hundred feet farther downhill, where bunchberry and trailing bramble are more exposed in snow-free patches under the largest trees. Heavy snows continue to fall, and by February, more than three feet has accumulated at sea level, forcing most deer down to the lowest portions of their winter range. Near the coast, some deer move out onto beaches, where at low tide, they feed on kelp—a low-quality food of last resort. The doe beds down beneath a large hemlock half a mile inland. Even under the big stands of old growth, the best forage is buried. To conserve energy, she spends more time resting than looking for food. When she does eat, she is restricted to the woody stems of shrubs and conifers and to arboreal lichens that are blown down out of the canopy. The doe manages to fill her rumen, but none of these foods are very nutritious. By spring she will have lost 20 percent of her summer weight.

During especially severe winters, as in 1972, snow may keep piling up for half the year even at sea level, reaching peak depths of more than six feet. At such times, more than 75 percent of the region’s deer perish and beaches are littered with their carcasses. In mild winters, periodic heavy rainfall washes away
In summer, the Sitka blacktail lives in the high meadows and the upper fringe of the forest, above, about 2,500 feet above sea level. Once the snows come, the deer move down to feed under the oldest and largest trees, right, where vegetation is still exposed on the forest floor.

Both photographs by John W. Schoen
the snow below 1,000 feet, and most deer find adequate food to survive until spring.

With April come weeks of warm rains. The snow line recedes, and the doe—two months from bearing her first young—is beginning to eat well again. Now the deer prefer the scrubby old-growth forests because the relatively open canopy lets in abundant light, stimulating plant growth. In addition to the low-growing, broad-leaved plants until recently covered with snow, the deer seek out the emerging tips of the yellow, candlelike spadix of skunk cabbage. At this time of year, few of the nutritious shoots escape the deer’s attention. As spring merges into summer, a new crop of fawns are born, and soon the doe, this time accompanied by her first offspring, will move to the high country. The annual cycle begins again.

The Tongass is home to many mammals, including bears, mountain goat, marten, river otter, mink, and flying squirrel, and to innumerable birds. Each species has its own relationship with old-growth forest. Unlike deer, grizzlies use old growth most during the summer and early autumn, when hundreds of thousands of salmon are fighting their way upstream to spawn and die in the many rivers and streams dissecting the Tongass. To hike a fish stream on Admiralty, Baranof, or Chichagof Island is to step into a primordial world of bears, fish, and giant trees. Under ancient four- to eight-foot-diameter Sitka spruce trees, deep-rutted bear trails penetrate a jungle of thorny devil’s club and salmonberry shrubs and crisscross stream banks lined with half-eaten salmon. During this season, most bears spend nearly half their time in these stands of streamside Sitka spruce. These stands—which make up less than one percent of the entire forest—are very different from the big hemlock stands deer depend on in winter. As autumn advances, grizzlies head to the high country to excavate their winter dens, which are often situated under the roots of large spruce trees or in the bases of big rotted snags.

Mountain goats in the Tongass use the old growth in winter, seeking out the protective cover of steep, forested sites near cliffs. Bald eagles build their nests along the coast, in big trees averaging more than 400 years old. Marbled murrelets nest on lichen-covered limbs high up in the canopy.

How does logging affect wildlife of the Tongass rain forest? Clear-cuts produce an abundance of summer forage, but they are often unusable during periods of winter snow. And after twenty to twenty-five years, the conifer canopy closes, creating a dark second-growth forest that produces few plants for herbivores to eat. This sterile condition persists for more than a century or until the stand is harvested again.

Only a small percentage of the Tongass Forest is scheduled for logging annually, but by going after the stands of large trees along low-elevation slopes and stream sides, loggers are eliminating some of the most valuable wildlife habitat. As, as is proposed, prime old-growth habitat is cut and then placed under harvest rotations of 90 to 125 years, it will be gone forever. Deer numbers will decrease over the long term in logged areas. Grizzlies will lose important summer habitat and, most significantly, will find themselves increasingly in conflict with humans as more and more logging roads are built. Inevitably, other species dependent on the Tongass will suffer, too. Loss or reduction of individual species is part of a larger problem: reduction of natural forest diversity.

The old-growth rain forest on the Tongass is a rare and valuable resource. Although trees are renewable, old growth—which requires centuries to develop fully—is not. Responsible stewardship of the Tongass rain forest will require far-sighted planning to maintain the integrity of this complex ecosystem, including its ancient trees, black-tailed deer, grizzlies, bald eagles, salmon, and myriad other plants and animals. Management decisions made today will forever affect the opportunities of future generations to use and enjoy this unique forest.
Fish among the Trees

by Stan Gregory

The streams and rivers in old-growth forests like those of the Tongass cascade around boulders covered by luxuriant carpets of moss, the result of centuries of shading by spruce, red cedar, and hemlock. How do these streams differ from those that pass through younger, deciduous forests of big-leaf maple, red alder, or cottonwood?

Conifers resist decay better than most deciduous trees. When a conifer dies and falls into a stream channel, the trunk and limbs can remain intact and affect the stream’s flow for a century or longer. The dead logs accumulate, often amassing more than sixty pounds of wood per square yard of stream. Wood jams deflect the stream into slow-moving backwaters, eddies, and side channels. From the rain of needles, leaves, and wood from the forest canopy comes food for insects. The dense cover of towering conifers blocks out light and limits the growth of algae and other water plants. Most insects live in the slow-moving waters, where they attract trout, juvenile salmon, and salamanders. Coho salmon, one of eleven species of salmon, trout, and char in the Pacific Northwest, generally live in the streams for a year before migrating to the ocean. When coho fry emerge in the spring from eggs buried in gravel deposits, they move to the slow shallows along the stream margins. As they grow, they migrate to the pools of the main channel, where the fallen logs provide cover and protection.

During the torrential winter floods, the streams deepen and the currents accelerate, inundating side channels and flood plains. The massive trunks and roots of the old-growth forest and the debris on the flood plain slow the waters and protect the young salmon from being washed downstream. And in the spring, when the juvenile coho salmon migrate to the ocean after their first winter, they rest at the pools created by the accumulation of logs and branches.

At the end of their ocean existence, coho swim back up these same streams to the tributaries of their birth. They again rest in these large pools, and at the end of their journey, dig nests, or redds, in gravel deposits that often lie behind large pieces of fallen trees. After spawning, the fish die, and their carcasses, trapped in the log dams and backwaters, become an abundant, high-quality food for insects and crustaceans that eventually feed a new generation of salmon.

In areas that have been clear-cut for lumber, the trunks and fallen branches become increasingly rare as the debris from the previous old-growth forests decays, breaks up, or is transported downstream. (Before the critical role of such fallen wood was recognized, fishery biologists used to demand that loggers clear the debris from the streams.) After old-growth forests are logged, the effects on fish are unpredictable. More sunlight may mean more algae, more insect life, and at first, more fish. But the loss of log-jammed backwaters may mean fewer places for the fish to overwinter. Exposed streams also become warmer, an effect that can have mixed results. In British Columbia, chum salmon in streams warmed by loss of forest grew faster, but they migrated from the protection of the streams sooner, leaving them exposed longer to predators in the open estuaries. The result was an eventual decline in the population. Many of the physical characteristics of the streams, rivers, and forests recover within the first several decades, but what simply cannot be renewed or replaced are the trees that took several centuries to grow, die, and fall.
When streams cascade over fallen trees in uncut ancient forests they dig depressions in the stream bed. These pools provide shelter and food for both young fish and migrating adults. Coho salmon, left, spend their first year in the streams, migrate to the ocean, then return, as three-year-olds, to spawn.
Buried Treasures

by Chris Maser

Northern flying squirrels are at home in treetops, nesting comfortably in the upper reaches of conifers. But after dark, these arborealists descend from the heights to the forest floor. There, they dig into the soil to unearth a foodstuff deemed a delicacy by fungi fanciers and now found to be a staple in the diets of many small mammals—truffles.

Known to botanists as sporocarps, truffles are the fruiting parts of various species of subterranean fungi. As they mature, truffles, which look like little potatoes, emit a strong odor that attracts foraging squirrels. In Alaska, truffles are the primary food of northern flying squirrels from spring through autumn. In some parts of their extensive range, flying squirrels live almost exclusively on fungi and lichens. Both the squirrels and the truffles are agents in a complex cycle vital to the health of the forest and its trees.

The cycle begins underground, with mycorrhizae, or “fungus roots,” the symbiotic association of certain fungi—including those that produce truffles—with the roots of woody plants. Lacking chlorophyll, a mycorrhizal fungus cannot manufacture its own sugars nor can it derive sufficient nutrients from dead or decaying organic material alone. The host tree—a Sitka spruce or a western hemlock, for example—provides the fungus with photosynthesized sugars. The fungus, in turn, transfers minerals, water, and other nutrients it has absorbed from the soil to the tree through threadlike hyphae (the “mold” part of the fungus), which penetrate the host’s tiny rootlets. Within the mycorrhizae, species of the nitrogen-fixing bacteria *Azospirillum* use a fungal “extract” as food and reciprocate by converting atmospheric nitrogen to a form usable by both the fungus and the host tree. Many kinds of mycorrhizal fungi produce growth regulators that stimulate production of new root tips and increase their life span, and some fungi even protect the tree from pathogens. In effect, these fungi serve as a highly efficient extension of the host’s root system.

As the fruiting bodies of fungi, truffles contain the spores of a new generation. But unlike mushrooms, truffles develop entirely underground and cannot depend upon air currents to disperse their spores. Flying squirrels, lured by the pungent odors of the truffles, provide that service. But the connection between squirrels and the tasty truffles goes beyond one of simple “eat and excrete.” When flying squirrels and other small mammals eat truffles, they consume not only needed nutrients and spores for dispersal, but also a blend of ingredients designed to promote forest symbiosis.

Bits of truffle pass through the squirrel’s stomach and small intestine and into the pouchlike cecum, which functions like an eddy in a swift stream, concentrating and mixing spores, nitrogen-fixing bacteria, and yeast. This blend then “ferments” inside the cecum. (Captive deer mice are known to have retained spores in the cecum for more than a month after ingesting them.) Eventually, the undigested ingredients are shunted to the colon, where they are compressed into pellets for excretion. Yeast works on the other pellet components, stimulating the growth of still-viable spores as well as growth and nitrogen fixation in the bacteria. The fecal pellets contain all the elements needed to give life to a tree.

Pellets excreted by flying squirrels in the forest canopy might drop to fertile ground—the environs of a moist, rotting log, for
example—and introduce spores, bacteria, and yeast into the wood, while pellets excreted on an open area of the forest floor might encounter conifer rootlets ripe for inoculation with mycorrhizal fungus when spores germinate. If environmental conditions are right and root tips are available, a new fungal colony may be founded. Or hyphae may fuse with, and contribute new genetic material to, an already established fungus.

The northern flying squirrel plays a dynamic role in a series of forest mutualisms that range through the tree canopy, down to the forest floor, and into the soil mantle. There, through mycorrhizal fungi, nutrients are conducted back through roots, up the trunk, and into the crown of the tree, perhaps even into the flying squirrel’s own nest tree.

Northern flying squirrels reside in the boughs of conifers, left, but make nightly forays to ground level to delve for underground fungi. Above: A squirrel prepares to relish a truffle.
Winter Hideouts

by Jeffrey Hughes

Winter in the coastal rain forest of southeastern Alaska is a bottleneck through which few of the forest birds pass. Only a fraction of the fifty or so species that breed in the old growth stay past early October. Most migrate, avoiding southeastern Alaska’s wind, rain, snow, and freezing temperatures. By the middle of winter, food is scarce and daylight lasts for eight hours or less—drastically reducing a bird’s foraging time.

A few species, however, do remain. On Admiralty Island, where I work, a mid-February walk in the forest will often turn up a flock of golden-crowned kinglets or chestnut-backed chickadees, a brown creeper searching for dormant spiders in the deep, loosely fluted bark of a western hemlock or a hairy woodpecker probing for insects in the soft wood of a dead Sitka spruce.

Brown creepers and chestnut-backed chickadees are abundant in these old-growth stands in winter, when they appear to move short distances from inland areas to the milder climate of the adjacent coastal rain forest. Once there, they settle in stands of large, 300- to 1,000-year-old trees. One of the most critical elements in the birds’ winter survival is the presence of snags—standing dead trees—which run about six to the acre in the old growth.

Snags are storehouses of high-quality food all year round, but they are particularly important in winter, when they provide a rare source of animal protein in the form of overwintering insects found in bark crevices and in the wood below. Brown creepers and hairy woodpeckers are bark foragers, and they, as well as chickadees, exploit snags for their high-energy foods in the cold months. But even a dependable food supply is not enough to sustain small birds when temperatures plunge during long winter nights. In this respect, too, the snags are a vital resource. Large snags may contain abandoned nest cavities, many of them excavated by red-breasted sapsuckers in preceding summers.

When the sapsuckers leave for the winter, their nests become roosts for the birds that stay behind. Since nights may be sixteen hours long, and the birds typically roost from before sunset to sunrise, chickadees, creepers, and hairy woodpeckers essentially spend most of the winter in these tree holes. A single hole often contains more than one bird and may be crowded with roostmates of a few different species.

In southeastern Alaska, where from 60 to more than 200 inches of precipitation fall each year, the most important function of the cavity roosts may well be protection from wind, rain, and snow, but they are also excellent insulation against the cold. A thick layer of wood limits conduction and radiation of the birds’ body heat to the surrounding air; as a result, the temperature inside an occupied cavity can range from six to eleven degrees Fahrenheit above that of the outdoors, even in subfreezing weather.

All snags are not alike; standing dead trees vary throughout the old growth by species, size, and condition. Certain types are preferred. Western hemlocks may live as long as 500 years, and Sitka spruce often survive to 700 or 800 years of age. Insects or disease eventually fells these old veterans, and their demise creates prime real estate for cavity-dependent birds. Excavating birds almost always choose large, well-decayed western hemlocks that still retain most of their bark. (The bark keeps the interior wood moist, hastening heartrot, which softens the interior.) More than three-fourths of cavities are found in the upper third of hemlocks with missing or broken tops. Strong winds apparently remove the tops, providing an entry point for
heartwood-rotting fungi. The upper portion of a broken-topped snag is probably most suitable for excavation because it is in a more advanced stage of decay. On Admiralty Island, nesting birds also prefer thick snags, usually twenty-two inches or more in diameter. Thicker walls not only provide better insulation, they also affect the survival of small birds by affording better protection from nocturnal predators, such as great horned owls and pine martens.

Logging old-growth stands radically changes the habitat for birds. Cultivated second-growth trees, cut down every 100 to 120 years, would not supply the kind of snags so critical to the birds' survival, since stands less than 100 years old rarely contain trees with heartwood decay. Without the well-decayed snags, at least twelve cavity-dependent bird species would not be able to find suitable nest sites in Tongass in summer, and nearly half of the forest's permanent avian residents would not find an adequate winter habitat. The result would be a much diminished forest.

The chesnut-backed chickadee does not migrate away from the Alaskan rain forest in winter. Instead, it moves into stands of large, old trees, where during the long nights and frequent spells of bad weather, it takes refuge in abandoned woodpecker holes.

R.H. Armstrong: Animals Animals
Making and Breaking the Tongass

1907: The Alexander Archipelago of southeastern Alaska, named a forest preserve by President Theodore Roosevelt in 1902, is renamed the Tongass National Forest by an act of Congress. Its 16.8 million acres, roughly the size of the state of West Virginia, make it the country’s largest national forest.

1947: The Tongass Timber Act authorizes the secretary of agriculture to contract sales of Tongass timber. Passed over the objections of native Tlingit and Haida leaders, the act sets aside receipts from timber sales “until the rights to the land and timber are determined.” The Ketchikan Pulp Company and the Alaska Pulp Company are eventually awarded fifty-year contracts to log eight billion and five billion board feet, respectively. Native rights are eventually denied.

1971: In recognition of Native claims, the Alaskan Native Claim Settlement Act awards Native corporations 500,000 acres of the Tongass National Forest.

1980: The Alaska National Interest Lands Conservation Act designates 5.5 million acres, some one-third of the Tongass, as wilderness. To maintain jobs in the timber industry, section 705 of the act mandates the Forest Service to offer an average of 450 million board feet of timber for sale each year. As an incentive to industry to buy and cut the available reserves, the Forest Service must spend $40 million a year to build access roads into economically marginal timber stands, thin young stands of timber to increase growth, and conduct research into logging techniques. The Service can also lower the price of the timber, which it does drastically in 1983. But employment drops, as do timber sales.

1988: The Tongass Timber Reform Act would do away with mandatory timber sales and expenditures. The bill before the House of Representatives also renegotiates the fifty-year contracts with the two logging firms and sets a five-year moratorium on logging in nineteen environmentally sensitive areas.
Logging roads connect clear-cut areas of the forest above Freshwater Bay on Chichagof Island.
August Showers

by Thomas D. Nicholson

One of the most spectacular events sky watchers ever see is a so-called shooting star. What we call “shooting” or “falling” stars are quite common; ten or more per hour can be seen on almost any clear, dark night if you are far enough away from bright lights. These objects are, of course, not really stars nor are they falling or shooting (although they look as though they are). Instead, they are small pieces of rocky or metallic debris that fly into the earth’s atmosphere from outer space. Because they travel as fast as fifty to sixty miles per second, friction with the air causes them to glow.

Every year as the earth orbits the sun, it passes through the same regions, some of which are especially full of meteoric debris. For several days in August, we orbit through the swarm of debris that produces the Perseid meteor shower. It is named for the constellation Perseus because its meteors appear to come from the direction of that constellation. One August is as good as another, and August this year, from the 9th through the 16th, is no exception. You can count on the Perseids to put on a good show and that’s what makes them ideal for meteor watching. You should be able to see about twenty-five to thirty shooting...
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events per hour (with luck as many as sixty),
but the best night for viewing is August
12/13, when the shower is at maximum.
The time of the night at which to watch
is important. While shooting stars can be
seen any time the sky is dark, the greatest
numbers and the brightest of them are
usually seen after midnight. This is
because our location on earth will then have
rotated toward the direction the earth is
moving as it orbits the sun. Some of
the space debris that causes shooting
stars then meets us head-on.

Watching is simple. The idea is to have
as much of the sky as possible within view.
Find a place relatively free of trees and tall
buildings and away from direct lights. Ly-
ing down or sitting in a reclining position
allows you to view a large part of the sky
without neck strain. For the Perseids,
concentrate on the northeastern part of the
sky where Perseus is located. Since shoot-
ing stars can appear anywhere in the sky,
you will probably see a meteor directly; more often you will catch it
out of the corner of your eye. By turning
quickly, you can then see its brightness as
it streaks through the sky. Patience is
important. You may have to wait awhile
to see your first meteor, but you will see the
next one faster and more easily, and with experience, relatively few will escape you.
Serious meteor observers often work in
teams in order to miss as few as possible,
so this is a nice group activity.

Events in the calendar below occur in
local time unless otherwise indicated.

August 1: Moonrise is after 9:00 P.M.
The reddish object nearly is Mars, rap-
idly approaching Jupiter in brightness.
The moon is in Pisces, Mars is in Cetus,
and both are near the vernal equinox.

August 2: The moon rises with Mars
tonight, to the planet's left, accompanying
it in the morning hours. Mercury passes
the sun at superior conjunction (in line
with and beyond the sun) just before mid-
night, changing from a morning to an even-
ing object.

August 4: Last-quarter moon is at 1:22
P.M., EST, in Aries.

August 5-8: The morning crescent
moon is in Taurus, rising later after mid-
night each night and remaining visible
until dawn. The bright object near it at
daybreak on the 6th is Jupiter. The moon
is also close to the Pleiades star cluster.

August 8: The crescent moon is near
Venus this morning, to the left, or north, of
it. The moon, Venus, and Jupiter make a
striking narrow triangle, with Jupiter at the
apex.

August 9-16: The Perseid meteor
shower, usually the year's best, occurs. The shower will reach its maximum about the 12th, when up to sixty meteors per hour can be seen. The best viewing is after midnight, and this year there is no bright moon to interfere, so viewing should be particularly good.

August 12: New moon occurs at 7:31 A.M. in Leo. Mars is at perihelion (nearest the sun).

August 13-14: We may see the young crescent moon (in Leo) on the 13th but surely on the 14th. It is at aphelion (farthest from the earth) on the 14th.

August 15-18: Virgo is home to the evening crescent moon, which is close to the constellation's brightest star, Spica, on the 17th.

August 20-21: First-quarter moon is at 10:51 A.M., EST, in Libra. Antares is the star to the moon's left on the 20th and to its right on the 21st, after the moon occults the star over parts of the Southern Hemisphere.

August 22: Venus, our brilliant morning star, is at greatest elongation to the sun's right, its best position as a morning star during this cycle of configurations. The moon and Saturn, the brightest object near it tonight, are in Sagittarius.

August 23: Still in Sagittarius, the moon is now left of Saturn, in the "handle" of the Archer's teapot-shaped star arrangement.

August 24-26: Moving from the western to the eastern border of Capricornus, the waxing moon brightens too fast for the constellation's dim stars to be visible.

August 27: Full moon is at 5:56 A.M., EST, and a partial lunar eclipse will be visible, at least in part, nearly everywhere in North America. Perigee moon (nearest the earth) occurs only six hours after full moon, and the effect on the normally high spring tide (which is caused by a new or full moon) will be substantial. Strong onshore winds tonight or tomorrow could cause flooding tides along coastal areas.

August 29: The moon is near Mars for the second time this month, and the planet will be much brighter than at its earlier conjunction on the 2d.

August 30: Saturn is stationary, ending its westerly drift through the stars and resuming its normal easterly motion, a signal that the planet will leave the evening sky in a few months (by late fall).

August 31: The waning gibbous moon rises shortly before 9:00 P.M. in Aries, far below and to the left of the brilliant Mars.

Editor's Note: The Sky Map in the July issue shows the stars and constellations for his month and gives the dates and times of its use.
Tibetan Sand Mandala

The sand mandala of Tibetan tradition is a "painting"—made of sand, jewels, flowers, rice, or stones—that represents the home of Buddhist deities. For six weeks, visitors to the American Museum can watch the Venerable Lobsang Samten, one of four personal assistants to the Dalai Lama, create the first Tibetan sand mandala to be constructed in public view in the United States.

The Kalachakra, or Wheel of Time, a design passed from teacher to student for more than two thousand years, represents 722 Buddhist deities within its seven-foot-square geometric pattern. The monk will construct it out of colored sand, often applying only a few grains at a time.

The sand mandala will be housed in a thekpo, an enclosure resembling a pagoda, in the Leonhardt People Center, where visitors can see the artist at work from July 9 through August 21. Viewing hours are from 10:00 A.M. to 5:00 P.M. on Tuesdays, Thursdays, and Sundays and from 10:00 A.M. to 8:00 P.M. on Wednesdays, Fridays, and Saturdays. For more information call (212) 769-5305.

Australia: A Bicentennial Celebration

Rare books depicting Australian fauna, flora, and history are currently on exhibit at the American Museum in celebration of Australia's bicentennial. Illustrations, several by the English naturalist John Gould, include depictions of the kookaburra, cockatoo, and lyrebird, as well as such unique Australian mammals as the wombat, dingo, kangaroo, tree wallaby, koala, and platypus. Also on display are documents of the first English landing three hundred years ago by the pirate William Dampier, the 1768-79 voyages of Capt. James Cook, the British penal colony at Botany Bay, and the Napoleonic expeditions of the early 1800s. The exhibit will be on view in the Library Gallery through August.

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THE PRINTING PRESSABLE PRESSABLE PRESSABLE PRESSABLE PRESSABLE...
The Glasnost Gourmet

When dining in the Soviet Union, togetherness counts

by Raymond Sokolov

For a child of the forties and fifties like me, a visit to the Soviet Union for the first time was a voyage into fear. No matter how much I had been reading and hearing about the new openness and the struggle to restructure the lumbering post-Stalin economy, I could not help hearing the words gulag and KGB when other people said glasnost and perestroika. Although I had no intention of seeking out refuseniks or in any other way riling the Soviet authorities, I was traveling officially for the Wall Street Journal, and the recently staged arrest of the American correspondent Danilov was hard to forget. In my calmer moments, I told myself that it was extremely improbable that I would be victimized by the secret police and that even Danilov had been released after a short time in an apparently comfortable cell.

My other major fear was that I would be constantly hungry. For years I had been hearing about the inefficiency of the Soviet food delivery system and, in particular, how long and troublesome each meal was for tourists struggling with waiters and kitchens uninspired by economic incentives or economic risks.

As things turned out during my ten-day visit to Moscow and Leningrad last January, I was not arrested and not even tailed by the KGB (so far as I was able to tell). Meals were served promptly in the hotels I stayed in, with one exception, which was probably a misunderstanding—I was alone and the waiter assumed incorrectly that I was waiting for other people.

But the question of whom one was eating with underlay every meal and is one of the reasons that American visitors to the Soviet Union are so frequently unhappy at the table in the worker’s paradise. The worker gets served promptly—not necessarily well, but promptly—because he eats lunch with the people he is supposed to eat with. He eats with his collective or, rather, with one of his collectives. At home, he eats with his family unit; at work, he eats with co-workers in a cafeteria or buffet (bufyet) set up to feed a predictable group at a predictable time.

This is, of course, subsidized lunching but not much different in concept from company cafeterias throughout the United States. My only experience with a Soviet workplace lunch of this kind was almost certainly better than most, if only for its setting. I speak of the bufyet of the Writers’ Union in Moscow, whose headquaters occupy the yellow neoclassical mansion once owned by the family after whom Tolstoy modeled the Rostovs in War and Peace. The bufyet is in the cellar, small but cheerful, quiet and well supplied with smoked fish, various sandwiches, and the omnipresent fruit salad cum fruit drink called kompot. The cost was a few kopecks and there was no line.

In hotels, there was always some facility designed for expeditious eating, a grill or a dining room intended for my collective: travelers living under the collective umbrella of Intourist, the official travel agency. There were also restaurants in my hotels that were not primarily intended for people in my category. These were really nightclubs implanted in the former ballrooms of the hotels, and they catered well, after their fashion, to groups that were making an occasion out of the evening—groups of celebrating Soviet citizens or of travelers with a comparably relaxed sense of time and a previously advertised interest in an opulent meal, including Georgian champagne, caviar, and the other accouterments of a blowout, Soviet style. Live entertainment of a sort not ready for Las Vegas or even U. S. public-access cable television rounded out the meal.

The solo traveler or couple in search of an à la carte gastronomic experience such as might be found in almost any first-
world hotel do not fit into this ambience. At most, self-guided diners must abandon hope of ordering from the semimythical items on the printed menu and attach themselves to the food being prepared for the set banquets all around them. And they must resign themselves to conforming to the more leisurely schedule of the revelers for whom the system was designed. In effect, they must join the collective banquets. The same principle applies to free-standing restaurants. To walk in without first establishing a collective connection through Intourist is a sure way to join other solitary malcontents in a static line out in the snow.

To all of this, there are alternatives. In Moscow and some other major cities, new laws have encouraged the creation of so-called cooperative restaurants. They are allowed to set their own prices and to arrange for their own food supplies in the open market, with its more appealing and more expensive ingredients. Since there is no advertising, the only guide to the cooperativas was assembled by a resident Western diplomat, who deduced their existence from an official list of new enterprises. He located more than eighty cooperativas. I ate in one and found it overpriced but not much different from the best of the Intourist restaurants. Shashlik is shashlik. Second-rate caviar is second-rate caviar. Service was perhaps more personal. The very limited number of foods available in Moscow in January at any price put a ceiling on culinary innovation. One tended to see the same pickled and smoked foods on every table.

No doubt the cooperatives have already improved from what I was able to see, but it is a slight distortion to think of them as experiments in pure free enterprise. All of them are licensed and strictly controlled by the state. Their name is not euphemism, since they really are structured as
collective enterprises of limited size, and the technicalities of the law make cooperatives especially appealing to families.

For the moment, given their cost, cooperative restaurants are not affecting the lives of ordinary citizens. Normal people do, however, have two major sources of prepared food conveniently available to them outside the home and the workplace. There are street vendors selling everything from pirozhki (hot, savory pastries stuffed with meat, cabbage, and many other things) to pyelmeni (Siberian ravioli) to excellent ice cream. And for a full meal, there are very simple cafeterias called stolovias—literally, places with tables. I ate in two and found them cheerful, well-served, clean sources of filling plain food—soups, stews, bread, kompot. Stolovias are the exception that proves the rule. They are restaurants for people temporarily without a group, for the collective of the uncollectivized.

For a visitor who was soon to return to the bounty of capitalist supermarkets and restaurants, a brief exposure to the realities of the Moscow food scene was no hardship. There was just enough variety and novelty to make meals interesting. I was spending much more cash, of course, than my Soviet counterparts could afford and I also had access to better food than they normally did. I didn't have to depend on one of those bleak, crowded little food stores with their meager selection of frozen fish and anonymous meat. And even those joyless emporia were magnets for people in the less well supplied hinterland, who came into the capital by train to shop for groceries and then carried them home by train to their villages.

One of the effects of this gastronomic barrenness has been to constrict and perhaps to destroy much of traditional Russian food. As Anne Volokh put it in _The Art of Russian Cooking_ (1983), "Russian cuisine exists in Russia itself only in a lamentably reduced form, a fact I experienced at firsthand during my seven years as a food writer for a Moscow Sunday newspaper."

This is surely so even today, but at least the Russian national beverage survives and prosperes. I am not speaking of vodka, which General Secretary Gorbachev has subjected to various controls in his trouble-ridden attempt to curb the problem of Russian alcoholism (moonshiners have filled the gap and created a sugar shortage). The drink I have in mind is kvass, the mildly alcoholic, yeast-fermented, malty brew whose main ingredient is usually rye bread.

At all levels of society, Russians have been drinking kvass for more than a thousand years. Not only bread but currants, raspberries, lemons, and almost every other kind of available fruit has been made into kvass in that time. Peter the Great is said to have liked the smell of kvass when splashed on the hot stones in a steam bath. Kvass is more commonly used as a tangy base for cold soups, notably the vegetable soup called okroshka and the extravaganza called botvinia.

Czar Nicholas II, according to Anne Volokh, liked to demonstrate the proper method for eating botvinia. Each guest receives three plates—one for cold fish and shellfish, a second for ice cubes, and a third for a vegetable soup of sorrel, spinach, beet greens, and beets. You put an ice cube in your soup. Then you eat some fish and then some soup.

Most kvass is, however, plain old sour, fizzy bread kvass and is consumed neat and unrefrigerated, straight from the barrel in the street, most frequently in the summer. But Russians will line up for ice cream outdoors in January, so the kvass trade never really stops.

I saw the telltale Cyrillic letters KBAC on a plain little building near the Smolenskaya subway station at one end of the Arbat, a zippy pedestrian artery in central Moscow. Inside the store, men in overcoats (a sign that we might as well still be outdoors; Russians always take their coats off and hang them up or check them when they enter a home or building) were practicing an arcane ritual. First they took glass mugs from a table where the previous customers had left them. Then they washed them in a gravity-fed jet of water recessed into the wall. Then they put a coin in a slot and held their mugs under a spout. Out poured kvass. I followed their lead and enjoyed my quarter liter. It was something like root beer, but sour as well as sweet. And it had the freshness of old-fashioned fermentation, perishable and unstabilized.

So far as I know, kvass is not sold in bottles, but kvass concentrate is sold for easy preparation at home. Back in the United States, I had hoped to find some in one of the many Russian groceries along Brighton Beach Avenue in Brooklyn, where so many Soviet emigres live. There wasn't any; as is so often the case in Russian stores of all kinds, the inventory was "in deficit." But just as I was about to climb back into the elevated subway station, I saw a sign saying KBAC. A big old man was selling kvass in plastic cups for thirty-five cents. It was homemade. He operated out of the window of a grocery and also sold ponchiki, doughnuts stuffed with various fillings. I got in line, feeling transported back to Moscow. I chose a cabbage ponchik, following the lead of a teen-age black girl. Soon I was juggling the ponchik and a cup of excellent kvass in a crowd of customers who were all eating and drinking and talking in Russian. An elderly woman passed by and looked at me and laughed. Did I like kvass, she asked, obviously pleased to have spotted a greenhorn. Mouth full of ponchik, I grunted in the affirmative, "da."

Perhaps kvass is the next food craze. I invite you to join me in this pleasant indulgence before everyone else jumps in. Maybe you don't want to ride the D train to Brighton Beach, but if someone in your crowd offers you kvass instead of white wine, just say "da."

Raymond Sokolov is a writer whose special interests are the history and preparation of food.
Bread Kvass

(Based on a recipe in *The Art of Russian Cuisine*, by Anne Volokh, Macmillan Publishing Co., 1983)

1 pound rye bread cut into ¼-inch slices
1 ½ cups sugar
1 package dry active yeast
1 tablespoon all-purpose flour
1 cup fresh mint leaves (optional)

1. Preheat oven to 325° F.
2. Dry the bread in the oven until golden brown, about 30 minutes.
3. Cool, then chop into ¼-inch pieces in a blender or food processor.
4. Bring 4 quarts of water to a boil, then cool to 175° F. Add the bread, stirring with a spatula, cover, and leave in a warm place for 1 hour. Strain, reserving both bread and liquid.
5. Bring 2½ quarts of water to a boil. Cool to 175° and add to bread. Cover and leave in a warm place again for 1 ½ hours. Strain, discarding the bread and combining both batches of liquid.
6. In a heavy, nonstick skillet, continuously stir ½ cup sugar with 1 tablespoon water until golden brown (be careful not to burn it). Remove from the heat, gradually blend in ½ cup of reserved liquid, then stir into rest of liquid.
7. Stir 1 cup of water together with the remaining 1 ¼ cups sugar in a small saucepan, bringing the mixture to a boil. Lower the heat and simmer for 10 minutes, skimming once or twice. Stir this syrup into reserved liquid. If necessary, raise the temperature of the liquid to 75°.
8. Mix yeast with all-purpose flour and combine with 1 cup of liquid, then return this mixture into the pot of reserved liquid.
9. In a saucepan, cover the mint leaves with boiling water and let stand, covered, for 2 hours. Strain and add the infusion to the pot.
10. Cover the pot with two layers of cheesecloth and leave in a warm place for 8 to 12 hours. When fermentation has ended, cool the kvass to 50°–54°, pour into bottles, seal tightly, and refrigerate for 24 hours. Now the kvass is ready to drink. It will keep for two to three days under refrigeration.

Yield: 5 quarts

Okroshka

(Cold kvass soup with vegetables, adapted from *Russian Cooking*, Mir Publishers, Moscow, 1974)

2 hard-boiled eggs
Mustard
1 boiled potato, grated
2 scallions, trimmed, minced, sprinkled with salt, and rubbed with spoon until soft and juice appears
1 teaspoon sugar
1 quart bread kvass
1 boiled carrot, cooled and diced
1 medium cucumber, peeled and diced
Mincéd dill
2 tablespoons sour cream

1. Separate the egg whites from the yolks. Chop the whites. Beat a little mustard into the yolks.
2. In a serving bowl, combine potato, scallions, yolk–mustard mixture, sugar, and salt. Stir in the kvass. Add carrot, cucumber, and egg whites.
3. When you serve the okroshka, garnish with dill and sour cream.

Yield: 4 servings

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Natural Moment
The story, to judge by the details on Mycenaean pottery, was an ancient one and always went something like this: The fruits or leaves of certain trees fall into the sea and become barnacles. The barnacles themselves then grow on logs or ships' timbers, and at a certain point they fall off into the sea and become geese, either barnacle geese or Brant geese.

In the early thirteenth century the goose barnacle became a source of some clerical controversy. Irish priests had been caught eating geese during Lent. Because they had never seen the arctic nests of these migrating birds, the priests believed they arose from the goose-necked shells with the feathery tendrils. So they considered them seafood, not fowl. But Pope Innocent III had his doubts and issued a bull in 1215 forbidding the eating of barnacle geese during Lent. Meanwhile, Rabbi Izaak ben Joseph of Corbeil, in France, concluded that if these geese did grow from the barnacles on the drifting wood, then Jews couldn't eat them because they were shellfish and so were forbidden under dietary laws.

Not until the eighteenth century was it more generally agreed that a barnacle was neither shellfish nor fowl (although Linnaeus called these barnacles Lepas anserifera, or "wild goose shellfish") but a crustacean, "a little shrimplike animal," as Thomas Huxley said, "standing on its head within a limestone house and kicking its food into its mouth with its feet." The goose barnacle's "feet" are the feathery cirri that wave back and forth in the currents, capturing floating food and pulling it into its mouth.

B.D.S.

Photograph by Nancy Sefton
Forty research cruises studying ocean currents off the Gulf Stream in the western Atlantic convinced Chris Haney (page 32) that these frontal currents, that formed off the continental shelf were for the birds. The question was, Why? The answer led to his doctorate in zoology from the University of Georgia, where he worked at the Skidaway Institute of Oceanography. He now works as senior ecologist with LGL, Alaska Research in Anchorage) on seabirds of the Bering Sea, specifically, the auklets of Saint Lawrence Island, Alaska. The most difficult part of his new research, he says, is getting used to the seven-month-long Alaskan winter after living in the southern United States for thirty years. For further reading, he recommends two books by Peter Harrison, Seabirds: An Identification Guide (Boston: Houghton Mifflin Co., 1983) and the Field Guide to Seabirds of the World: A Photographic Guide (London: Christopher Helm Publishers, Ltd., 1987), and Seabirds: Feeding Ecology and Role in Marine Ecosystems, edited by J. P. Croxall (Cambridge: Cambridge University Press, 1987).
Ecologist Paul Alaback (page 44) first went to Alaska in 1974 for a summer job near Sitka and quickly became interested in the spectacular rain forest along the coast. For his doctorate in forest ecology at Oregon State University, his subject was the succession of plants after logging. Over the past decade, he has been studying forest flora in Oregon, Washington, and Alaska. He has spent the past three years as a research ecologist at the U.S. Forest Service's Pacific Northwest Research Station in Alaska. Since much of southern Alaska is an archipelago, Alaback has many opportunities to pursue his favorite sport of sea kayaking with his family. He supplements their meals on the trips by foraging. For more information about the dynamics of forests, Alaback suggests reading "Clonal Plant Populations," by R. E. Cook (American Scientist, vol. 71, 1984), and Patterns and Process in a Forested Ecosystem, by F. H. Bormann and G. E. Likens (New York: Springer-Verlag New York, Inc., 1979).

For the last sixteen years, John W. Schoen (page 52) has investigated the intricate relationships that exist between a forest and the animals that live in it. In Alaska, where he is a research biologist with the state Department of Fish and Game and an affiliate assistant professor at the University of Alaska, Schoen has studied the role of old-growth forest in the lives of mountain goats, Sitka blacktailed deer, and brown bears. For the last ten years, he has conducted year-round fieldwork in the southeastern part of the state. This narrow band of land—not more than 120 miles wide—has nearly 30,000 miles of marine shoreland and hundreds of islands. Schoen can't visit them all, but his small research vessel and airplane help. He is currently concentrating on the brown bears of Admiralty Island (see "Last Stronghold of the Grizzly," Natural History, January 1987). Schoen says Fragmented Forest, by Larry D. Harris (Chicago: University of Chicago Press, 1984), andConserving Biological Diversity in Our National Forests, by E. A. Norse et al., published in 1986 by The Wilderness Society, will be of interest to readers who want to know more about this subject.
Stan Gregory (page 56) has studied the effects of logging on forest stream ecosystems for some years. But at his present study site on Mount Saint Helens, he has seen greater changes than any that logging could produce. Yet even there, where the volcano’s 1980 eruption wiped out entire drainages—water, trees, fish, and all—he says stream life is beginning to return; small pockets of habitat left intact by the eruption have began to seed the devastated stream beds. Gregory works out of the Department of Fisheries and Wildlife at Oregon State University, where he is an associate professor.

Chris Maser (page 58) became aware of fungi-hungry mammals in 1970 when he tried to find out why the small animals he was studying had knock-out breath redolent of dead fish laced with garlic. Mammalian fungus eating is just one aspect of forest ecology Maser has investigated. An Oregon-based private consultant in sustainable forestry, he is working on ways to grow not “tree plantations” but healthy forests that, in turn, could support a healthy industry. He sees unmanaged forests, including old growth, as “blueprints” of a self-perpetuating natural system. Maser, who has done much of his fieldwork in the Pacific Northwest, spent the summer of 1985 studying forests in Germany, Switzerland, and France.

Jeffrey Hughes (page 60) moved to Alaska from Idaho in 1976 to work as a wildlife biologist for the U.S. Forest Service and has lived in the state ever since. Currently the nongame wildlife coordinator for the Alaska Department of Fish and Game, he has a natural concern with the long-term impact of timber harvesting on wildlife. Although much of his research is on bats, he has had lifelong interest in birds. A highlight of his work in Alaska was his part in discovering a marbled murrelet’s nest—one of the very few known to science. At the age of forty-two, he is giving some consideration to the question of when adults should give up climbing trees to locate nests, but he plans to continue field-testing the life expectancy of canoes constructed of various materials.
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Cover: Fall colors tinge the mixed hardwood forest near Bell Smith Springs,
in the Shawnee National Forest. Photograph by R. Hamilton Smith. Story on
page 22.
Stoats Redeemed

Mikael Sandell's story, "Stop-and-Go Stoats" (June 1988), stultified (stoatified?) me. Since long ago, when I read that wonderful children's book The Wind in the Willows, I have detested stoats: in that tale, a gang of "desperate ferrets" and "skirmishing stoats" seized Mr. Toad's "handsome, dignified old house"—Toad Hall itself—when Mr. T. was away, and trashed it. True Toad, mighty Mole, brave Badger, and righteous Rat had to fight fiercely to get those "bloodthirsty villains" out. Now I find from your story that stoats are attractive, worthy animals—curious, alert, patient, resourceful, and other good things.

JOHN WHITE
Cambridge, Massachusetts

Future Founders

I enjoyed reading Jared Diamond's informative article on the founder effect ("Nature's Infinite Book," June 1988). I was uncomfortable with his conclusion, however, which although theoretically accurate, painted an extremely bleak picture of the future of humankind and the ecosphere after nuclear war. A more optimistic image of the future would have humans working out our earthly differences, avoiding nuclear catastrophe, and beginning to colonize space. If so, what are the long-term ramifications of the founder effect on widely separated and genetically restricted human colonial populations?

While Diamond's grim scenario is indeed possible, let us continue to work toward a future in which the founder effect may influence the evolution of a prosperous, healthy, and synergetic humanity.

J. EICHINGER
Claremont, California

Dry Assumptions

Given the notoriously hygroscopic characteristics of, for example, flour, sugar, and salt, I am inclined to query Mr. Sokolov's perhaps too facile assumption in "A Matter of Taste," July 1988, that dry ingredient measurement by weight is much more accurate than volume measure. With the midwestern climate's typical indoor humidities—hovering in the 10 to 20 percent range in winter and between 70 and 80 percent in summer—I should think the weight of adsorbed moisture could throw off weight measurements almost as much as density does volume.

Perhaps this is one more instance of the relatively constant humidity of England, coupled with British disdain for desiccating central heating, making life simpler—and possibly healthier—for the artisan. This is certainly the case of my craft of cabinetmaking!

RICHARD CLARK
Galena, Illinois

Erratum. The photograph on page 22 of our July 1988 issue ("Big Scrub, Florida") was not of scrub but of another Florida vegetational community known as a hydric hammock, a section of raised ground moister than its surroundings, which supports live oak, red bay, and magnolia trees. The foreground plants identified as saw palmettos are the cabbage palms typical of the hydric hammock understory.

A stoat: villainous ferret or worthy weasel?
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The climate is right for New Zealand.
The Mystery of the Gracious Hosts

_Insect guests don't get under the skin of some accommodating rodents_

by Robert M. Timm and James S. Ashe

Most of the 40,000 species in the rove beetle family are indeed rovers, being free-living predators. But 40 of those 40,000—known to scientists as amblyopinines—travel by clinging to the fur of small mammals. Most amblyopinines live in cool temperate forests and cloud forests throughout Central and South America. We have studied them and their associated hosts, native rats and mice, in Central America for three years and have found this mammal–insect relationship to be a most unusual one.

A European professional collector, C. Jelski, discovered adult beetles on Peruvian rice rats in 1875 and was the first to report on the amblyopinines. Jelski offered circumstantial evidence that the beetles were parasitic, stating that they were "frequently attached very firmly to the living mice—almost as tenaciously as ticks and lice." He also reported that the rodents' hair was damaged and the skin swollen at the base of the tail, where the beetles were ensconced. In 1900 the French entomologist Albert Fauvel published similar observations of amblyopinines found on tuco-tucos, endemic South American burrowing rodents. These early observations became the basis of a rich, but highly speculative, literature on the unusual habits of amblyopinines, which were labeled "obligate" ectoparasites, external parasites unable to live or reproduce if separated from their hosts. After an experiment in the 1960s revealed mammalian blood in the gut of one species, the view of these beetles as blood feeders was widely accepted. This conferred a unique status on amblyopinines: while some other beetles are parasitic, none is known or even suspected to feed on blood.

But many facets of the rodent–rove beetle relationship remained puzzling. Most inexplicable were observations made in Colombia in 1952 by Philip Hershkovitz, a mammalologist from the Field Museum of Natural History in Chicago, on the behavior of one amblyopinine species on captive rice rats. He noted that hosts took no notice of the beetles even when they ran across their eyes and whiskers—far from the usual reaction of a host to a bloodsucking parasite, especially one that is one-tenth of the host's own length. An amblyopinine two-fifths of an inch long would presumably be a nasty encumbrance for a rodent only four to five inches long. Interestingly, Hershkovitz was not able to find any skin damage caused by the beetles. His anecdotal observations suggested a more benign association of insect and rodent.

Furthermore, although amblyopinines share some physical traits with other insects that live in mammalian fur—they are wingless, for example—many of their attributes are inconsistent with a parasitic mode of life. Their mouthparts are not very different from those of the free-living rove beetles; their tarsi are not modified for grasping hair (as is often found in parasitic arthropods); and the body is not flattened to the degree normally seen in parasitic insects.

The more we read, the more we realized that the conclusion that amblyopinines are blood-feeding parasites was based on surprisingly little objective data. With this problem in mind, we began to study these insects intensively in the cool temperate and cloud forests of the Talamanca and Tilaran highlands of Costa Rica, where amblyopinines live on small and mediumsized rodents. Our basic approach was to live-trap the rodents, examine them for amblyopinines and any skin damage that could be attributed to beetles, then mark and release them.

By retrapping marked mice over several successive days, we were able to confirm host relationships and track changes

Photographs by Barbara L. Clauson

High-elevation forest, like that of the continental divide at Monteverde in Costa Rica, is prime habitat for amblyopinine rove beetles.
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in beetle activity for individual mice. In supplemental laboratory experiments that year and the following year, we maintained the mice and beetles in captivity and observed them day and night. We also examined the reaction of amblyopinines to other parasites that they were likely to encounter, either on the host or in the host’s nest.

During our first trip we examined 326 wild-caught rodents (many snared several days in succession) for beetles and other external parasites. In all, 254 beetles were found on 69 hosts. The number of beetles on each host varied from 1 to 13, with an average of 3.7. Amblyopinines in our study area were most commonly attached to the base of the host’s ears, nape of its neck, or elsewhere on the head. The sight of ten or more of these large beetles on the head of a small mouse is unnerving. Yet, as Hershkovitz reported more than three decades earlier, the hosts seem unconcerned and even oblivious to the presence of the beetles.

Amblyopinine beetles, like most parasites, show a marked host specificity. Host specificity is the restriction of a parasite to a single species or closely related group of hosts. Although we captured ten species of rodents that could conceivably serve as hosts for the beetles, amblyopinines were found only on three species. One species of *Amblyopus* was found almost exclusively on the naked-footed deer mouse (with the exception of a few individuals that were found on the Chiriquí harvest mouse). A second species of *Amblyopus*, which we discovered for the first time in Costa Rica, was restricted to Tome’s Neotropical rice rat. Captive beetles provided with a choice of host species consistently choose the host on which they are normally found in the wild. On the surface, this host specificity appears to confirm the beetles’ parasitic habits.

We were, however, unable to substantiate many of the observations in the earliest literature. Given the amblyopinines’ size and armored mandibles, we expected that their bites would be readily visible upon close examination of the host’s skin. But we consistently found that rather than embedding their formidable jaws in the rodent’s skin, the beetles used their mandibles to grasp clumps of hair. Because attachment is tight and very near the skin, and because hair is often torn out as the beetle is forcibly removed, casual observations could easily have led to the conclusion that the mandibles actually pierced the skin. We found not a single instance of beetles pinching or biting the skin of the rodents nor could we discern any damage caused by the beetles, even on heavily infested hosts. Instead, infested hosts were in excellent condition: their fur was rich and luxuriant, and their skin healthy. The same was true of the infested captive rodents. After several weeks of observing them, we found no evidence that amblyopinines feed on the rodents’ blood, skin, or secretions.

All of our observations were consistent with those of Hershkovitz. Hosts made no response to movements of the beetles through the fur and around the very sensitive eyes and whiskers, or to prolonged attachment at the base of the ears or elsewhere on the head. Was it possible that the mice were not aware of the beetles? We tested this by transferring beetles to other species of similarly sized rodents that also had long, soft fur. One test species, Alston’s brown mouse, is a common forest rodent in areas where amblyopinines live; however, beetles are not naturally found on it. The beetles burrowed into the fur of Alston’s brown mouse seemingly exactly as they did on their usual hosts. The brown mice, however, were very irritated by both the movements and the attachment of the beetles and vigorously attempted to dislodge them. When this succeeded, they immediately killed the beetle. Otherwise, the mice persisted in biting and scratching at the pest until we removed it. The beetles refused to attach to other species of mice, such as spiny pocket mice, that have stiff, bristly fur.

If the beetles did not feed directly on the host or any product of the host, and the rodents tolerated their presence, just what was the animals’ relationship? To answer this question, we began to observe the beetles and their hosts continuously over several days and nights. Since amblyopinines had previously been collected only from the fur of their hosts, the assumption had been that they spend most, if not all, of their time either feeding on the host or
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attached to it. And as most of the hosts are nocturnal, collecting was done at night, with the rodents and their accompanying beetles gathered from traps at first light. What we found, however, was that the beetles occupy the host only at night. At sunrise, they disembark and spend all day, every day, in the host’s nest. The beetles’ very different daytime activity proved to be one of the keys to understanding their biology.

Our next step was to find out what the beetles were actually feeding on. If they were not feeding on the rodents, then where did the blood, which had been reported from the gut of one species, come from? We decided to test the reaction of ambylopineines to parasites with which they were likely to come into contact. We placed several beetles of the blood-containing species and fleas taken from the same host into a petri dish. To our surprise, we immediately witnessed a beetle grabbing a flea in its mandibles and eating it! All the fleas in the petri dish were soon consumed. The beetles reacted to these fleas exactly as free-living predacious rove beetles do toward their prey, impaling the victim on their mandibles and, after manipulating it with their other mouthparts, crushing and devouring the soft portions and discarding the remaining hard parts. We later found that another species of ambylopineine feeds in a similar way on large parasitic mites that are common on their host. When we finally found consumed fleas in the bedding material of captive mice, we knew that ambylopineines are not parasites at all but, like other rove beetles, predators. The mammalian blood previously reported in an ambylopineine gut had come from a flea, tick, or other parasite feeding on the rodent’s blood and had been secondarily ingested when the beetle, in turn, preyed upon the parasite.

The pieces of the puzzle were now available to us. Ambylopineines are not the blood-sucking parasites they were long thought to be; instead, they are specialists that prey on the ectoparasites of their host. They spend half of their time, daylight, hunting in the host’s nest material. At night, before the rodent leaves the nest on its nocturnal rounds, the beetles climb on board and hold snugly to its fur. On the host, they are remarkably stationary, moving only from one attachment point to another. We saw no activity that could be interpreted as hunting on the host and can only conclude that the beetles do not feed while in the fur.

If most of the feeding occurs in the nest, why should beetles attach themselves to the host at night? Host behavior patterns must have been important in the evolution of this aspect of beetle activity. The host rodents sleep during the day and forage actively outside of the nest at night. The physical and behavioral modifications—for example, winglessness—that make ambylopineines unusual among rove beetles, but similar to many true parasites, appear to be directly related to maintaining their position in the host’s fur and being transported to any number of nests used by the host. We don’t yet know for sure, but we suspect that these rove species use a variety of nests in a pattern unpredictable to the beetles. Thus, it is to the beetles’ advantage to travel with the host during its nocturnal foraging bouts.

Both members of this association benefit, thereby making the relationship truly mutualistic. The beetles have evolved ways of tracking host behavior, allowing them access to a specialized food supply. The host tolerates the beetles because they greatly reduce its parasite load. Such a mutualism between a macroscopic invertebrate and a vertebrate is rare. Although some are known among aquatic systems—for example, cleaner shrimp and some tropical reef fish—we have not found another example among land animals. An analogous example of such mutualism between two vertebrate partners is the removal and consumption of ticks by oxpecker birds from large African mammals such as rhinos, elephants, and giraffes. Perhaps ambylopineine rove beetles can be viewed as the oxpeckers of the mouse world.

Although many of the puzzles about the ambylopineine–rodent relationship have been clarified, much remains a mystery. For example, what is it about the nesting biology of the rodents that has led to the evolution of this system? We have studied only a few of the many ambylopineine species. Do the others also have mutualistic associations with their hosts or have other species made the evolutionary transition to true parasitism? Where do immature beetles live, and why have they never been encountered on the rodent hosts? Finally, if ambylopineines are primarily predators rather than parasites, why are they so strictly matched to certain rodent hosts and not others? These broader questions will form the basis of our continued study of the ecology and patterns of evolution of the night-riding rove beetles.

Robert M. Timm is an assistant professor of systematics and ecology and curator of mammals at the Museum of Natural History at the University of Kansas in Lawrence. James S. Ashe is head of the Division of Insects at the Field Museum of Natural History in Chicago.
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Genesis and Geology

Are you interested in the rock of ages, or the age of rocks?

by Stephen Jay Gould

Herbert Hoover produced a fine translation, still in use, of Agricola’s sixteenth-century Latin treatise on mining and geology. In the midst of his last presidential campaign, Teddy Roosevelt published a major monograph on the evolutionary significance of animal coloration (see my essay of May 1985). Woodrow Wilson was no intellectual slouch, and John F. Kennedy did aptly remark to a group of Nobel laureates assembled at the White House that the building then contained more intellectual power than at any moment since the last time Thomas Jefferson dined there alone.

Still, when we seek a political past of intellectual eminence in the midst of current emptiness, we cannot do better than the helm of Victorian Britain. High ability may not have prevailed generally, as the wise Private Willis, guard to the House of Commons, reminds us in Gilbert and Sullivan’s Iolanthe:

When in that House M.P.’s divide,
If they’ve a brain and cerebellum, too,
They’ve got to leave that brain outside,
And vote just as their leaders tell ’em to.
But then the prospect of a lot
Of dull M.P.’s in close proximity
All thinking for themselves is what
No man can face with equanimity.

But the men at the top—the Tory leader Benjamin Disraeli and his Liberal counterpart W. E. Gladstone—were formidable in many various ways. Disraeli maintained an active career as a respected romantic novelist, publishing the three-volume Endymion in 1880, at the height of his prestige and just a year before his death. Gladstone, a distinguished Greek scholar, wrote his three-volume Studies on Homer and the Homeric Age (1858) while temporarily out of office.

In 1885, following a series of setbacks including the death of General Gordon at Khartoum, Gladstone’s government fell, and he resigned as prime minister. He did not immediately proceed to unwind with his generation’s rum swizzle on a Caribbean beach (Chivas Regal on the links of Saint Andrews, perhaps). Instead, he occupied his enforced leisure by writing an article on the scientific truth of the book of Genesis—“Dawn of Creation and of Worship,” published in The Nineteenth Century, in November 1885. Thomas Henry Huxley, who invented the word agnostic to describe his own feelings, read Gladstone’s effort with disgust and wrote a response to initiate one of the most raucous, if forgotten, free-for-alls of late nineteenth century rhetoric. (Huxley disliked Gladstone and once described him as suffering from “severely copious chronic glossorrhoea.”)

But why bring up a forgotten and musty argument, even if the protagonists were two of the most colorful and brilliant men of the nineteenth century. I do so because current events have brought their old subject—the correlation of Genesis with geology—to renewed attention.

Our legislative victory over “creation science” (Supreme Court in Edwards v. Aguillard, June 1987) ended an important chapter in American social history, one that stretched back to the Scopes trial of 1925. (Biblical literalism will never go away, so long as cash flows and unreason retains its popularity, but the legislative strategy of passing off dogma as creation science and forcing its instruction in classrooms has been defeated.) In this happy light, we are now free to ask the right question once again: in what helpful ways may science and religion coexist?

Ever since the Edwards decision, I have received a rash of well-meaning letters suggesting a resolution very much like Gladstone’s. These letters begin by professing pleasure at the defeat of fundamentalism. Obviously, six days of creation and circa 6,000 years of biblical chronology will not encompass the earth’s history. But, they continue, once we get past the nonsense of literalism, are we not now free to read Genesis 1 as factual in a more general sense? Of course the days of creation can’t be twenty-four hours long. Of course the origin of life three days before the creation of the sun poses problems. But isn’t the general order and story consistent with modern science, from the big bang to Darwinian theory? After all, plants come first in Genesis, then creatures of the sea, then land animals, and finally humans. Well, isn’t this right? And, if so, then isn’t Genesis true in the broad sense? And if true, especially since the scribes of Genesis could not have understood the geological evidence, must not the words be divinely inspired? This sequence of claims is the precise focus of Gladstone’s article. Huxley’s words therefore deserve a resurrection.

Huxley’s rebuttal is no different from the argument that most intellectuals—scientists and theologians alike—make today. First, while the broadest brush of the Genesis sequence might be correct—plants first, people last—many details are dead wrong by the testimony of geological evidence from the fossil record. Second, this lack of correlation has nothing whatever negative to say about the power and purpose of religion or its relationship with the sciences. Genesis is not a treatise on natural history.

Gladstone wrote his original article as a response to a book by Prof. Alfred Réville of the Collège de France—Prolegomena to the History of Religions (1884). Gladstone fancied himself an expert on Homer, and he had labored for thirty years to show that common themes of the Bible and the most ancient Greek texts could be harmonized to expose the divine plan revealed by the earliest historical records of different
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cultures. Gladstone was most offended by Réville’s dismissal of his Homeric claims, but his article focuses on the veracity of

Gladstone did not advocate the literal truth of Genesis; science had foreclosed this possibility to any Victorian intellectual. He accepted, for example, the standard argument that the “days” of creation are metaphors for periods of undetermined length separating the major acts of a coherent sequence. But Gladstone then insisted that these major acts conform precisely to the order best specified by modern science—the cosmological events of the first four days (Genesis 1:1–19) to Laplace’s “nebular hypothesis” for the origin of the sun and planets, and the biological events of “days” five and six (Genesis 1:20–31) to the geological record of fossils and Darwin’s theory of evolution. He placed special emphasis on a fourfold sequence in the appearance of animals: the “water population” followed by the “air population” on the fifth day, and the “land population” and its “consummation in man” on the sixth day:

And God said, Let the waters bring forth abundantly the moving creature that hath life, and fowl that may fly above the earth in the open firmament of heaven [verse 20]. . . And God said, Let the earth bring forth the living creature after its kind, cattle, and creeping thing, and beast of the earth after its kind; and it was so [verse 24]. . . And God said, Let us make man in our image [verse 26].

Gladstone then caps his argument with the claim still echoed by modern reconcilers: this order, too good to be guessed by writers ignorant of geological evidence, must have been revealed by God to the scribes of Genesis:

Then, I ask, how came . . . the author of the first chapter of Genesis to know that order, to possess knowledge which natural science has only within the present century for the first time dug out of the bowels of the earth? It is surely impossible to avoid the conclusion, first, that either this writer was gifted with faculties passing all human experience, or else his knowledge was divine.

In a closing flourish, Gladstone enlarged his critique in a manner sure to inspire Huxley’s wrath. He professed himself satisfied as to the possibility of physical evolution, even by Darwin’s mechanism. But the spirit, the soul, the “mind of man” must be divine in origin, thereby dwarfing to insignificance anything of the merely material world. Gladstone chided Darwin for reaching too far, for trying to render the ethereal realm by his crass and heartless mechanism. He ridiculed the idea “that natural selection and the survival of the fittest, all in the physical order, exhibit to us the great arcum of creation, the sun and center of life, so that mind and spirit are dethroned from their old supremacy, are no longer sovereign by right, but may find somewhere by charity a place assigned them, as appendages, perhaps only as excrescences, of the material creation.”

Ending on a note of deep sadness, Gladstone feared for our equanimity, our happiness, our political stability, our hopes for a moral order, should the festering sore of agnosticism undermine our assurance of God’s existence and benevolence—“this belief, which has satisfied the doubts and wiped away the tears, and found guidance for the footsteps of so many a weary wanderer on earth, which among the best and greatest of our race has been so cherished by those who had it, and so longed and sought for by those who had it not.” If science could now illustrate God by proving that he knew his stuff when he whispered into Moses’ ear, then surely that sore could be healed.

Huxley, who had formally retired just a few months before, and who had forewarned future controversy of exactly this kind, responded with an article in the December issue of The Nineteenth Century—“The Interpreters of Genesis and the Interpreters of Nature.” Obviously pleased with himself, and happy with his return to fighting form, he wrote to Herbert Spencer: “Do read my polishing off of the G.O.M. [Gladstone was known to friends and enemies alike, as the “Grand Old Man”]. I am proud of it as a work of art, and as evidence that the volcano is not yet exhausted.”

Huxley begins by ridiculing the very notion that harmonizing Genesis with geology has any hope of success or intellectual potential to illustrate anything meaningful. He places Gladstone among “those modern representatives of Sisyphus, the reconcilers of Genesis with science.” (Sisyphus, king of Corinth, tried to cheat death and was punished in Hades with the eternal task of repeatedly rolling a large stone to the top of a hill, only to have it roll down again just as it reached the top.)

Huxley arranged his critique by citing four arguments against Gladstone’s insistence that Genesis specified an accurate “fourfold order” of creation—water population, air population, land population, and man. Huxley wrote:

If I know anything at all about the results attained by the natural sciences of our time, it is a demonstrated conclusion and established fact that the fourfold order given by Mr. Gladstone is not that in which the evidence at our disposal tends to show that the water, air and land populations of the globe have made their appearance . . . The facts which demolish his whole argument are of the commonest notoriety. [Huxley uses “notoriety” not in its current, pejorative meaning, but in the old sense of “easily and evidently known to all.”]

He then presents his arguments in sequence:

1. Direct geological evidence shows that land animals arose before flying creatures. This reversal of biblical sequence is true whether we view the Genesis text as referring only to vertebrates (for terrestrial amphibians and reptiles long preceded birds) or to all animals (for such terrestrial arthropods as scorpions arise before flying insects).

2. Even if we didn’t know, or chose not to trust, the geological sequence, we could deduce on purely anatomical grounds that flying creatures must have evolved from preexisting terrestrial ancestors. Structures used in flight are derived modifications of terrestrial features:

   Every beginner in the study of animal morphology is aware that the organization of a bat, of a bird, or of a pterodactyl, presupposes that of a terrestrial quadruped, and that it is intelligible only as an extreme modification of the organization of a terrestrial mammal or reptile. In the same way, winged insects (if they are to be counted among the “air-population”) presuppose insects which were wingless, and therefore as “creeping things,” which were part of the land-population.

3. Whatever the order of first appearances, new species within all groups—water, air, and land dwellers—have continued to arise throughout subsequent time, whereas Genesis implies that God made all the sea creatures, then all the denizens of the air, and so on.

4. However we may wish to quibble about the order of animals, Gladstone should not so conveniently excise plants from his discussion. Genesis pushes their origin back to the third day, before the origin of any animal. But plants do not precede animals in the fossil record; and the terrestrial flowering plants specifically mentioned in Genesis (grass and fruit tree) arise very late, long after the first mammals.

Huxley then ends his essay with a powerful statement—every bit as relevant today as 100 years ago at its composition—on the proper domains and interactions of science and religion. Huxley expresses no antipathy for religion, properly conceived, and he criticizes scientists who overstep the boundaries and possibilities of their discipline as roundly as he condemns an antiquated and overextended role for the biblical text:
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the weak rejoinder that reptiles are disgusting and degenerate things, destined only for our inattention (despite Eve and the serpent): “Reptiles are a family fallen from greatness; instead of stamping on a great period of life its leading character, they merely skulked upon the earth.” Yet Gladstone sensed his difficulty and admitted that while reptiles didn’t disprove his story, they certainly didn’t help him either: “However this case may be regarded, of course I cannot draw from it any support to my general contention.”

Huxley, smelling victory, moved in for the kill. He derided Gladstone’s slithery argument about reptiles and continued to highlight the evident discrepancies of Genesis, read literally, with geology (“Mr. Gladstone and Genesis,” The Nineteenth Century, 1896).

However reprehensible, and indeed contemptible, terrestrial reptiles may be, the only question which appears to me to be relevant to my argument is whether these creatures are or are not comprised under the denomination of “everything that creepeth upon the ground.”

Contrasting the approved tactics of Parliament and science, Huxley obliquely suggested that Gladstone might emulate the wise cobbler and stick to his last. Invoking reptiles once again, he wrote:

Still, the wretched creatures stand there, importunately demanding notice; and, however different may be the practice in that contentious atmosphere with which Mr. Gladstone expresses and laments his familiarity, in the atmosphere of science it really is of no avail whatever to shut one’s eyes to facts, or to try to bury them out of sight under a tumultus of rhetoric.

Gladstone’s new sequence of fish, bird, mammal, and man performs no better than his first attempt in reconciling Genesis and geology. The entire enterprise, Huxley asserts, is misguided, wrong, and useless: “Natural science appears to me to decline to have anything to do with either [of Gladstone’s two sequences]; they are as wrong in detail as they are mistaken in principle.” Genesis is a great work of literature and morality, not a treatise on natural history:

The Pentateuchal story of the creation is simply a myth [in the literary, not pejorative, sense of the term]. I suppose it to be a hypothesis respecting the origin of the universe which some ancient thinker found himself able to reconcile with his knowledge, or what he thought was knowledge, of the nature of things, and therefore assumed to be true. As such, I hold it to be not merely an interesting but a venerable monument of a stage in the mental progress of mankind.

Gladstone, who was soon to enjoy a fourth stint as prime minister, did not respond. The controversy then flickered, shifting from the pages of The Nineteenth Century to the letters column of the Times. Then it died for a while, only to be reborn from time to time ever since.

I find something enormously ironical in this old battle, fought by Huxley and Gladstone a century ago and by much lesser lights even today. It doesn’t matter a damn because Huxley was right in asserting that correspondence between Genesis and the fossil record has no significance for religion or for science. Still, I think that Gladstone and most modern purveyors of his argument have missed the essence of the kind of myth that Genesis 1 represents. Nothing could possibly be more vain, temperate, or unseemly than a trip on these waters by someone lacking even a rudder or a paddle in any domain of appropriate expertise. Still, I do feel that when read simply for its underlying metaphor, the story of Genesis 1 does contradict Gladstone’s fundamental premise. Gladstone’s effort rests upon the notion that Genesis 1 is a tale about addition and linear sequence—God makes this, then this, and then this in a sensible order. Since Gladstone also views evolution and geology as a similar story of progress by accretion, reconciliation becomes possible. Gladstone is quite explicit about this form of story:

Evolution is, to me, a series with development. And like series in mathematics, whether arithmetical or geometrical, it establishes in things an unbroken progression; it places each thing... in a distinct relation to every other thing, and makes each a witness to all that have preceded it, a prophecy of all that are to follow it.

But I can’t read Genesis 1 as a story about linear addition at all. I think that its essential theme rests upon a different metaphor—differentiation rather than accretion. God creates a chaotic and formless totality at first, and then proceeds to make divisions within it, to precipitate islands of stability and growing complexity from the vast, encompassing potential of an initial state. Consider the sequence of “days.”

On day one, God makes two primary and orthogonal divisions: He separates heaven from earth, and light from darkness. But each category is only diffuse potential, containing no differentiated complexity. The earth is “without form and void”; and no sun, moon, or stars yet concentrate the division of light from darkness. On the second day, God consolidates the separation of heaven and earth by creating the firmament and calling it heaven. The third day is then devoted to differentiating the chaotic earth into its stable parts—land and sea. Land then develops further by bringing forth plants. (Does this indicate that the writer of Genesis viewed life with a taxonomy very different from ours? Did he see plants as essentially of the earth and animals as something separate? Would he have held that plants have closer affinity with soil than with animals?) The fourth day does for the firmament what the third day accomplished for earth: heaven differentiates and light becomes concentrated into two great bodies, the sun and moon.

The fifth and sixth days are devoted to the creation of animal life, but again the intended metaphor may be differentiation rather than linear addition. On the fifth day, the sea and then the air bring forth their intended complexity of living forms. On the sixth day, the land follows suit. The animals are not simply placed by God in their proper places. Rather, the places themselves “bring forth” or differentiate their appropriate inhabitants at the appointed times.

The result is a candyboxful of intricately sculpted pieces, with varying degrees of complexity. But how did the box arise? Did the candy maker just add items piece by piece, according to a prefigured plan—Gladstone’s model of linear addition? Or did he start with the equivalent of a tray of fudge, and then make finer and finer divisions with his knife, decorating each piece as he cut by sculpting wondrous forms from the potential inherent in the original material? I read the story in this second manner. And if differentiation be the more appropriate metaphor, then Genesis cannot be matching Gladstone’s linear view of evolution. The two stories rest on different premises of organization—addition and differentiation.

But does life’s history really match either of these two stories? Addition and differentiation are not mutually exclusive truths to be discovered in nature. They are schemata of organization for human thought, two among a strictly limited number of ways that we have devised to tell stories about nature’s patterns. Battles have been fought in their names many times before, sometimes strictly within biology. Most dramatic, perhaps, was the early nineteenth century struggle in German embryology between one of the greatest of all natural scientists, Karl Ernst von Baer, who viewed development as a process of differentiation from general forms to specific structures, and the Naturphilosophen (nature philosophers) with their romantic conviction that all developmental processes (including embryology) must proceed by linear addition of complexity as spirit struggles to incarnate itself in the highest, human form (see
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Bell Smith Springs, Illinois

by Robert H. Mohlenbrock

At Bell Smith Springs, in the heart of southern Illinois's Shawnee National Forest, one major and several minor springs feed Bay Creek as it flows placidly through a wooded ravine. Huge beech trees, tulip poplars, and sugar maples form a dense, closed canopy throughout the growing season, except in April and early May, when sunlight breaks through to bring out carpets of violets, trilliums, larkspurs, gingers, geraniums, and other wildflowers. These woods are framed by exposed sandstone bluffs, which bear the scars of erosion. House-size boulders have broken off and tumbled down, and at one place, a thirty-foot-high natural bridge, carved by a now dry tributary stream, spans about 125 feet. Surrounding all this is an upland forest dominated by oaks and hickories, part of what ecologist E. Lucy Braun called the western mesophytic (medium moist) forest, which stretches from southwestern Ohio to northern Mississippi.

Lying twenty miles southwest of Harrisburg—and forty-five miles southeast of my own home in Carbondale—Bell Smith Springs can be reached by several routes. I favor a dirt and gravel road that approaches from the northwest and winds around the property lines of several struggling farms before ending abruptly at a parking lot carved into a densely wooded slope. From the parking lot, a trail meanders slightly downhill through the upland forest of scarlet oak, black oak, northern red oak, shagbark hickory, and pignut hickory. These nut trees provide shelter and ample food for many of the mammals and birds that live there. Then, as the trail approaches the cliff overlooking the ravine, the thin mantle of soil that supports the upland forest disappears, revealing extensive openings of smooth, flat sandstone, known locally as sandstone pavements. During the summer, when the daytime air temperature hovers around the 100° mark, the sandstone is often twenty degrees hotter. Nevertheless, there are plants that brave the heat and consequent dryness, taking root in the pockets of soil that accumulate in shallow depressions and cracks in the "pavement."

Where the back edge of a sandstone
American beeches and red maples grow along Bay Creek.

Willard Clay
pavement borders the upland woods, stunted blackjack and post oak trees eke out a meager existence, sending an extensive root system through narrow crevices to reach moisture that has seeped under the rock layers. These trees grow very little each year, and the rigorous climate gives them a gnarled appearance. Trees only twenty feet tall may be more than 100 years old. To lessen the loss of water, the thick, leathery leaves have a shiny, heavy layer of wax on their upper surface and, in the case of the post oaks, a dense mat of minute, branched hairs on their undersides.

Shallow pockets of soil provide a habitat for a surprisingly rich variety of flowering plants. Prickly pear cactus, whose two-inch-wide, waxy yellow flowers provide endless color in early June, is abundant. The thick, succulent stems of this cactus store water for the inevitable droughty conditions of summer. The plant has no leaves; photosynthesis is carried out in the stems. Growing with the cactus is the Illinois agave, a species related to the century plants of the western states. Its wax-coated leaves, which form a rosette at the surface of the sandstone pavement, are thick and leathery and are able to store some reserve water. Flower-of-an-hour is another succulent that survives here. As its name suggests, its bright pink flowers bloom for only one hour and then wither.

Wild petunia and goat’s-rue, whose showy flowers bloom throughout the summer, have a dense covering of hair on their leaves and stems. The hairy leaves of the rushfoil, a six-inch-tall member of the spurge family, also have flat, brownish scales on their lower surface, which protect the plant from sun reflecting off the sandstone pavement. Several species have minimal leaf surfaces: Saint Johnswort has one-sixteenth-inch-long, scalelike leaves along its wiry green stem; while threadleaved sundrops, a delicate-looking member of the evening primrose family, has leaves as slender as threads below its attractive yellow flowers. Pinweed makes it through the heat of summer with very narrow, short leaves, but forms larger leaves that persist throughout the winter.

A small plant that sprawls on the sandstone is Saint-Andrew’s-cross. The roots of this low-growing species penetrate deep into every available crack in the sandstone pavement. The purple oxalis stores food reserves in underground bulbs. Often protruding downward from the bulb of the purple oxalis is a long, icicle-shaped root that serves as a water-storage organ.

Other plants beat the heat and drought by germinating in March, flowering in April, setting seeds in May, and withering by the first of June as the summer approaches. These annuals include tiny bluet, or Quaker-ladies, a dwarf species of plantain; and a slender grass known as six-weeks rescue because it completes its life cycle in about forty days.

"This Land" highlights the biological phenomena of the 154 U. S. national forests. Robert H. Mohlenbrock is Distinguished Professor of Botany at Southern Illinois University at Carbondale.
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Why Do Tommies Stott?

This gazelle jumps not for joy but to communicate

by Tim Caro

Thomson’s gazelles, or Tommies as they are known colloquially in East Africa, are a familiar sight on the African plains. These small gazelles are largely taken for granted by visitors in search of bigger animals, such as elephants and rhinos, and of photogenic predators, such as cheetahs and wild dogs. Yet Tommies support many of the populations of East Africa’s notorious carnivores. Their behavior in the face of these predators has caused a great deal of discussion by big game hunters, naturalists, and scientists because Tommies have an impressive repertoire of antipredator behavior. The most notable of these is stotting, a conspicuous, stiff-legged, bounding gait that propels the gazelle almost straight up as much as two feet off the ground. This and similar acts also performed by other animals, such as springboks, wildebeests, and hartebeests, puzzle observers. One would presume that stotting would slow the Tommies down as they run away from would-be predators. Surely, therefore, to do so in the face of danger would be foolhardy. So mysterious is the function of this behavior that numerous theories have been put forward to explain it.

Beginning in 1980, I spent three and a half years in the Serengeti National Park in Tanzania studying cheetahs as part of a long-term project on the behavioral ecology of this species. I also kept records of Tommy behavior in the face of predators in an attempt to decipher the circumstances and consequences of stotting and thereby discover the reasons why Thomson’s gazelles stott.

Slender and graceful, with dark brown backs, white bellies, and a black flank stripe, Tommies are representative of the genus *Gazella*. They are typical of relatively dry savanna habitats and abound on the East African plains. Males weigh about fifty-five pounds and have ringed, S-shaped horns more than a foot long. Females are smaller, under forty-five pounds, and most have shorter, straight, ear-length horns. They can give birth twice a year to a single dark brown infant weighing about four and a half pounds.

Serengeti gazelles are migratory. Almost a third of a million trek annually from the shortgrass plains in the southeast, where they spend the wet season between November and May, to the long grass plains and woodland areas of the northwest during the June to October dry season. Cheetahs and wild dogs follow this migration. I, too, followed in a Land-Rover, tracking individually known cheetahs and noting predator-prey interactions.

Gazelles have many ways of reacting to predators. They continually interrupt their feeding to look up and monitor the surrounding vegetation. If they spot a predator, especially their prime attacker, the cheetah, they turn toward it with neck erect and back stiff and stare at it continu-

An adult male Thomson’s gazelle leaves the ground as the stott begins.
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ous for as long as it remains in view. They may stamp a front foot or emit one or more loud snorts, which are probably alarm signals. If the predator is approaching slowly, the Tommy will often run for thirty to sixty feet, stotting a variable number of times. This initial flight usually describes a J-shaped path, ending with the gazelle turning to face the predator again. But a gazelle rarely stots during its getaway if a cheetah is making a fast approach when first seen. Instead, the gazelle takes off at a full gallop.

Several East African naturalists had suggested that stotting imposes costs of time, energy, or survivorship on gazelles. I wanted to check on these hypotheses. Because I was unable to measure the energy cost in the field, I looked only at time and survivorship. Contrary to previous fieldworkers' reports, I could find no time cost to stotting in situations in which it normally occurred. By calculating the gazelles' rate of flight away from the cheetah and away from my Land-Rover, I found that during a slow flight gazelles did not cover fewer feet forward per second than the stotts they performed. This may be because stotting involves a slight forward motion. In addition, Tommies stot in the middle or at the end of a flight whether the flight is for as little as 30 feet or as much as 250 feet. Thus stotting did not seem to delay escape from potentially dangerous situations; either it does not slow down running or is a slow form of travel used when the gazelle is not running at top speed. But I found that stotting did slow down the Tommies' flight when they were running at top speed.

As far as survivorship goes, I did not find that cheetahs were more successful in catching the gazelles that stotted the most. For one thing, gazelles never stotted until they were at a safe distance from a cheetah. Cheetahs hunt under concealment, slowly stalking their unwary prey and freezing each time the quarry looks up, in nature's version of a children's game. When less than about ninety feet from their intended victim, cheetahs make an open rush toward it that usually results in capture. If the cheetahs reveal themselves at greater distances, the hunt usually fails. On the average, the gazelle's first stott occurred when a cheetah was as far as 200 feet away, a distance at which the gazelle will almost certainly be unsuccessful. So stotting appeared to inflict no survivorship cost.

I turned my attention next to the benefits that Tommies might gain from stotting. The many hypotheses in this category fell into three distinct groups: stotting as a signal to the predator; as a

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signal to other gazelles, usually kin; and as a means of surveying the environment but with no signaling function at all.

One of the several signaling hypotheses is that since stotting occurs at safe distances from cheetahs, it informs the predator that it has been seen. The detection hypothesis, as this is called, is predicated on the cheetahs' reliance on a concealed approach and predicts that they will abandon hunts once they know they have been seen. This is exactly what I found. For example, a cheetah might approach a single male Tommy in the open, stalking the gazelle every time it lowered its head to feed. If it spotted the cheetah, the gazelle often ran about fifty to sixty feet, stotting a few times. The cheetah would then lie down or continue to walk openly, rather than stealthily, toward the prey. That meant the cheetah had lost the advantage of surprise and the hunt had ended. And when only one gazelle in a group stotted and several stared, the cheetah also seemed to get the message that it had been seen by the whole group. Other reasons also influencing whether a cheetah will give up the hunt depend on the predator's level of hunger, whether it has cubs of its own to feed, and the possibility of making a capture somewhere else.

Another version of the signaling hypothesis is that gazelles stott to inform the predator that they are fit enough to outrun it in a long chase. In this case, many gazelles would be expected to stott simultaneously, trying to outdo the others in displaying its good condition. Since only a single gazelle in a group usually stotts in response to a cheetah, this hypothesis is unlikely to apply here.

The Tommies' response to another predator, the wild dog, however, differs from that to the cheetah. Unlike cheetahs, wild dogs hunt their prey without concealment, counting on outrunning the prey in a long chase. In this instance, many gazelles will stott at the same time, and as Clare Fitzgibbon and John Fanshawe, scientists at Cambridge University in England, have found, stotting in response to wild dogs does signal the gazelles' ability to outrun the predator in a long and demanding race.

All gazelles are so-called hider species. Mothers leave their newborns hidden in the grass for the first two weeks of life, returning periodically to nurse and lick them. These neonates also stott and some people have suggested that their stotting is meant to signal to their mothers that they are moving from one location to another. Another suggestion is that they require their mothers' aid to fend off a predator. But young Tommies do not always recognize cheetahs as predators. I have seen neonates attempt to play with young cheetahs or even try to suckle from them. I also found that concealed neonates that I disturbed with my Land-Rover stotted much more often than unconcealed neonates that could be seen by their mothers. I also noted that the farther concealed youngsters were from their mothers, the more they stotted. Both findings give some support to the idea that neonate stotting provides the mothers with information of their offspring's whereabouts.

I found that mothers themselves stott at a high rate in front of predators when their neonates are in danger. Positioning themselves between their fleeing neonates and the pursuing cheetahs, the mothers zigzag and stott during the ensuing chase. On one occasion, when a Thomson's gazelle with a fawn saw an adolescent cheetah running at them from about 300 feet away, she jumped very high straight up, almost three times as high as a normal stott in response to a cheetah, then stotted eight times and stopped. Again, she jumped high, stotted, and then ran zigzag between the cheetah and her offspring. But after a
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**Tim Caro is a behavioral ecologist in the Evolution and Human Behavior Program at the University of Michigan.**
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Untouched Food

Why don't we consume the food of an exotic culture in our very midst?

by Raymond Sokolov

The first Spanish settlement in what is now the United States ought to be a mecca for history buffs and patriots. And since it has had as long as most Western European countries to develop a modern cuisine, it should also attract the same gastronomes who haunt regional restaurants and make polenta from Navajo blue cornmeal in their homes. Moreover, this place I am thinking of has more than just a few exotic chilies and pine nuts to show for itself. Its cosmopolitan past and welcoming climate have made it a melting pot for food plants from Europe, Africa, South America, and Asia. With such a larder to draw from, its cooks invented dozens and dozens of new dishes, so many in fact that this place should probably be considered the home of the most fertile and diverse of all our regional cuisines. Not only that, but many of its foodstuffs and dishes are widely available on a daily basis in New York and other major American cities. And yet almost no one who is not from this place ever eats its cuisine or thinks of it as a source of interesting food and food ideas. This neglect is not new; outsiders have always turned their backs on Puerto Rico.

On his second voyage, propelled by favorable winds, Columbus discovered the island. He named it San Juan Bautista and never returned.

In 1508, Juan Ponce de León set sail from nearby Española (Hispaniola, now divided between Haiti and the Dominican Republic), site of the first post-Columbian

*A Puerto Rican cook prepares meat-filled fritters whose dough is a mixture of plantain and white yautia, a starchy root.*
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European settlement. Ponce de León colonized the smaller island, which its indigenous Taino inhabitants knew as Borinquén. But Ponce de León did not fall in love with Puerto Rico. He decamped for the mainland in search of the Fountain of Youth and died from an arrow wound incurred in Florida. Today, there is a statue of him in San Juan, but as Puerto Ricans are fond of pointing out, it gazes west toward Santo Domingo. Disdain and contempt have colored the outside world’s attitude toward Puerto Rico ever since.

After almost four centuries of Spanish hegemony—400 years in which the Tainos all but vanished as a result of European diseases and intermarriage, 400 years in which gold deposits were exhausted and African slave labor manned the ranches and grew the sugar and coffee that kept this colonial backwater economically afloat—the United States took over the island during the Spanish-American War in 1898. Puerto Ricans have been U.S. citizens since 1917 and the island has been called a Commonwealth since 1952, but most non-Puerto Rican U.S. citizens still have to be reminded that people from the island are citizens of the same country that they are.

The Immigration Department maintains an immigration check at the San Juan airport for passengers boarding flights to New York. This is the route that has already brought hundreds of thousands of Puerto Ricans to the mainland. Their presence has dramatically changed the face of New York. With the help of other Spanish-speaking immigrants from many other places, but overwhelmingly through their own numbers, Puerto Ricans have made New York a bilingual city. This is a fact that everyone in the Anglophone so-called master culture does his best to ignore, hoping that the Puerto Ricans will finally join the rest of us by switching to English.

Perhaps they will. Thousands are already bilingual, and their Spanish has evolved into an Americanized dialect jokingly referred to as Spanglish, with hybrid words such as el super. But for now, English-speaking New Yorkers and people in other cities with Puerto Rican and other Hispanophone neighbors are mostly neglecting the best opportunity many Americans have ever had to pick up another language from native speakers. And instead of fighting proposals for bilingual education in public schools as a sop to Hispanics, we ought to be pressing for it as an opportunity for our own children to learn the other major American language. Similarly, we ought to be pursuing the food of Puerto Rico in Puerto Rican restaurants, just as we flock to the restaurants of other cultures in our midst. But have you ever heard anyone say, “Let’s eat Puerto Rican tonight”?

Why is this? Why do our two cultures go merrily on their separate ways with so little of the usual contact you would expect to occur between them? Why is it, for example, that most people I know have never cooked the plantains or true yams or other tropical vegetables always present in their supermarkets? Why is it that when I buy Oriental ingredients in Chinatown or at a Korean grocer on Upper Broadway, the cashier shows no surprise, but when I shop at a Hispanic butcher two blocks from my home on the Upper West Side of Manhattan, the man behind the counter...
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<tr>
<td>G18</td>
<td>1</td>
<td>1988 American Eagle Proof Gold (One Ounce)</td>
<td>$585.00</td>
</tr>
<tr>
<td>G28</td>
<td>1</td>
<td>1988 American Eagle Proof Gold (One-half Ounce)</td>
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<td>G38</td>
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<td>1988 American Eagle Proof Gold (One-quarter Ounce)</td>
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<td>G48</td>
<td>1</td>
<td>1988 American Eagle Proof Gold (One-tenth Ounce)</td>
<td>$65.00</td>
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<tr>
<td>G58</td>
<td>4</td>
<td>4-Coin Set, One Ounce, One-half Ounce, One-quarter Ounce &amp; One-tenth Ounce Proof Gold</td>
<td>$1,065.00</td>
</tr>
<tr>
<td>S18</td>
<td>1</td>
<td>1988 American Eagle Proof Silver (One Ounce)</td>
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TAN SAHSA

A shopper selects plantains; above them, white yautias are stacked in a carton.
ing array of tubers and roots, from cassava to taro to yam.

But if you were to compare Puerto Rican and Dominican cookbooks you would immediately be struck, as I was, by the different names for the same or similar dishes. The broad-leaved “coriander” (*Eryngium foetidum*) looks roughly like a bay leaf but tastes like a stronger, bolder relative of European coriander (*Coriandrum sativum*), which it is, and is known in Puerto Rico as *culantro* or *culantro de monte* or *recaí.* The last is also the name given there to a mixture of *culantro* and regular coriander, known locally as *cilantrillo, culantrillo,* and *cualantro.* The mixture, bottled and commonly available in New York as *recaíto,* is an essential part of the cooked condiment called *sorrito,* a mixture of *recaíto,* fatback, ham, lard colored with annatto (the seed of the originally Amazonian Bixa orellana, also called *achiote, bija,* and *bijol*), garlic, onion, tomato, green pepper, and oregano that is the starting point of numerous soups and stews. Ligia de Bornia in her book *La Cocina Dominicana* speaks instead of *recaíto verde,* *ciantran ancho* (wide *culantro*), *ciantran sabanero* (*culantro* of the savanna, evidently *E. foetidum*), and *ciantran de España* (probably *C. sativum*).

The dialectal differences between these two islands cannot be exaggerated, and there is a useful task awaiting some sun-loving soul who will compile a glossary of

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food words in use in all the islands of the Caribbean (as well as the countries of Central and South America). School Spanish is no help in a world where *plátano* does not mean banana but plantain, and where some, but not all, people say *guineo* when they mean banana.

Fortunately, Dominicans and Puerto Ricans mean the same thing when they say *mofongo* (not to be confused with *mondongo*, or tripe). I assume *mofongo* is an African word imported to both islands by slaves. It is a purée of plantain mixed with bits of crushed pork cracklings (*chicharrones*). You will often find this sophisticated mixture of chewy plantain and crunchy pork sold in tennis-ball-size spheres at *cuchifrito* stands here and in Puerto Rico. Even more complex and original is the *alcapurria*, a fritter whose dough is a clever mixture of two purées, glutinous plantain and starchy white yautia (*Xanthosoma sagittifolium*, an *old root native from Mexico to the Andes*), stuffed with the standard Puerto Rican meat filling, shaped into fritters and deep-fried. Like other Spanish words beginning with *al*, the Arabic definite article, *alcapurria* must have come to Puerto Rico from Spain where it would have begun as an Arabic term brought in by the Moors. Spanish dictionaries don’t mention it and its apparent connection with the Spanish word for caper, *alcaparra*, is unenlightening.

No one worries about this exotic linguistic remnant of the colonial past at the Piñones Forest beach near San Juan. In steamy bars competing with each other for the world fritter title, women grate yautias for *alcapurrias de juyes*, *alcapurrias* stuffed with great land crab.

Raymond Sokolov is a writer whose special interests are the history and preparation of food.

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### Mofongo

*(Adapted from *Puerto-Rican Dishes*, by Berta Cabanillas and Carmen Ginorio. *Editorial de la Universidad de Puerto Rico, 1984)*

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lard</td>
<td>½ pound pork rind, cut in 2-inch squares and soaked in cold water for 2 hours</td>
</tr>
<tr>
<td>Salt</td>
<td>4 green plantains, peeled, cut on bias in ½-inch slices, and soaked in salted water for an hour</td>
</tr>
</tbody>
</table>

1. Melt lard in a heavy pot. Set the pork skin squares in the lard, fat side down, cover, and cook over low heat until tender, 15 to 20 minutes. Remove cover, raise heat to medium, and fry another 15 minutes or until crisp. Drain off excess fat. Sprinkle with salted water to make the cracklings (*chicharrones*) puff up. Drain on paper toweling.
2. While the *chicharrones* are crisping, drain the plantain slices and fry gently in lard until tender but not browned.
3. Mash the plantain slices with a mortar and pestle. Add the *chicharrones* and continue mashing so as to crush the *chicharrones*.
4. Form into balls with your hands and serve while still warm.

**Yield:** 6 to 8 *mofongos*

### Alcapurrias

*(Adapted from *Puerto-Rican Dishes*, by Berta Cabanillas and Carmen Ginorio. *Editorial de la Universidad de Puerto Rico, 1984)*

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount</th>
</tr>
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<tbody>
<tr>
<td>Salt</td>
<td>1 pound ground pork</td>
</tr>
<tr>
<td></td>
<td>2 ounces ham, finely chopped</td>
</tr>
<tr>
<td></td>
<td>1 ounce salt pork, finely chopped</td>
</tr>
<tr>
<td></td>
<td>2 tablespoons finely chopped green pepper</td>
</tr>
<tr>
<td></td>
<td>¼ cup finely chopped tomato</td>
</tr>
<tr>
<td></td>
<td>2 tablespoons finely chopped onion</td>
</tr>
<tr>
<td></td>
<td>2 tablespoons lard</td>
</tr>
<tr>
<td></td>
<td>2 tablespoons chopped pitted green olives</td>
</tr>
<tr>
<td></td>
<td>1 tablespoon capers</td>
</tr>
</tbody>
</table>

1. Peel the plantains and the yautia and soak in salted water while you prepare the meat filling.
2. Combine the pork, ham, salt pork, green pepper, tomato, and onion. Heat the lard in a skillet and sauté the meat mixture until the meat is lightly browned. Add olives and capers off heat. Reserve.
3. Drain the plantain and yautia. Then grate them, separately, on the fine blades of a grater or process thoroughly in a processor with the metal blade. Mix together and salt to taste.
4. Grease a sheet of waxed paper or a plantain leaf. Put 2 to 3 tablespoons of the mash on it and spread until you have a ¼-inch-thick oval. Put 2 teaspoons of the meat mixture in the center and spread it lengthwise a bit. Using the waxed paper or the leaf, fold the mash around the filling and roll to make a little pie that is somewhat longer than it is wide. Continue in this manner until you have used up all the mash and filling.
5. Heat lard or vegetable oil and deep fry a few *alcapurrias* at a time until golden brown.

**Yield:** 6 servings

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Henna Party

An orange-red cosmetic raises Moroccan women’s spirits

by Maria Messina

Henna is the common name for a small shrub (Lawsonia inermis) and for the orange-red dye made from its leaves, familiar as a hair rinse in Western beauty parlors. The plant grows as an ornamental in the United States (where it is called the mignonette tree) and England (the Egyptian privet) and has been naturalized to tropical regions of the New World, but its original native range is North Africa, Asia, and Australia. The dye has long been used to dye cloth, stain leather, and color the hoofs and manes of horses. And for centuries, women in India and the Middle East have used henna to dye fingernails and other parts of their hands and feet to enhance their beauty. This last use of henna is especially popular with Moslem peoples, although it may have originated in India (where henna is called mehndi) and entered the Moslem tradition in the Mogul period (sixteenth to eighteenth centuries), when thousands of Hindus converted to Islam.

In Morocco, where I studied the use of henna for body decoration, men occasionally rub the paste made from the ground leaves onto their hands and beards, in emulation of the Prophet Mohammed, but the application of henna is primarily a female affair. A young girl is first decorated with henna around the age of three or four, in preparation for the twenty-seventh day of Ramadan, the month of fasting. This holiday commemorates the beginning of the Koranic revelation to the Prophet. The mother or a sister applies the paste to the girl’s hands as an overall coloring or (if the child is patient enough to sit still) in a geometric design, leaving it on overnight to create a temporary stain on the skin. The next day, the newly adorned girl enters the medina, or old quarter of town, to promenade proudly in her best clothes or a new white dress.

A young girl is considered too old for this annual custom at the onset of menstruation. Her next occasion to use henna comes when she gets married, typically in her late teens or early twenties, marking her transition to womanhood. “The night of henna” is the first day in the three-day marriage celebration. Before her hands and feet are decorated, the bride goes to the public bath to insure her physical and spiritual purity. Once a woman is married, her next “henna party” (hafla diel henna) is apt to come toward the end of her first pregnancy—many say during the seventh month—because by then she is weary of being pregnant and needs the distraction. Seven is also an auspicious number.

Ashura, the tenth day in the lunar month of Muharram, marks the Moslem New Year and provides another opportunity for married women to decorate themselves with henna. Many women say they apply henna to their hands and feet at this time to prevent illness during the year. In Morocco, illness or misfortune is often attributed to jinn (jinn), invisible spirits who live on earth and are believed to be able to enter or take possession of a person’s body. Like people, jinn range in nature from good to evil, partly in response to human actions. A henna party may serve to placate a malevolent jinni or please a protective one. For similar motives, women often apply henna toward the end of the eighth month, Sha’ban, after completing the household tasks that precede Ramadan. Some women call Sha’ban “the month of henna,” since for many it is the crucial period when they must have a specific design applied to appease or please a particular jinni.

Resembling lace gloves and stockings, the more elaborate henna designs obviously serve as beautifying cosmetics. In this respect, the widespread popularity of henna in Morocco and many other predominantly Islamic countries in North Africa and the Middle East is paradoxical, since according to Islamic tradition Allah curses those women who transform or de-nature his work. Those who give or receive tattoos, wear false hair, or pluck their eyebrows are condemned. Since henna designs are in a sense temporary tattoos, by implication they too are unorthodox. In fact, the whole festive occasion that springs up around henna is a matter for disapproval, and in some quarters it is considered forbidden, blasphemous, and a source of embarrassment.

Nonetheless, henna parties are commonly held by Moroccan women and last as long as three days. If a woman can
I afford to, she hires a specialist (mu'allima), who is normally paid cash and presented with a tray on which there are cigarettes, sweets, cookies, and a five-pound cone of sugar. The specialist also expects to be entertained with music and to be served mint tea during her breaks or to smoke a cigarette, a privilege enjoyed only by women of questionable status. Even though their artistic skill is respected, these specialists are often poorer women whose former occupations led them to dance or consort otherwise with men, an automatic source of low repute.

The specialist may learn the art of decoringating from her mother, but any girl or woman may adopt the craft. Techniques in applying henna paste vary: some specialists use the tube of an empty pen or a syringe, through which a very fine line of henna paste may be squeezed; others use a thin, pointed implement from which the henna can be dripped. The woman being decorated usually provides the henna, and its richness of color and staining qualities are a matter of pride. Essence of orange blossom and sugar are also made available to mix with the paste and aromatically subdue any unpleasant odor from the henna plant.
Just as henna use varies among Moslems from country to country, within Morocco designs differ from one city to another (the women of Fez and Marrakesh, for example, are particularly known for the delicacy of their designs). While certain pattern types are likely to emerge in a particular region, the specialist imposes her own preference, interpretation, and style as well. New ideas in design evolve over time, and each specialist creates a design appropriate for the recipient and the occasion. A recent and fashionable development among younger women in Fez is to decorate a single finger with a design that extends to the wrist on the top (back) of one hand. Although some specialists create arabesques that hint of foliage or heartlike shapes, the designs generally have no explicit meanings, since representational art (art that depicts any figures or forms found in nature or culture) is forbidden in Islam.

For the dye to take to the skin, the henna must be left to set at least through the night. The specialist may begin mid-morning, detailing thin lines of the thick, green paste into lacelike patterns on both sides of the hands and feet. After one hand is completed, usually the left, there will be a recess for lunch, while the henna recipient can still feed herself with her free right hand. Once the second hand is completed—often with a somewhat different design than that of the first hand—the woman may make her last visit to the toilet until the next day, since soon her feet will be completely covered with delicate lines of henna paste.

To achieve a ritual state of purity, a woman is likely to go to the public bath and may even fast prior to the henna party. This may have some practical consequence, in that by fasting a woman minimizes her necessary bodily functions, alleviating some of the problems of having both the hands and the feet out of commissión. Fasting is not part of the henna party itself; in fact, women say they cannot have a henna party during Ramadan, since such a party is incompatible with fasting.

After the henna is applied to a hand or foot, it is baked onto the skin over the heat from aromatic coals. When all the limbs have been decorated, the claylike paste is covered with cotton and each hand and foot is wrapped in scarves, to protect the henna from crumbling while the woman sleeps. Ideally, the henna must be applied twice, on consecutive days, for the design to be clear and bold. Thus, on the second morning, the paste will be scraped off, breakfast will be served, and the entire process will be repeated. The longer the henna remains on the skin, the deeper and more permanent the color.

One consequence of having henna applied is that a woman is immobilized for at least an entire day and night. Moreover, once the decoration has been completed, a woman should exempt herself from ordinary activities. When other women see that she has had her body embellished with henna, they greet her with B-sahaa-
Skin stained with henna, below, retains the design for three to four weeks. Right: In the Sudan, henna paste is scraped off prior to smoking the design to make it darker. The floral patterns of the clothing and henna conflict with the orthodox Moslem proscription of representational art.

Nicholas DeVore

_Henna_, or roughly, “Wear the henna in good health!” It would be shameful for a woman in this condition to soil her hands with mundane tasks, so other household females attend to these responsibilities.

Henna application serves more than a cosmetic function. Women believe that henna also has a medicinal effect. Since many women have their hands in water for hours on end, they often complain that their skin is “tired and worn-out.” They therefore cover their hands and the soles of their feet with henna to renew and soften the skin. Women also say the henna makes them feel better when they are tired or sick and that if they are nervous, it helps to calm them.

A woman who has henna done regularly looks forward all year to this celebration of her body. Friends visit, songs may be sung, and young girls or other guests may dance around the woman who is being decorated. The specialist may intermittently break the intense concentration of her work by telling a bawdy joke or tale. Taped music is played, and if she can afford it, the recipient is likely to arrange for musicians. A significant aspect of the henna party is that women are the focal point of attention. The few men who may attend (musicians or the spouse) are there in the service of the women and remain physically on the periphery.

Finally, according to popular belief, henna serves as a spiritual prophylactic, fending off the evil eye (the envy or ill intent of another person) and pleasing the jinn. Jinn may be either male or female, but it is the female jinn who sometimes request or demand that a woman do a henna design and possibly have a more elaborate ceremony and dance. The henna
Jinn live in dark, damp places such as toilets, drains, public baths, and rivers. Small problems like a glass breaking, an article of clothing disappearing, or arguments among household members, for example, may be attributed to having poured hot water down the drain and angered the jinni who lives there. On a more serious scale, physical maladies or deformities, general malaise, or any manifestations of bizarre, unexplainable behavior are often attributed to jinn, especially when medical doctors or other health practitioners are unable to treat them. Many a woman becomes entangled with these unpredictable beings by requesting fertility, protection, or prosperity and promising in return to host a henna party. If she does not keep up her end of a bargain with a jinni, disaster is likely to follow.

Jinn communicate their desires to ordi-
Male musicians and a professional dancer perform at an elaborate henna party, below. The climactic role of the music is to induce trance and spirit possession among participants. Women, opposite page, dance for the bride and groom at a wedding celebration. Both photographs by Maria Mosinski

nary people through dreams and trance states. Sometimes women consult a female seer (shuwwafa), who goes into a trance to discover which jinn are causing trouble and what specific actions are needed to placate them. The seer may also attend a henna party, where the jinn speak through her or she interprets what is being said through other women in trance. Jinn sometimes want things, and if their wishes are not complied with, they will bring additional troubles or cause illness. Of course, women may thus voice their own wishes for material goods and attention by saying their jinni has demanded that they host a party, purchase a garment of a particular color, or wear a favored scent.

Certain henna patterns "belong to," or are meant for, particular jinn, who also have preferences with regard to color of clothing, incense, music, and songs. Some of the more popular jinn are cast with the following names and preferences: Lalla Mallika, the most esteemed jinni in Fez, likes intricate designs, incense, and orange blossom water; her preferred colors are mauve, pink, and sky blue; she likes to joke and dance. Lalla Mira likes yellow and wants women to put henna on both sides of their hands up to the wrist and on the feet up to the ankles without any design. The favorite color of Sidi Hammou (a male jinni) is red, and he wants the henna to completely cover the palm, while on the top of the hand, only the nails, first joints, and perhaps the area in between should be colored. 'Aisha likes black and prefers the henna to obscure both sides of the hands until it's very dark. As one woman explains, "Jinn are born like us... there are many different kinds."

The henna occasion incorporates aspects of religious orthodoxy. For example, the practice of Islam is inseparable from the notion and definition of cleanliness. All bodily secretions are considered defiling, and a Moslem who is in a defiled state may not fast, enter a mosque or holy shrine, pray, or recite or touch the Koran. The believer must first wash all or part of the body to achieve a ritual state of purity. Similarly, a woman having henna done is concerned with her physical and spiritual purity and performs the prescribed ablutions at the public bath. The Islamic tradition also regulates sexual relations, desires, and needs, prescribing modest behavior and dress. In deference to these rules, in having henna done, a woman embellishes only the permissibly exposed parts of her body.

At the same time, the henna party provides a lively departure from formal Islamic expectations of proper female comportment. Not only is the body decoration itself questionable, but so are many of the characters from both the human and spiritual orders. The specialists are women who work outside their homes, travel in the night, usually smoke cigarettes, and may even drink alcohol—all of which are considered reprehensible activities. Even more suspect are the female seers who may be called in to identify jinn causing trouble or plan an appropriate henna party to strike a bargain with the spirits. Above all, even though the existence of jinn is referred to in Koranic texts, any appeal to them for help is considered blasphemous in Islam: the only proper appeal is made directly between humans and Allah.

Contact with spiritual forces can be highly dangerous, and the outcome is uncertain. An individual would not attempt this alone or openly in public, but a henna party provides a woman with an opportunity to have her problems taken seriously and, through communal celebration and support, to seek resolution. Caution and fear are counterbalanced by the joy and spiritual fulfillment a woman is likely to experience during this occasion.

Trance is the climactic element of the henna party that helps establish harmony with the jinn. On the last day of a three-day party, after the decoration with henna has been completed, the henna recipient reclines amid her entourage, in full finery. Taped music is played and hot coals spiced with incense perfume the room and illuminate it with an orange-red glow. To help induce the required atmosphere for trance, the recipient inhales the incense, coaxing the rising smoke toward her face with her hand, and intermittently sips essence of orange blossom. During the night, live music begins, and their jewelry flashing, the attending women begin to dance around the henna recipient. No shame is attached to the sometimes suggestive dancing, since generally only women are present.

The energy of the dancing and the modulating rhythms of the music are meant to awaken a jinni who has possessed the adorned woman or to enable jinn to enter her body. Eventually she also rises to dance, and more incense is placed beneath her so she can inhale the smoke. In time a pained expression crosses her face, and she enters a trance state where her movements are no longer thought to be her own. Others may also be drawn into a trance, and as the music intensifies, their movements become more frenetic and spasmodic. Those who are not carried away grip the belts of those who have been called by the jinn. While those in trance violently jackknife their bodies, scarves become undone and hair whips about. Others remain seated as tears fill their eyes, for the presence of jinn is said to affect people in different ways. Finally the jinn tire and leave, and the trance session comes to an end with a heap of women collapsed on the floor, where they are tended until they revive.
Sent as an invasion force in 1588, Spanish ships confront English forces in a sixteenth-century painting of the English School. In the foreground, an Armada galleass that flies the papal banner is framed by two English warships. A preaching monk, a jester, and other figures on the galleass are drawn in a satirical manner that suggests the artist's anti-Catholic bias.

National Maritime Museum, Greenwich, England
At the end of May 1588, a naval task force sailed slowly out of the harbor of Lisbon. So large was the fleet that it took two days to cross the bar at the mouth of the Tagus River. The fleet consisted of 130 different-sized ships, most three-masted, with square-rigged mainmasts and foremasts and a lateen-rigged (with a triangular sail) mizzenmast. Sixty-five were warships or converted merchant ships; twenty-five were transports; four were galleasses, propelled by oars as well as sails (with slaves, prisoners, and "volunteers" chained to their oars); and four were oared galleys. In addition, there were thirty-two smaller vessels, mainly fast dispatch boats. The largest of the ships was la Regazona, rated at 1,249 tons, an indication of cargo-carrying capacity, rather than displacement. These ships were crammed with men: besides 8,050 officers and sailors, there were 19,295 soldiers aboard. The soldiers were mainly an invasion force, but they were also prepared to board enemy ships, then the prevalent form of winning victories at sea. The fleet carried 2,431 pieces of ordnance of all sizes: the better ones, 1,497 in number, of bronze; the rest of iron.

This was the Spanish Armada, assembled by Philip II, the Catholic king of Spain, to invade and conquer an England ruled by his Protestant sister-in-law, Elizabeth. The reasons for the projected invasion were partly political, to consolidate Spain's position as the most powerful nation in Europe; partly economic, to put an end to the raids by English privateers on the galleons bringing to Spain the treasures of the New World; and partly religious, to bring England back to the Catholic fold. This last aspect of the "Enterprise of England" cannot be minimized. Philip was intensely devout and sincerely believed that his undertaking was divinely inspired. The sails bore the Holy Cross in red, the ships flew religious banners, and ninety-six of the ships bore the names of saints. Among those sailing were 180 priests and monks, and services were held daily. The orders issued to the Armada proclaimed: "First and foremost it must be clearly understood by all, from the
highest to the lowest, that the principal aim of His Majesty is the service of God."

Since the fleet was an invasion force, it had to carry all the necessary military equipment, including great siege guns to batter the walls of London, along with the horses and mules to drag them, and gunpowder and shot of stone and iron for these as well as for the ships’ guns. The soldiers had small firearms—muskets and arquebuses—with lead shot and lead ingots for casting more. There were also pikes and bows. In addition, the fleet had to carry provisions for a projected six-month campaign. The shopping list was prodigious: barrels of water and wine, 30,000 gallons of oil, and more than 60,000 gallons of vinegar. There were biscuits, bread, and cheese; rice, beans, and peas; codfish, tuna, and sardines; mutton, beef, pork, and bacon. A weekly menu was drawn up that amounted to some 23,000 calories per man per week.

To distribute the rations to the men there were measures for wine and for water and scales and weights to weigh out the dry goods. Pottery plates, bowls, and jugs and wooden plates and bowls were issued for the soldiers’ and sailors’ mess—the officers and gentlemen of the fleet supplied their own. There were lanterns and candles and medical supplies, tools and materials for making repairs at sea, and spare anchors and sail canvas. There were also religious medals. Every need had to be met, and all supplies had to be acquired and assembled in the right place, at the right time, and meticulously accounted for. Manifests for many of the ships are preserved in the Spanish archives. That for one ship, la Trinidad Valencera, details some of the consignments: 5,618 pounds of fresh bread, 992 pounds of mutton, 3,664 pounds of pork, 6,000 sardines, and 28,160 gallons of water.

The intention was that 30,000 Spanish troops from the Netherlands, with additional supplies, would be escorted across the English Channel by the Armada, making a total invasion force of nearly 50,000 men. To prevent this rendezvous and the subsequent invasion, an English fleet assembled, ultimately consisting of some 175 mostly smaller ships. In attendance on the English fleet were twenty-two victu-
Unfortunately for the Spanish fleet, as it sailed farther and farther north, the bad weather that had cursed it from the minute it sailed from Lisbon did not improve. If anything it got worse, and the Spaniards encountered freezing fog and almost incessant storms. By August 20, the fleet, still together, had rounded the Shetlands, but on September 3 a dispatch was sent to King Philip, stating that in the course of two weeks they had had four nights of storms and that seventeen ships had disappeared from view. Three thousand men were sick and a large number were wounded; many were dying.

Of the seventeen missing ships, four formed a little group: three transports—the Castillo Negro, the Barca de Amburg, and el Gran Grifon—and a large Venetian merchant ship, la Trinidad Valencera. This little group was particularly unfortunate. Somewhere off the north coast of Ireland, in deep water, the pumps of the Barca de Amburg could no longer cope; her crew of 250 transferred to two of the other ships, el Gran Grifon and la Trinidad Valencera, and she sank into the cold waters of the Atlantic. The Castillo Negro disappeared into the night, and is likely to have been the first ship of the Armada to have perished on the Irish coast, for she is probably the ship reported by the English as having gone down with her 314 men near Dunluce, in County Antrim. For the crew of the Barca de Amburg, the stay of execution was all too short. After severe punishment from the gales, both el Gran Grifon and la Trinidad Valencera were wrecked, one on Fair Isle between the Orkneys and the Shetlands, the other on a reef in Kinnagoe Bay, County Donegal.

All along the west coast of Ireland similar tragedies were taking place, not because the ships disobeyed the sailing instructions but because they were driven onto the Irish coast by storms or because they had to seek refuge at all costs rather than sink in the open sea. In Blacksod Bay, County Mayo, a Genoese ship, la Rata Sancta Maria Encoronada, under Don Alonso de Leiva, one of the most respected commanders in the fleet, was driven ashore on September 17. He successfully disembarked all his men and occupied a small castle overlooking the bay. Three days later, farther north, in County Sligo, three great ships were driven ashore on the sandy beach at Skeydeagh—the Juliana, la Lavia, and the Santa Maria de Vision. Their crews, as they struggled ashore only half alive, were butchered by the English forces. In mortal fear of the arrival on the scantily defended island of Ireland of thousands of well-armed, well-trained Spanish troops, the English in Dublin had issued instructions to “apprehend and execute all Spaniards found there, of what quality soever.” Contemporary accounts estimated that more than a thousand bodies were stretched out along the strand at Skeydeagh.

In Blasket Sound in County Kerry,
Among the items recovered off Northern Ireland from the wreck of the Girona was a gold pendant, below, with rubies set in the form of a cross. The somewhat fanciful animal may be a Kuhl's gecko, a "flying" lizard from Southeast Asia. Also salvaged was a Cross of a Knight of Santiago, right, whose owner, Don Alonso de Leiva, survived two previous wrecks only to perish on the Girona.
The turned wooden base of a mariner's compass, below, was salvaged from the wreck of *la Trinidad Valencera*. A compass card, to which was attached a magnetized needle, would have pivoted on the steel pin, now bent. The Cross of a Knight of Saint John of Jerusalem, left, belonged to the captain of the Girona.
three Spanish ships took refuge from the storms. While they were lying at anchor, another ship, the *Santa Maria de la Rosa*, her sails in tatters, limped in. Signalling great distress, she fired one shot, then another. Shortly after casting her sole surviving anchor she suddenly sank, to the horror of the crews of the other ships. It was September 21, the day the main body of the fleet arrived back in Spain.

Meanwhile, back in Blacksol Bay, Don Alonso had learned that another Spanish ship, the *Duquesa Santa Ana*, was anchored a little way around the coast to the northeast. He transferred his men and set sail again, only to be wrecked a second time, at Loughros More, in southwest Donegal. Again Don Alonso created a fortified camp, and again he heard of another Spanish ship nearby. The mighty galleass *Girona* was at Killybegs, some twenty miles away across the mountains. Don Alonso moved his crew and, after carrying out repairs to the *Girona*, set sail. This time, however, his luck ran out. His third wreck, on October 26 at Lacaed Point in north Antrim, was fatal, both for him and for 1,300 of his shipmates. Only five or six survived. This, the most grievous single wreck of the Armada was also the last to take place on the Irish coast. Those who perished included not only Don Alonso but also members of some of Spain's most distinguished families, who had followed him on the great Enterprise.

A
together between twenty and twenty-four Armada ships were wrecked on the coast of Ireland. So far the wrecks of six have been located and identified. The first to be discovered and excavated was the last one to be wrecked. In 1967, after many years of research on the Armada, Robert Sténuit, the celebrated Belgian historian and nautical archeologist, entered the icy waters at Port na Spaniagh in north Antrim. As he swam along the east face of the cruel talon of rock that is Lacaed Point, he observed a boat-shaped lead ingot, which he recognized as being of Armada type. Then he found the barrel of first one, then another, bronze gun. He knew he had found the wreck of the *Girona*.

In April of the following year, Sténuit returned with a fully equipped team of excavators, including Marc Jasinski, an expert photographer both above and below water. Work on the very difficult site, where winter storms can send forty-ton boulders from one side of the bay to the other, took two seasons and 6,000 hours of diving. No part of the vessel's hull survived—the water was too shallow and the seas too violent, with the result that the vessel had broken up, the pieces dashed against the rocks and then carried out to sea. Nevertheless, the excavations produced a wealth of material. The two guns observed on the first dive proved to be a muzzle-loading bronze half-saker (a small short-range gun) and a breech-loading esmeril (a swiveling antipersonnel weapon). A piece of the muzzle of another gun was found, but no others, an indication that ordnance was dumped overboard so that the ship could accommodate the men inherited from the two previous wrecks.

Two astrolabes were recovered, as well as pairs of navigational dividers and sounding leads. Divers also brought up a small iron anchor, probably a kedge (used to move a ship by drawing in the attached cable, such an anchor could be picked up by the ship's longboats). Dozens of bronze coaks (small squares of bronze, with a central hole) were also found; these had been used on the ship's rigging as bearings for blocks.

Among the most spectacular artifacts were the coins—405 of gold, 756 of silver, and 115 of copper. While most of the silver and gold coins were struck in Seville, coins from thirteen other mints from six different countries were found as well. Even New World mints were represented: Mexico, Lima, and Potosí. One reason for this is that this was no official treasure, but the personal property of those on board.

As spectacular—and at first sight more surprising—was the array of Renaissance jewelry recovered. But the Renaissance was a jewelled age, and the Spanish officers and noblemen in the invasion fleet had every intention of looking their best when strutting, victorious, through the streets of London. Badges of orders of chivalry were to be expected, counting almost as badges of rank. Among those found was a Cross of the Order of Santiago (St. James)—a gold cross in the shape of the saint's lily-hilted sword, covered in red enamel. This belonged to the formidable Don Alonso de Leiva: his cross has survived three shipwrecks, he did not. The Cross of a Knight of Saint John of Jerusalem, in the form of a so-called Maltese cross (the order had moved from Rhodes to Malta in 1530), probably belonged to Fabricio Spinola of Genoa, the captain of the *Girona*. The owner of the badge of another Spanish order of chivalry, that of Alcantara, has not been identified. The badge is in the form of a little oval gold container for a relic, with an engraving of an elderly saint (Saint Julian of the Pear Tree, after whom the order was originally named). In addition there was an assortment of gold chains—some simple and heavy, others fine and light—from which the badges could be suspended. The heavy chains, which were constructed so that a link or two could be detached to pay for goods or services, had the disadvantage that they could have helped drag their wealthy owners to the bottom of the sea. One, of 407 links, weighs more than four pounds.

Among the rings discovered, one turned out to be of particular significance: a large, heavy gold ring inscribed "Madame de Champagner MDXXIII [1524]." Research by Robert Sténuit shows that this was worn by the woman's grandson Don Tomas Perrenotto, whose death on the *Girona* is recorded. Another ring is the most poignant item recovered: it is inscribed "No tengo mas que dar te" (I have nothing more to give thee), and one terminal is in the form of a hand clasping a heart. It was clearly a parting gift to a Spanish gentleman from his lover.

Philip II of Spain, above, saw the planned invasion of England as a Catholic mission. Right: A map from a series that narrates the Armada campaign, published in England in 1590, depicts the Spanish ships in a defensive crescent formation, pursued by the English fleet.
Other items recovered include fragments of an assortment of decorated silver-gilt dishes, silver candlesticks, and table forks with elaborate cast handles. Some of the forks have two prongs, some three, some four, and others five. A small silver lid bearing an “A” is almost certainly from an altar cruets, the A standing for _aqua_ (water). The _Girona_ may well have been carrying a complete set of altarware for the saying of Mass—possibly the property of the Bishop of Killaloe (in Ireland), who sailed with the Armada.

The second wreck to be investigated was that of the _Santa Maria de la Rosa_, in Blasket Sound. Although her sinking had been witnessed, her exact position in the four square miles of the dangerous sound was not known; it took a five-year search by the adventurer Sydney Wignall and his team to find her. Her attraction was that as an _almiranta_, a “vice flagship,” she might have been carrying official treasure, and as she had sunk suddenly in deep water, substantial portions of her hull might be preserved. In fact, part of the hull was discovered, showing that the ship’s planking was attached to the frame with wooden fasteners. The arrangement of the ballast was preserved, and the galley fire proved to have been casually positioned on top of the ballast in the hold. The results of the excavations were otherwise disappointing, however. Of the material salvaged, which included several muskets and arquebuses, little has been preserved, because there was inadequate provision for conserving material that had lain in saltwater for 400 years. Two pewter plates inscribed “Matute” were important because they helped to identify the wreck—Francisco Ruiz Matute being recorded as an infantry officer on board.

A third wreck was discovered, literally by accident, in February 1971, by members of the City of Derry Sub-Aqua Club on a training dive in Kinnagoe Bay, County Donegal. One of the divers spotted a bronze gun, then another was seen. Since the latter bore the royal arms of Philip of Spain and the legend “Philipus Rex,” the members of the club were reasonably confident they had found the wreck of _la Trinidad Valencera_. They resolved that the excavation was to be properly conducted, and were fortunate to obtain the services of Colin Martin, of Saint Andrews University in Scotland, as archaeological director.

The ordnance recovered was a nice confirmation of the entries in the ship’s manifest. The gun bearing the arms of Philip II was a siege gun, cast in Malines in the Low Countries in 1556 by Remigy de Halut and one of three listed in the manifest (the other two have also been recovered). In addition, there were three Venetian guns, part of the ship’s original armament. Also discovered were wheels and axles of gun carriages. Small arms included muskets, arquebuses, and a firepot, a type of grenade discussed in contemporary works on gunnery.

The domestic equipment included a vast array of pewter plates, dishes, bowls, jugs, flagons, drinking cups, and candlesticks. Two of the plates were made in London by a noted pewterer, Edward Roe. Among the pottery recovered was a beautiful porcelain bowl from China—the property of a rich officer or nobleman. The standard issue of earthenware—plates, bowls, and jugs—was also represented, as were simple wooden bowls and a little wooden spoon. Two traditional Spanish wineskins were found, but did not sur-
vive the difficult problems of conservation. There were even textiles: fragments of woolen garments, including a complete sock, and silk tassels, ribbons, and braid, as well as a handsome spat. Some of the textiles had been dyed with cochineal, a labor-intensive dye from Mexico, then imported in quantity by Spain. There were shoes, not merely the heavier soles but the more fragile uppers as well. A soggy, shapeless mass of woven fabric, with ropes and wooden toggles attached, proved to be a tent—one of dos tiendas de campagna listed in the manifest.

A tambourine and the neck of a stringed instrument testify to shipboard entertainment. Another item testifies to shipboard squalor: the skeleton of a rat, the seaman's constant companion. This one failed to abandon the sinking ship.

Three more Armada wrecks have been located and identified, those ill-fated to run aground on the strand at Streedagh. From one of these (the Juliana), Francesco Cuellar made his way back to Spain, leaving a notable account of his experiences as one of the few survivors of Ireland's Armada wrecks. Newly enacted legislation in the Republic of Ireland has sensibly inhibited excavation at Streedagh because of the absence of needed conservation facilities. Lifting materials from the seabed is easy; preserving this legacy for the enjoyment and edification of future generations is not.

If the Spanish Armada, the largest invasion force ever seen until then, had succeeded in the Enterprise of England, the course of European and even world history would have been changed, at least temporarily. Instead, some 10,000 brave soldiers and sailors perished in the Irish wrecks, easily ten times the number lost engaging the enemy in the English Channel. Other wrecks occurred off Scotland or farther along the route of retreat. In the end only about 80 of the original 130 ships made it back to Spain. Ironically, had the Spanish commanders reconciled themselves to the failure of their original mission and settled, in its place, on an invasion of Ireland, they could have had a significant success. If so, Ireland might have become Spanish-speaking and, as Philip would have hoped, entirely Catholic. □
A detail of a painting by H. C. Vroom (1566–1640), traditionally regarded as depicting the Spanish Armada in action, is now believed by art historians to be of the battle of Cadiz, 1596, a preemptive strike against Spain to ward off another suspected invasion of England.

Private Collection; Bridgeman/Art Resource, New York
Living on Borrowed Turf

The tiny, but tricky, burrowing owl uses the tunnels of its enemy, the badger, for breeding in Oregon's Columbia Basin

by Gregory A. Green

A solitary badger, awakened from his slumber by hunger, emerges from his day den, shakes the dust from his pelt, and shuffles across the moonlit field of drying cheatgrass in search of food. Following his nose, he zigzags among the several burrows he has excavated in the sandy soil during the past year. Some of these burrows are day dens, some the remnants of a subterranean pursuit of prey, but each is explored for the fresh scent of mice or gophers that may have recently taken up residence within. For the badger, this is a successful foraging technique: first provide an attractive home for your prey—then raid it. But on this night the badger is confused by one den in particular. The den emits neither the alluring smell of prey nor the intimate odors of the badger's own musk, urine, and feces. Instead, there is the overwhelming pungency of drying cattle dung; the tunnel and chamber are thickly layered with shredded cow pies. The badger moves on without entering the burrow and without knowing he has been deceived. For inside is a female burrowing owl, still encumbered by egg laying, and half a clutch of eggs.

I've never witnessed the above scenario, but after three years of studying burrowing owls and badgers in the Columbia Basin region of north-central Oregon, I believe it is accurate. The badger is a tenacious predator with a prodigious sense of smell. Nonetheless, I have observed fresh badger tracks at the entrances of burrows that I knew harbored burrowing owl eggs or nestlings and found the burrows to be undisturbed. In each case, these nest holes were copiously lined with shredded cattle dung.

I began examining the curious relationship between badgers and burrowing owls in the Columbia Basin seven years ago, while I was a student with the Oregon Cooperative Wildlife Research Unit at Oregon State University and a biologist with the Umatilla National Wildlife Refuge. Particularly intriguing was that burrowing owls successfully reproduced in this shrub-steppe region of Oregon and Washington by nesting almost exclusively in badger burrows. Much better known is the owl's habit of nesting in prairie dog...
colonies in the Midwest. Pioneers crossing the Great Plains in the mid-1800s remarked in their journals and diaries on the great numbers of "prairie dog owls" living within vast prairie dog towns. For the burrowing owl, the relationship is remarkably convenient. Prairie dogs not only provide large numbers of suitable nest burrows, but they also graze and clip the vegetation to a level that provides an unobscured view of approaching predators. Therefore I could easily understand this owl’s practice of nesting among a colony of innocuous herbivorous rodents, but why would a bird choose to incubate its eggs in a badger’s den? Relentless carnivores that would not hesitate to devour burrowing owl eggs, nestlings, or even an adult, badgers regularly return to old den sites, making encounters between predator and prey almost certain.

The burrowing owl is a quail-sized raptor found in North America on the prairies and plains west of the Mississippi River, with an isolated population occurring in Florida. The owl’s scientific name, *Athene cunicularia*, alludes to its practice of nesting underground; *cunicularia* means “little miner.” While burrowing owls may be capable of digging a den, most do not “mine,” but instead depend upon other animals, usually colonial prairie dogs or large ground squirrels, to provide nests holes. Within these burrows, which protect them from inclement weather, burrowing owls produce clutches and broods larger than those of other owls. I’ve observed clutches of up to twelve eggs and successful fledgling of ten young, although five to seven fledglings are more common. The burrow also provides protection from predation by other raptors.

But suitable nest holes for Columbia Basin burrowing owls are limited. Prairie dogs have never inhabited these rolling hills of shrub-steppe. Situated in the rain shadow of the Cascade Mountains, the Columbia Basin of north-central Oregon and eastern Washington is very arid (less than nine inches of precipitation annually in my study area), especially during the summer months. The region is much too arid for prairie dogs, which need more moisture and succulent vegetation than the basin has to offer in order to survive the summer. Cheatgrass and bunchgrass, the dominant basin grasses, dry out quickly in the hot sun, and many of the common shrubs, such as rabbitbrush, are unpalatable. Even the small ground squirrels endemic to the basin survive only by estivating (entering summer dormancy) through the hot months. (Also because of
the arid climate, most basin insects and small rodents lead a nocturnal or crepuscular life, and although Columbia Basin burrowing owls can be seen readily during the daylight hours, their foraging periods follow the activity patterns of their prey.)

The local ground squirrels also dig too small a hole for nesting burrowing owls, although yellow-bellied marmot burrows located in open terrain may be used. Next to badger burrows, coyote dens may be the most common natural burrow used by Columbia Basin owls; however, these sites are scarce and pose much the same problem as badger burrows. I found that burrowing owls in the basin, like burrowing owls throughout their range, were very opportunistic when natural burrows weren’t available. I have observed pairs nesting in irrigation pipes, dry spring boxes, and even the interior of a buried car. A constant need for adequate nest sites probably explains their adaptability and why they take readily to artificial nest boxes in suitable habitat. Nevertheless, most burrowing owls nest in dens dangerously exposed to ground predators, and the owls in my study area most commonly chose to nest in the very homes of the ground predators.

The burrowing owl’s use of cattle dung is most prevalent, and probably most important, during the egg-laying stage of the nest cycle, which generally begins in April. Just prior to egg laying, the male carries large chunks of dried dung in his beak to the soil mound at the burrow entrance, where it is left for the female to carry into the burrow and shred. (I’ve never observed a male completely enter a nest burrow except to escape an avian predator.) Egg laying itself may last two weeks, during which the female must spend much of the time nearly immobile while the fragile eggs develop within her oviducts. She only occasionally comes out of the burrow during this period, probably between laying bouts, to get food left at the burrow entrance by the attending male. Since defense against a predator attack or even a quick escape from the hole could be hindered by a burdensome developing egg, the female’s best defense is concealment. And since coyotes and badgers hunt by smell, she must hide from the predators’ noses as well as their eyes. Even the male, who is normally conspicuous on a nearby perch, hides away from the nest during these periods, probably to avoid drawing unnecessary attention to the nest site.

Biologist Dennis Martin, then at the University of New Mexico, was the first to hypothesize that burrowing owls were using cattle or horse dung to deter predators. He had no way to test his hunch, however, since all the pairs he was studying in New Mexico were using dung, and any dung he removed was quickly replaced. Since nearly half of the pairs I studied did not use dung (generally because it was not available), I could compare predation rates. Of twenty-five nests lined with dung, only two (8 percent) were lost to badgers in 1981, whereas 54 percent (thirteen of twenty-four) of the unlined nests were destroyed by these carnivores. The fresh badger tracks I occasionally saw near undisturbed nests further support the “olfactory concealment” hypothesis.

Dung remains in the nest throughout the incubation and brooding periods and is eventually removed by the active young, which scrape the burrow clean while removing soil to enlarge the tunnel and nest

Month-old siblings, left, assembled on the concrete side of an irrigation box, are on home ground; they were born inside the pipe running into the box. To cool off, the heat-stressed young, below, droop their wings to expose skin between feathers and shade their long legs.

Both photographs by Art Wolfe
chamber. Enlarging the burrow alleviates crowding of the growing brood. Although the young continue to be vulnerable to nest predation long after their malodorous "protection" has been removed, the female is by then free to assist the male in nest defense up until the young begin dispersing when they are about seven to eight weeks of age.

By no means do I wish to imply that burrowing owls use dung solely for nest defense. Dried cattle dung also provides good insulation, perhaps controlling both temperature and nest humidity around the eggs. One suggestion is that dung, like sprigs of vegetation used by other raptors, may serve to control parasites, such as ticks and fleas. (Nevertheless, it did not do well at deterring fleas at my study sites.) Therefore, the use of dung as a deterrent to predators may be an added benefit, perpetuated by the higher nest success it provides. But if dung is used as a nest insulator, then burrowing owls are definitely among the few owls that provide their own nest material.

Almost all North American burrowing owls use cattle dung for nesting. But livestock are a recent introduction into the New World. So when did this behavioral trait evolve? One might argue that burrowing owls were using bison dung before cattle arrived, and this is probably true where burrowing owls and bison lived together. However, burrowing owls in the Columbia Basin (and Florida) were not associated with bison, at least in the last several hundred years, and the owls inhabited the basin before the arrival of cattle. Perhaps, before cattle were present, burrowing owls in the Columbia Basin used no nest lining at all and consequently suffered more from predation but managed to remain a part of the local ecosystem by virtue of their high reproductive output when they were successful.

Once egg laying is complete (usually by April or early May), the male stands a nearly continuous day-and-night watch over the burrow. Without warnings from him, the nest occupants could easily be trapped within the burrow by a predator and killed. The only time the male is not on duty is when he is hunting (and then the female usually takes over) and during the hot midday when even diurnal predators, such as coyotes, are not active. The vista from the burrow entrance of a Columbia Basin owl nest is generally obstructed, since there are no herbivores such as prairie dogs to remove surrounding plants. Even after grazing by cattle, the taller, unpalatable forbs and shrubs remain. But Columbia Basin burrowing owl males can and do extend their horizontal vision by using elevated perches. With a few exceptions, every nest site in my study area had at least one perch. Perch use is definitely not restricted to Columbia Basin owl populations, but perches may play a greater role here than in the nesting ecology of owls in prairie dog colonies. In comparing abandoned badger burrows selected by nesting owl pairs with those not selected in cheatgrass grassland and bitterbrush shrubland, I found that a major difference between the sites was the lack of suitable perches near the unused burrows. Sometimes active perches weren't very substantial—a prominent rock or survey stake. If available, a stout bitterbrush branch or a fence post was most commonly used.

Perches not only improve the owl's ability to spot predators but they also help in the detection of prey and allow the male to regulate his body temperature more easily. Heat radiating from the sandy soil can drive the air temperatures to well over 100°F and soil surface temperatures to 160°F. The male's long, lightly feathered legs may help expel heat in an environment cooler than his body temperature. By perching away from the warm ground and, when it gets really hot, dropping his wings to create shade for his legs, the male
Good vantage points are scarce in the shrub-steppe regions of the Columbia Basin. A male on daytime sentry duty, left, found a dead but stout branch of a spindly rabbitbrush from which to scan the landscape for predators. Below: An owl grips a grasshopper, a staple food for burrowing owls during the hot, arid summer.

Stephen J. Kraseman, Nolan Photos

can perform his watch duties and still thermoregulate effectively.

Some burrowing owls in my study did not use perches. An isolated group of six pairs was found nestling in an intensively grazed sheep pasture, where the surrounding vegetation averaged less than two inches tall and the field looked like a dried-up golf course. When it became hot, these males simply backed down the hole and shaded their legs in the tunnel's shadow. Because the vegetation was short, they could see great distances by simply peering over the burrow lip. This habitat may closely resemble the conditions of a prairie dog town.

Despite the use of dung and perches to increase their nesting success, Columbia Basin burrowing owls, like most burrowing owl populations, did not succeed very well. Nesting success was barely more than 50 percent for two years. The major reason for failure was not predation but nest abandonment. Nesting pairs at a third of the nests simply pulled up stakes, leaving behind eggs or young. Several times I found the consequences of an abandoned nest: lethargic, starving young at the burrow entrance, too weak to retreat from my approach. At first I thought these tragedies were a result of adult mortality, but then a pattern began to emerge. Every abandoned nest site was within 330 feet of another nest. And when two sites were within 150 feet of each other, both were deserted. The direct relationship between proximity of nesting pairs and abandonment seemed a bona fide case of intraspecific competition.

But why? Why hadn't the rigors of natural selection forced them to nest farther apart? And why did the owls abandon their young in the middle of the nesting cycle after they had already invested a great deal of energy? Furthermore, why hasn't nest abandonment been reported to be a factor in other burrowing owl populations, especially in the Midwest where they regularly nest in colonies? The answers, I feel, have to do with the owl's association with badgers and with the local climate.

My sampling of nesting habitat led me to the conclusion that Columbia Basin burrowing owls need three things in a nest site: first, obviously, is a suitable burrow; second, a suitable perch (or very low vegetation); and third, a high percentage of bare ground (approximately 50 percent). To burrowing owls, which feed largely on small rodents and large ground-dwelling insects, bare ground indicates a good supply of available prey. Many of the large ground-dwelling insects and rodents inhabiting the arid shrub-steppe avoid grassy areas because the dense stems make movement difficult. Dense grass also provides concealment for other potential owl prey, making them less available than prey in open areas.

A well-grazed prairie dog colony meets all three requirements because of the digging and herbivory of prairie dogs. But in the Columbia Basin, each component is independent of the others. Where there is a suitable burrow, there may not be a nearby perch or the grass may be too high. If a perch is available, the grass may be too dense. On the rare occasion that a suitable burrow is found along with the other two characteristics, it is likely that other burrows will be very close by, since badger burrows tend to be clustered. Therefore, a newly arriving pair of burrowing owls may have to choose between not nesting or nesting close to a neighbor.

In the beginning of the season, nesting close to another pair of owls may not be a problem. From March to May, burrowing owls in my study area consumed small nocturnal mammals almost exclusively, but by summer, they had gradually switched to a diet that was dominated by crepuscular insects. Burrowing owls foraging on rodents tended to travel far from the nest, a feasible strategy due to the relatively large amount of food each small mammal provided and the low demands of unborn or newly hatched young. The farther that adults from different nests traveled, the less they would compete for the same resource. Nesting adults also hunted rodents intermittently throughout the night (virtually all rodent prey in my study area, such as pocket mice and kangaroo rats, were nocturnal); therefore neighboring pairs were not necessarily for-
In the Columbia Basin, burrowing owls use abandoned badger holes as nests. By lining the nest with the odorous shreds of cow dung, the owls mask their scent and greatly reduce the risk of a badger’s returning to prey on the nest’s inhabitants. A parent, right, takes a defensive stance at the edge of its burrow.

Larry H. Dito

Aging at the same time. But as the seasonal temperatures become warmer, insects emerge and rodents spend more time underground.

The switch to the smaller insect prey forces pairs to forage closer to the nest. Because insects are only captured one at a time and they are relatively small items, adults cannot make too many long-distance runs before there is a deficit in energy expended to energy gained, especially since most of the food is going to a large brood of young at the peak of their growth rate. As a result, adults rarely traveled farther than 150 to 200 feet from the nest to forage for insects. To further confound the energy demand on the owls, the peak period for insect activity was only about one hour in the morning and one hour in the evening. Feeding is hectic at these times (I once observed two adults deliver eighty-eight beetles to six young in fifty-five minutes). Nesting pairs that peacefully coexisted in the cool of spring, when energy demands were low, probably found themselves competing both spatially and temporally for the same food supply in summer, as their feeding territories suddenly overlapped. I believe it is at this point that pairs unable to meet demands begin abandoning their nests.

Another factor in nest abandonment may be a low degree of food competition within burrowing owl broods. Unlike other raptors, parent burrowing owls distribute food evenly among their young—whose ages may vary by as much as two weeks—and therefore, older and younger nestlings are not radically different in size after a few weeks of growth. This means older nestlings do not have the great competitive advantage over young nestlings as in other owl species. Instead of allowing the brood size to be reduced as a result of sibling competition (the dying off of smaller nestlings when resources are scarce), adults must continue to try and meet the demands of an oversized brood—or simply give up.

Despite the problems of nesting in badger burrows or of nesting too close to neighbors, overall, enough burrowing owls are fledged each year to currently maintain a strong breeding population in the Columbia Basin. Yet for all their cleverness, such as using livestock dung to avoid predation, burrowing owls cannot avoid the plow. The Columbia Basin is now undergoing an agricultural boom brought about by large irrigation projects. Pivot irrigators are watering crops on lands only recently occupied by badgers and burrowing owls, especially the flat lowlands favored by both burrowing owls and irrigation farmers. My study area spanned the northern half of three counties; yet more than 90 percent of the pairs I studied were nesting, not on private lands, but on parklands, refuges, or military installations with large areas of native shrub-steppe. If these lands, too, finally succumb to the pressures of agriculture, then the future for such shrub-steppe wildlife as the burrowing owl looks grim.
Underdog

For decades, its population declined, but now, a little fox of the prairie may find that the race is once again to the swift

Text by Thomas R. Laurion • Photographs by Pat Powell

“Speed of lightning, sound of thunder,” was the rallying cry of Underdog, the 1960s cartoon canine of steel. I’m rooting for a real life underdog with plenty of speed, but no thunder, no cape, no muscles of steel: the swift fox. This smallest of all North American canids (at roughly five pounds, it is about the same size as a house cat) is currently fighting for a comeback over most of its historical range—the shortgrass and midgrass prairies of the Great Plains.

During 1819 and 1820, Maj. Stephen H. Long led an expedition from Pittsburgh to the Rocky Mountains and back. Accompanying Long was naturalist and pioneer entomologist Thomas Say. An account of the expedition was published in 1823, and in it Say gave an anatomical description, as best he could from two badly decomposed specimens, of the little foxes they had observed. Say concluded his scientific remarks with thoughts he had recorded after seeing one of these foxes running across the plains. He compared the animal’s grace to that of “a bird skimming the surface of the earth” and claimed that “in fleetness it even exceeded that extraordinary animal [pronghorn antelope] famed for swiftness.” With this in mind he proposed the name Canis velox. We now know it as Vulpes velox, the “swift fox.”

Long before white settlers knew this animal as either Canis velox or Vulpes velox, Native Americans had given it many names in different languages and dialects. Fox societies formed within many tribes. The Kit Fox of the Cheyenne was a powerful society of warriors, revering the swift fox for its quickness and ferocity when cornered. The Kit Fox Society of the Sioux was also a group of prominent warriors, duty bound to act for the good of the tribe in times of conflict—inter- and intra-tribal—and hunger. (The kit fox and swift fox are synonymous on the Great Plains, but are not the same as Vulpes macrotis, the desert kit fox, found primarily west of the Rocky Mountains.)

My own formal introduction to the swift fox came at dawn on a cool, clear June morning in 1983. In the company of a high-school senior just beginning his summer as a Youth Conservation Corps volunteer, I was driving down a dirt road in southeast Colorado, where the U.S. Army had recently purchased 650 square miles of former ranchland, most of it shortgrass prairie. Before beginning training maneuvers there, the Army—working with several universities and the U.S. Fish and Wildlife Service—wanted to gather basic ecological information on the area and its wildlife and develop a management plan. At that time, I was assisting with a pronghorn antelope study.

The earliness of the hour, rather than the gravity of our work, had us slumped in our seats at the start of our ride. But traversing endless potholes in what seemed to be a suspensionless pickup truck had us fully awake by the time a swift fox appeared in the road before us. We stopped and watched this small canid work its way along the road, surprisingly unperturbed by our presence, but wired, in a ready-to-move sort of way. The fox was beautiful in the yellow light of dawn—its fur, the road, and the last summer’s dried seed heads all shades of beige and rust. It trotted to the middle of the road, picked up a dead horned lark, and with its prize securely but delicately held in its jaws, lightly passed back onto the prairie. Changing its pace from a fast walk to a lope, then back to a walk, the fox looked back regularly as it angled away from us, first one way and then the other.

After spending a couple of minutes trying to answer my assistant’s questions about swift foxes, I realized I was as much in the dark as he was and was hooked on the idea of learning more. The next winter I was either on skis or horseback, following swift fox tracks in new snow. Now—after two more winters, more than 180 live fox captures, thousands of hours tracking individuals with radio transmitters, the help of four technicians, a never-ending literature review, and the support of Orrin J. Rongstad at the University of Wisconsin—my admiration for these little foxes, and my ability to answer questions about them, have grown.

Thomas Say may have been the first to propose a scientific name for the swift fox, but he was certainly not the first settler or
Alert to a pursuer, an adult swift fox may take advantage of its speed and head for the nearest den. Its small size and light brown coloration also offer some protection on the prairie, where the animals sometimes seem to melt into their surroundings.
explorer to observe the animal. Lewis and Clark wrote of seeing the foxes during their expeditions of 1804–06. They were also well known by trappers, who called them “kits” because of their small size. One settler, R. M. Wright, writing of his pioneer days in Kansas, recalled their abundance: “There was the cunning prairie dog—millions of them; and next in number to them was the little swift . . . fox.”

Yet by 1900 this fox was considered rare throughout much of its former range. To a considerable extent, the fox was an incidental casualty in the settlers’ all-out war on the wolf. In the first half of the nineteenth century, wolves were common on the prairies. In his journal entry for July 17, 1806, Meriwether Lewis related that “immense and numerous herds of buffalo were seen feeding attended by their scarcely less numerous shepherds, the wolves.” But that, too, was to change. George A. Allman, another early settler in Kansas, is reported to have said that it was the general custom of early cattlemen to place poison at all the undevoured buffalo carcasses to destroy the wolves. Allman also observed that the swift fox was always the first to take the poison.

Notoriously easy to trap or poison, the swift fox has been described as trusting or unwary, but perhaps in centuries past, it simply had little to fear. Wolves may have paid little attention to the diminutive foxes orbiting carcass sites, and through competition and/or predation, the wolves may have kept the numbers of coyotes—a much more serious threat to the foxes—significantly below their current level.

There is no way to reconstruct population figures for wolves and foxes before the trapping and poisoning began (although Ernest Thompson Seton estimated that two million wolves once roamed North America). Similarly, no precise count exists of how many succumbed to these early predator-control programs. Historical accounts, however, can give us some idea. One group of hunters who spent the winter of 1860–61 near Walnut Creek, in Rush County, Kansas, poisoned “750 wolves, 250 coyotes, and had several bales of skins of the little yellow fox.” In 1898, J. R. Mead, another trapper, stated, “Hunters with strychnine finally exterminated the wolves, myself and men killed some 5,000 of them.” Between 1835 and 1838 the American Fur Company alone bought 10,614 swift fox skins, and from 1833 to 1877 the Hudson’s Bay Company bought 117,025. Swift fox fur has relatively little commercial value and at that time was usually dyed to imitate the fur of other species.

By 1890, when fewer than 1,000 bison survived, the ecology of the Great Plains had changed. Some of the prairie’s biggest inhabitants were largely gone, and much of the land was being transformed by the plow. With these changes came more problems for the swift fox. As the prairie was turned into farmland, the red fox moved in, and with the wolf gone, the adaptable coyote proliferated. Both these canids can overpower and kill the smaller swift fox, and in some regions, such as the parts of Colorado where I worked, the coyote keeps the swift fox populations down very effectively.

Ten adult foxes lived in our study area. Swift foxes form lifelong pair bonds, producing one litter of two to six pups a year. Kits are born in late April or early May and first venture outside the den four weeks later. At about seven weeks of age, the pups are weaned and begin hunting with their parents, although they sometimes also split up, spending days apart and sleeping at different dens. From late August through September the young set off on their own.

In our study area, however, very few young survived their first year; the majority were killed by coyotes. And of the monitored adult foxes that died during the course of our study, all but one were also done in by coyotes. Other studies have documented similar levels of coyote predation on swift foxes. Bobcats, golden eagles, and possibly, great horned owls are also doing their share to keep the swift fox gene pool on its toes.

The swift fox is the most fossorial of North American canids and spends most of every day resting in or around the den. This attachment to the den may serve as a defense against winter blizzards, summer storms, heat, prairie fires, and predators, although my study left me unsure of how much the foxes depend on the den for protection from predators. I found that adults would often leave the den site to “escape” across the prairie when I approached during the day. When followed, they do not necessarily head for neighboring dens but stay just ahead of the pursuer, either making no attempt to hide or slinking low to the ground, ears back, through tall vegetation. And during the day I have found individuals curled up under a yucca or in open grassy areas not near any den.

The foxes generally dig the dens them-
selves, often taking over the burrow of a smaller animal and enlarging it to suit their needs. The dens, and the foxes for that matter, are jumping with fleas. Putting my arm down a den, with my cheek on the ground, often resulted in a cloud of jumping fleas enveloping my head. Handling a fox just about guaranteed fleas up each sleeve. The swift fox’s frequent moves from one den to another may be partly a response to an unbearable flea situation. The fleas, which can live for more than a year in a vacated den, wait.

Dens can be found almost anywhere in an individual’s home range. Some sites may be more desirable than others, but apart from the obvious futility of digging a den in an arroyo that will be flooded when the rains come, the dens are in all kinds of places. The common denominator is that the soil type is loosely textured loam, sand, or silt—supposedly easy to dig in, although after hours spent excavating dens with a pick and shovel on a hot day, I would argue the point. These soils are commonly found on ridges, so that most dens are usually on high ground and well drained. Some ridges are evidently very attractive den sites and look as if they had been subjected to a bombardment. Such ridgetops often support a whole range of animals, including skunks, burrowing owls, and rodents, all taking advantage of the abandoned dens or the loose soil and cavities of partly collapsed dens.

Since the foxes spend most of the daylight hours close to the den, anyone interested in the movements of these animals must become somewhat nocturnal, as my dedicated assistants and I discovered. Home ranges can vary greatly depending on prey abundance, habitat, and competition. A study done in Nebraska by Terrence Hines calculated the average swift fox home range to be about nine and a half square miles, although this varied from a four-square-mile low for females, to a seventeen-square-mile high for males. Our results showed less variation than those in Nebraska and a slightly bigger average home range size. The home ranges overlap considerably, in some cases almost completely. This overlap may allow neighboring foxes to take advantage of a concentrated food source such as a prairie dog town, kangaroo rat burrow, or the carcass of a large ungulate.

As was reflected by the unfortunate propensity of swift foxes to gather around poisoned carcasses in the 1800s and early 1900s, carrion is readily eaten by these canids. But carrion loses its appeal when coyotes are around. We borrowed a technique from L. David Mech and his fellow researcher Eric Gese, who use wolf scat and urine as a ruse, to make coyotes think wolves are present at a site. We found we could keep coyotes away from a cow carcass (supplied by us) as long as we put wolf urine on it each day. When one of our monitored foxes did visit the carcass, however, its visit was in vain, for it was unable to chew through the tough cowhide. The fox apparently needed a larger predator or scavenger to open the cupboard, so to speak. Again, the extirpation of the wolf seems to have put the little foxes at a disadvantage.

Nevertheless, the foxes are perfectly

At about two months and two pounds each, these pups, left, are vulnerable to predation and never stray far from the den before dark. Below: With nowhere to go but lots of energy, pups fight each other, and boredom, throughout the day.
Diets of neighboring swift fox families can differ, perhaps partly because individuals learn to specialize on certain types of prey. The first-year pup below has caught a horned toad, a common lizard of southeastern Colorado. Right: These pups belong to a litter of three that survived an attack by an eagle at the den. Two of the pups were later lost to coyotes, however, and the adult male was also killed, presumably by an eagle. A third pup’s fate was unknown at the close of the study.

capable predators in their own right. Even at their flyweight of five pounds, they capture and kill jack rabbits, which may be twice as heavy. James P. Fitzgerald, and his graduate students at Northern Colorado University, found that jack rabbits were a primary prey item of swift foxes living on the Pawnee National Grasslands of northern Colorado. No easy catch, however, jack rabbits have been known to initiate hostilities when approached by foxes and to force a fox to retreat by repeated kicking. We had no evidence of foxes directly killing hares in our southeastern Colorado study, although they unquestionably chased them. Our swift foxes certainly ate jack rabbit carcasses, probably the remains of coyote kills, but in our area, the desert cottontail—which at half the size of a swift fox is a much more manageable proposition—appeared in the diet more often throughout the year, although less so in the spring.

During spring and summer, the foxes commonly prey on ground-roosting and -nesting birds, such as horned larks, meadowlarks, and lark buntings. Horned larks are also taken in the winter. Other items that crop up in the scatological sorting tray are small mammals (kangaroo rats, mice of various species, wood rats, pocket gophers, and ground squirrels), grasshoppers, beetles, crickets, scorpions, large centipedes, various insect pupae and larvae, snakes, lizards, amphibians (to a much lesser extent), and some vegetable matter.

For a time, the swift fox seemed to be waging a losing battle for survival. Kansas, Oklahoma, Nebraska, and the Dakotas each had fifty-year periods without a swift fox sighting. But the tide may be turning. The species is now completely protected in North and South Dakota, Nebraska, Oklahoma, and Montana. Texas, Colorado, and Kansas have restricted trapping seasons. In the Canadian provinces of Alberta, Saskatchewan, and Manitoba, a captive breeding and reintro-duction program— involving trapping and transportation of individuals from Colorado, Wyoming, and South Dakota—is under way.

As a result of these measures, swift fox numbers are recovering over most of the species’ former range, although closer regulation of hunting and trapping is needed in some areas. With no wolves left to keep coyote numbers down, and with the prairie itself less extensive than it used to be, the foxes may never reach anything resembling their former abundance, but after decades of decline, they may well be facing a brighter future.
The Plant Hunter's Bounty

by Mary Durant

The great voyages of discovery that began in the late 1400s and the subsequent colonization of many far-flung territories brought a dazzling array of new plants to Europe and Britain: trees, shrubs, vines, fruits, vegetables, and flowers, flowers, flowers. By the 1700s, when the natural sciences were coming into full bloom, botany was a major field of study and the search for exotics in distant lands an open invitation to adventure. Sir Joseph Banks was a sterling example of the outstanding new breed of naturalists. He explored Labrador and Newfoundland for plants and insects in 1766, when he was 23, and upon his return, when asked if he were planning a grand tour through Europe, Banks's reply typified the spirit of the age: "Any blockhead can go to Italy."

Banks, with a staff of naturalists and artists, was going around the world with Captain Cook, who'd been commissioned to observe the transit of Venus over the South Pacific. (In Australia the voyage was immortalized in the naming of Botany Bay, so named by Cook because of the many new plants found there.) Banks served for more than fifty years as honorary director of the Royal Botanic Gardens at Kew, where he encouraged experimentation and hired and trained young naturalists for botanical forays to China and South Africa. And it was Banks who convinced George III that breadfruit from Tahiti should be transplanted as food for the slaves in the West Indies, thus launching Capt. William Bligh onto the pages of history aboard HMS Bounty.

Meanwhile, more and more new plants were reaching Britain from all corners of the earth, and descriptions and horticultural information were badly needed by landscape architects, nurserymen, and knowledgeable gardeners. When William Curtis published the first issue of his Botanical Magazine on February 1, 1787, it was an immediate success. It not only served as a guide to the care and cultivation of myriad new species, but its illustrations were a delight to the eye. When analytic details were later added to the illustrations, the magazine was brought into the fold of science as well.

Now under the aegis of Kew Gardens, and called Kew Magazine, the publication has set a record as the first continuously published, color-illustrated magazine in the world to achieve a bicentennial. The magazine also enjoys another astounding record. Until 1948, when the editors at


last turned to color-offset reproduction, each engraving and lithograph had been hand-colored by copyists working from master paintings.

A celebratory exhibition of selections from 10,000 of the magazine's original watercolors, now in the archives at Kew, will tour the United States this year, and our thanks go to Ruth Stiff of Vermont, who initiated the show. Mrs. Stiff, the author of Flowers from the Royal Gardens at Kew (the catalog for the exhibit), first came upon Botanical Magazine at the Dartmouth College library, when she was working toward a graduate degree in the history of art. She was struck by both the beauty of the plates and the "symbiotic collaboration between science and art" that she describes as one of the magical aspects of the magazine. The original paintings have rarely been seen by the general public, and it was on a visit to Kew that Mrs. Stiff suggested the idea of the current exhibition, some highlights of which are a historic display of techniques of painting and printing and a résumé of plant explorations extending from 1768 to the present day.

An essay on William Curtis has been contributed to the catalog by Christopher Grey-Wilson, present editor of Kew Magazine, who gives us a lively biography on

Amaryllis (Hippeastrum x johnsonii)
One island stacks up as the place for the happiest and most playful vacations. By day, play on miles of uninterrupted beaches or explore the many ways of enjoying the sea. On land, there is everything from prehistoric caves to shopping, tennis and other sports. At night, experience your favorite international cuisine or tasty local dishes and live shows. Then play some more at one or all of our six casinos. Or disco till the sun peeks in. We've got a Dutch heritage, but we speak fluent English. Know us yet? Look up. We spell fun in the Caribbean.

Aruba. One happy island. Come.
Bird of paradise (Strelitzia reginae)

Exhibition Sites

Dartmouth College
Hanover, New Hampshire
July 16–September 11, 1988

The Hunt Institute
for Botanical Documentation
Carnegie-Mellon University
Pittsburgh
October 11–December 16, 1988

The National Museum
of Natural History
Smithsonian Institution
Washington, D.C.
January 26–April 30, 1989

The New York Public Library
(with The New York Botanical Garden)
New York
June 3–September 2, 1989

Missouri Botanical Garden
Saint Louis
October 12–November 30, 1989

Chicago Botanic Garden
Chicago
March 9–April 22, 1990

the ups and downs of Curtis’s career from apothecary to publisher and also traces the fortunes of Botanical Magazine over the years. Grey-Wilson, by the way, is himself a plant hunter, and on an expedition to Nepal in 1981, he collected the ribbed-leaf arum, Arisaema costatum, which is pictured in the catalog.

An essay by R. G. C. Desmond, former chief librarian and archivist at Kew, gives us a chronicle of fashions in gardening, as mirrored in Botanical Magazine. The so-called American gardens, for example, were popularized in the mid-1700s with plantings of mountain laurel, azalea, Rhododendron maximum, and magnolia, to be followed over the centuries by floral treasures from the Cape of Good Hope, Australia, South America, China, and Southeast Asia. With the proliferation of greenhouses and palatial conservatories, came the orchid craze, the begonia craze, and the unfortunate Victorian craze for closely manicured carpet bedding (coleus and amaranthus, for example) set out for the summer in stiff geometric parterres. At the turn of the century, informality mercifully came into vogue with hardy perennials in massed borders of color and bloom, just like those in the cottage gardens grown by everyday folk.

The catalog carries forty-eight full-page color plates, a sampling from the exhibition, and they are a joy: the elegant simplicity of a single species per page, the drama of the close-up view, the seemingly chance turn of leaves and petals to demonstrate patterns, colors, or veining on the underside. Flowers, along with buds, are shown as an aid to identification, and minute brushstrokes indicate the downy stems or leaves. In Mrs. Stiff’s biographical sketches of the artists are a number of key names from the past: Sydenham Edwards, James Sowerby, W. H. Fitch, and William Jackson Hooker, who was also an editor of the magazine and the first official director of Kew Gardens. Francis Bauer, one of the great botanical artists, is mysteriously missing from this section, but you’ll find a brief biography in the notes on his watercolor of Pterostylis banksii, a greenhood orchid from New Zealand collected by Banks in 1768.

Among twentieth-century painters, one key name is the late Lilian Snelling, whose pen-and-ink analyses are not merely adjuncts but essential parts of the composition as a whole. Her stunning watercolor of the red-and-black Tulipa kuschkensis (1931) is on the cover, and from the text we learn that the name comes from Kuschk, a military town on the Russia-Afghanistan border, which brings me to Mrs. Stiff’s notes on the plates.

Here I am disappointed. The prospectus of the catalog promised “plant name origin” for each of the forty-eight species pictured. Kuschkensis was one of the cho-
I've been told that Mrs. Stiff's manuscript was vetted at Kew. If so, why didn't someone pick up on these omissions and inconsistencies. Mrs. Stiff, after all, is an art historian. Otherwise, her notes on the plates are informative, entertaining reading. There are wonderfully selected notes on the plant hunters, Sir Joseph Hooker, in the mid-1800s, collecting rhododendron at 10,000 feet in the Himalayas, describes the loathsome onslaught of leeches. Ernest "Chinese" Wilson tells of collecting several thousand creamy white-and-yellow regal lilies on a narrow mountain pass in China in 1910 where a disastrous rock slide broke his leg in two places, causing him to walk forever after with a "lily limp." But he said it was worth it.

And there are the Paphiopedilum, or Venus-slipper orchids of southwestern Asia, reportedly on the brink of extinction because of overcollection. The orchid craze is still going strong, and I am reminded of a quote from William Curtis lamenting the growing scarcity of the bee orchid around London, two hundred years ago. The "curiosity of Florists... prompts them to exceed the bounds of moderation, rooting up all they find, without leaving a single specimen to cheer the heart of the student in his botanical excursions."

Mary Durant, a former editor at American Heritage magazine, is the author of Who Named the Rose: A Roving Dictionary of American Wildflowers (Dodd, Mead).

Ribbed-leaf arum (Arisaema costatum)
Mars Is the ‘In’ Object

by Thomas D. Nicholson

This is Mars month the world over. In late September, the reddish planet comes closest to the earth since August 1971. Becoming the brightest starlike object in the night sky, it rises just after dark, is high in the south at midnight, and sets about dawn. Venus, Jupiter, and Mars make for a spectacular early morning sky, three brilliant planets spread across the sky before daybreak: Venus, the brightest, in the east; Mars near the western horizon; and Jupiter, ordinarily the second brightest planet but now briefly outshone by Mars, high in the south between them.

Among the inner planets of the solar system (Mercury, Venus, Earth, and Mars), Mars is about half again as far from the sun as we are—48.8 million miles farther away on average. In contrast, Venus has an orbit about 25.7 million miles closer to the sun than ours. But even though Venus is much larger and comes nearer to the earth than Mars, close approaches between Mars and the earth are spectacular, while those of Venus go unnoticed, the planet being lost in the sun’s glare.

The reason for this seeming anomaly is that Mars and Venus come closest to us at diametrically opposite places in their respective orbital cycles. Venus comes closest to the earth (as we saw last June) when it is between us and the sun (at inferior conjunction). It is then in the sky only during daylight, when its sunlit surface is turned away from the earth. Mars’ closest approach comes when it is opposite the sun in the sky (at opposition), above the horizon all night, with its entire sunlit surface facing the earth, as will happen at the end of this month.

Close approaches of Mars take place, on the average, every two years and two months. The extra two months make Mars’ successive oppositions slide forward in the calendar and shift eastward around the orbits of both the earth and the planet, as well as in the sky. The distance between Mars’ orbit and ours varies from 35.5 million to 62.6 million miles, because both orbits are elliptical. At a close opposition, Mars is about four times brighter than when our respective orbits are farthest apart, and some fifty times brighter than at conjunction, when the planets are across the sun from each other. Because of the way the orbits are oriented in space, favorable (close) oppositions always occur in late summer or early fall.

These favorable oppositions take place at intervals of about fifteen to seventeen years. The opposition this month is the best one since 1971. The next favorable one, in 2003, will be even better, with Mars slightly closer to the earth than during its present opposition. The opposition this month is doubly favorable for Northern Hemisphere observers. Mars is farther north and better placed for viewing than at other favorable oppositions, such as the one of 1986.

Events in the calendar below occur in local time unless otherwise indicated.

September 1: The waning gibbous moon (just short of last quarter) moves into Taurus and rises just after 9:00 P.M., EST. The moon is very close to the Pleiades cluster, which it will partly occult after midnight. Jupiter follows at approximately 10:00 P.M., and the moon leads the planet up the eastern sky in the morning.

September 2: Venus, Jupiter, Mars, the moon, and Gemini’s twin stars, Castor and Pollux, stretch across the morning sky. Mars is in the west, while Jupiter, the last-quarter moon (which occurs at 10:50 P.M., EST), and dazzling Venus (the lowest of the three) dominate the predawn eastern sky. Castor and Pollux are above and to the left of Venus. Note how Venus’ position relative to the twin stars changes during September.

September 4-8: The moon, now down to a waning crescent in the morning sky, slides between Jupiter and Venus, passing Venus on the night of the 6th. The thin crescent will still be visible left of Venus.
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on the 7th, but probably not on the 8th.
September 10: Apogee (farthest from the earth) at 10:00 A.M., EST, and new moon at 6:59 P.M., EST, occur today.
September 13: The new crescent moon should make its appearance low in the southwestern sky at dusk, near Virgo's bright star Spica.
September 15: Mercury is not visible at its greatest easterly elongation (left of the sun). It will be too low at sunset and lost in the solar glare.
September 17: The crescent moon's occultation of Antares at about 4:00 P.M. is above the horizon over South America. We can, however, see the moon occult the star Tau, in Scorpius to the left of Antares, during dusk.
September 18: First-quarter moon, at 10:18 P.M., EST, is low in the south at sunset, to the right of the "teapot" in Sagittarius. Saturn is the bright object directly above the moon; brilliant, ruddy Mars is above the horizon in the east.
September 19: The moon, left of Saturn, is in the center of the teapot, which is upright in the southern sky at dusk.
September 20-22: The growing gibbous moon moves into Capricornus, getting closer to Mars.
September 21-22: Mars is nearest the earth, 36.5 million miles away, and at its brightest.
September 22: The sun arrives at the autumnal equinox in Virgo, about midway between the constellation's bright star Spica and Leo's Regulus. When the sun crosses this point on the equator at 2:29 P.M., EST, summer ends and autumn begins in the Northern Hemisphere.
September 24: Jupiter begins its slow drift westward toward its November opposition from the sun and its entry into the evening sky. Measure its motion by its increasing distance to the right of Taurus' Aldebaran.
September 25: Full moon, the harvest moon, occurs at 2:07 P.M., EST.
September 25-26: The moon drifts slowly left above Mars, passing closest at about 11:00 P.M., EST.
September 27: Mars is at opposition from the sun at 11:00 P.M., EST.
September 28: Mercury is stationary and begins its westerly shift toward the sun, ending a poor evening display.
September 29-30: The moon rises about 8:00 P.M. on the 29th in Taurus. It is near Jupiter and Aldebaran (Jupiter is the brighter of the two). On the 30th, it rises about 8:45 P.M., below and left of Jupiter.

Editor's Note: The Sky Map in the July issue shows the stars and constellations for this month and gives the times for its use.
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Much Ado about Flashing Points of Light

Astronomers get turned on by anything in the universe they think is new

by Stephen P. Maran

Scientists recently thought a new kind of celestial object had been discovered with nothing more than the naked eye, binocular sightings, and simple color photography. The purported object, known as the Perseus Flasher, was first believed to be a point meteor, a previously known phenomenon. Then it was deemed a strange and possibly unknown kind of star. Its actual identity, however, turned out to be something much closer to home.

An ordinary meteor appears as a moving streak of light in the sky, hence the term shooting star. Meteors, of course, are not stars of any kind and the streaks of light with which they are associated result when tiny specks of interplanetary dust, or meteoroids, sweep into our atmosphere from space, heating the adjacent gas molecules until they glow. Around August 11 or 12, when the annual Perseid meteor shower appears, even the casual viewer can see many such meteors. Few people, however, are familiar with the so-called point meteors. These cause no streaks but appear as stationary bright points of light in the sky that last only one or two seconds.

Point meteors came into prominence in 1985 when Bill Katz, a Canadian amateur astronomer and expert meteor observer, noted flashes of light, which he then identified as a few point meteors. They appeared on different nights in the same direction in the sky, above the Pleiades star cluster and apparently in Aries, the Ram. When Katz and his colleagues saw several more of these flashes during that summer in Schomberg, Ontario, they soon realized that classifying them as point meteors made no sense. The observers assumed that point meteors exhibit no streak because they are coming straight at you. But the repeated sighting of point meteors from about the same place in the sky also indicated not one point meteor but a new meteor shower, with its origin in the constellation Aries. In a meteor shower, however, for every meteor coming right at you from a given location, there have to be many hundreds of others moving on divergent paths, which would be seen as streaks in the sky. But no such streaks were observed to accompany the flashes.

Katz’s reasoning wasn’t exactly correct because some point meteors do not head for the observer. A meteor too faint to be seen with the naked eye, for example, may streak unseen across the sky and then explode, for reasons not fully understood, reaching detectable brightness for just a moment. In that case, you would see it as a bright point at one location, although it is actually traveling along a line in the sky. Such events, however, are rare and do not explain why the points Katz reported were seen repeatedly at the same place in Aries.

The Canadians therefore suspected that they were witnessing a new kind of celestial phenomenon, one in which flashes of light visible to the naked eye were reaching the earth from an object, presumably a star, in the direction of Aries. Of twenty-five flashes that they witnessed, twenty-one seemed to come from the same general direction. Katz thought the flashes might represent a hitherto unobserved property of an old nova—a binary star that exploded long ago. Another suggestion was that the flashes might come from a gamma-ray burster, a mysterious, but known, object that manifests itself by producing enormous amounts of energy in brief and infrequent explosions that release powerful gamma rays. There is limited evidence that a few identified gamma-ray bursters may also have produced enough light to be photographed with telescopes during past outbursts, although very little is known on this subject.

Before long, Katz succeeded in photographing one of the flashes on color film. The photograph, made on March 18, 1985, showed that the flasher, whatever it might be, was actually over the border of Aries, in the adjacent Perseus constellation. The source of the light was accordingly dubbed the Perseus Flasher. Now that there was photographic evidence of the flashes, professional astronomers became interested. Katz’s single color slide showing the flasher was taken to the David Dunlap Observatory at the University of Toronto, where it was analyzed by a laboratory instrument that scans photographic transparencies with a narrow beam of light to determine the precise characteristics of the images. This analysis suggested that the supposed flash was a real phenomenon and not a flaw of some kind in the film.

The Canadians did not succeed in obtaining additional photographs of the Perseus Flasher, but the March 18 photograph was hard evidence and interest was mounting. Sky and Telescope magazine, read by thousands of amateur and professional astronomers, asked their readers to look for the phenomenon and later announced that by April 1985, “reports were arriving daily.” The reports, however, did not confirm that the flashes were coming from a single star or other object at a fixed location in Perseus. Instead, they covered a region about 6° wide, that is, about the size of the bowl in the Big Dipper. Fans of the Perseus Flasher were not too concerned about this seeming inconsistency, for making a split-second judgment about the location of a momentary gleam can be very difficult. Other investigators, however, were skeptical.

One of the skeptics was Paul D. Maley, an engineer with the Rockwell Shuttle Operations Company in Houston, Texas,
who has extensive experience observing artificial satellites of the earth. While most astronomers were focusing on the presumption that the flashes came from the same place among the constellations, Maley homed in on the location of the origin of the flash photographed on March 18 relative to the horizon. He was less interested in its seeming origin in Perseus than in the circumstance that when the flash occurred (as viewed from the Canadian location where the crucial photograph was made), its apparent direction was toward (and above) the sun, which had set only about two hours earlier. This circumstance suggested to Maley that the flash might be a glint of light from the sun bouncing off a satellite high above the earth and thus outside the shadow cast by the earth in space as it blocks out the light from the sun. He knew that under certain conditions solar light can bounce off a reflecting surface on an orbiting satellite at just the right angle so that the reflection appears much brighter than usual. In this way, a satellite that is ordinarily too faint to be seen from the earth, even though it is in sunlight, can cast a bright, momentary reflection if it presents just the right surface to the sun.

Maley was not the only one who suspected that the reported flashes, or at least some of them, might be sun glint from one or more satellites. He went on to investigate that possibility by calculating whether specific satellites might have been correctly positioned to cause the flashes from Perseus that the Katz group had seen. He screened the orbital information on thousands of objects tracked by the North American Air Defense Command, narrowing his search to those 1,440 satellites and chunks of space debris that were four or more inches in size and that would have been sunlit and above the horizon.

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**Sky Reporter**
zon at the place and time Katz took his photograph. He studied the orbits of those 1,440 objects and found that only three were likely candidates that could have passed through the right part of Perseus at the right time. Of those three, the Soviet satellite *Cosmos 1400*, which was much larger than the other two, had passed closest to the position of the Perseus Flasher on the night in question. It had also passed through the field of view of Katz's camera at a time closer to the estimated time of the flash (which had a margin of error of a few minutes) than the other two orbiting satellites.

According to Nicholas L. Johnson, an authority on the Soviet space program at Teledyne Brown Engineering in Colorado Springs, *Cosmos 1400* is a large electronic intelligence satellite. Launched in the early 1980s, it was probably designed to intercept radar and radio transmissions and by 1985 may have exhausted its operating life and been left aimlessly tumbling through space. Maley found "irregular pulsing" of light from *Cosmos 1400*, which sometimes became as bright as the North Star while he was monitoring it. But the other two candidates, which Maley also observed with a small telescope in Clear Lake City, Texas, in December 1986, always appeared as dim objects with no hint of bright flashes.

In the meantime, great efforts to identify the flashes were launched by astronomers fascinated by the Katz report and especially by the photograph of a flash from a specific location in Perseus. Accordingly, a team of American, Dutch, and Canadian scientists, led by an MIT space astronomer, Walter Lewin, scanned the Perseus location for more than five hours with the European Space Agency's X-ray observatory satellite, *EXOSAT*. They found no evidence of X-rays, whether flashing or steady, from the Perseus Flasher. Radio astronomers listened for signals from Perseus with three of the most powerful radiotelescopes in the world, the Very Large Array in New Mexico, the 1,000-foot bowl antenna at Arecibo, Puerto Rico, and the 150-foot radio dish at Canada's Algonquin Radio Observatory in Lake Traverse, Ontario. They heard nothing.

A physicist also looked for light flashes with a 30-foot-diameter reflector at the Whipple Observatory on Mount Hopkins in Arizona; and in California, members of the Santa Barbara Astronomy Group monitored the presumed flasher with telephoto lenses from two locations spaced slightly more than one mile apart. They carefully inspected the photographic negatives taken during 115 hours of observa-

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**Astronomer Stephen P. Maran has been contributing “Sky Reporter” columns to Natural History since 1974.**
From the Land of the Totem Poles

The Northwest Coast Indian Art Collection at the American Museum of Natural History

by Aldona Jonaitis

Less than a century ago, the Indian tribes living along the Northwest Coast of North America were under great pressure to forsake their cultural heritage. At stake were their religious practices, their mythology and customs, and their ancient way of life.

Franz Boas, a young curator at the American Museum of Natural History, later to become known as the "Father of American Anthropology," determined that this culture must survive, if not in daily practice, then within the protective walls of a great museum. In 1897, he launched what is still the biggest, most ambitious, and most important expedition in the history of American anthropology and gave impetus to the creation of the greatest collection of Northwest Coast art in the world.

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American Museum of Natural History, Central Park West at 79th Street, New York, NY 10024
Still Life with Flowers

by David A. Grimaldi

For the past two years, my search for some of the world's oldest amber has taken me, not to exotic locales, but rather to two clay pits in New Jersey, across the Hudson River from the American Museum. As an entomologist, I am mainly interested in the insects embalmed within the red and gold pieces of fossilized tree resin. Insects that blundered into, and became immersed in, the sticky resin millions of years ago often fossilized along with the amber, and some of these victims are preserved today in exquisite detail. Last year my quest for amber in New Jersey led me to a startling discovery even closer to home.

Amber is deposited worldwide, but some areas, such as the Baltic countries, Lebanon, and the Dominican Republic, are particularly rich in this fossil resin. The youngest insect-bearing fossilized resin, known as copal, is a mere few thousand years old, while the most ancient amber, from Lebanon, dates from the early Cretaceous, some 120 million years ago. New Jersey amber, and similar deposits found in Staten Island, Long Island, Cape Cod, and Maryland, is of late Cretaceous origin and ranges from 65 to 95 million years in age. A description written in 1967 by Harvard entomologists of the most primitive and oldest-known ant, found in New Jersey amber, first stimulated my curiosity about that state's possible amber wealth. Despite the discovery of the ant, I found that little was known...
about the amber's locations, abundance, age, composition, and contents.

An amber hunter in New Jersey begins by scouting out abandoned clay-mining pits with a thin, but dense, dark gray layer that bears lignite (wood in the process of fossilization). The rest of the work is done on hands and knees at a patch of rain-washed exposed clay. Even before they are cleaned, the unearthed bits sparkle ruby red and clear yellow, the characteristic colors of the two predominant kinds of amber in this area. Most pieces, however, are pinhead to pea sized, and a long day of foraging may yield just enough such specimens to cover the palm of a hand. Back at the lab, the specimens are washed, dried, coated with oil (to fill fractures and pits that obscure the view inside), and examined under a microscope. The presence of a tiny insect, a midge or a mite, for example, in one piece out of a hundred is a very nice find.

A small stockpile I collected with the help of two amateur paleontologists from New Jersey began to grow. For clues to where we might find more amber-productive sites, I consulted Joe Peters of the Museum's Department of Mineral Sciences. When he remarked that he had seen amber, some of it perhaps from New Jersey, stored in the Museum's basement, I was delighted and insisted that he guide me through the cavernous bowels of the building as soon as possible so I could see it for myself.

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At the American Museum

Margaret Mead Film Festival
America's premier forum for anthropological documentaries, the Margaret Mead Film Festival, will be presented at the American Museum of Natural History from Monday, September 26, through Thursday, September 29. The festival celebrates its twelfth year with themes including ritual and celebration, cultural survival, and child, coming of age, women's voices, and ways of seeing. Screenings will show rare Soviet footage depicting the immediate aftermath of the Chernobyl disaster; ceremonies in Mexico and Mali; and music and dance from Burkina Faso, Greece, Pakistan, and Spain, as well as Alaska and Brooklyn; the "unnatural history" of a toad taking over
the chemical properties of amber, he analyzed the specimen, verified the authenticity of the 80-million-year-old bee, and determined that the yellow amber was once exuded as resin from a primitive conifer. The prize bee was then shipped to a world authority, Charles Michener of the University of Kansas. Designated a new species, the bee was named Trigona prisca (ancient Trigona). It displays features shared by one living Trigona species, apparently its closest relative, which is found today from Brazil to Panama. Because the bee is twice as old as the previous record holder, and was already highly specialized, the discovery pushes the origin of bees back to at least the earliest Cretaceous, about 135 million years ago. This dating has major implications for theories of just when flowering plants first appeared on the earth. Because all bees, ancient and modern, make a living by gathering nectar and pollen, flowering plants must also have debuted by the early Cretaceous, much sooner than traditionally thought.

My search for New Jersey amber turned out more dramatically than I could have imagined. I was certainly unprepared for the magnitude of the find and surprised by its immediate source. Who knows what other treasures might still lie hidden just beyond the river and under our very noses?

David A. Grimaldi is an assistant curator in the American Museum's Department of Entomology.
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thirty cultures. Film makers from fifteen nations will be present to introduce and discuss their work. Screenings in four Museum theaters start at 6:30 P.M. and continue until 10:00 P.M. Admission is $5 per evening ($4 for members). Tickets, which will be sold at Museum entrances beginning at 5:00 P.M. each day, are for general admission; seating for particular films is on a first-come, first-served basis. For a free program call (212) 769-5305 on weekdays.

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Natural History

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Quick Kick

For fifteen years Cynthia Moss, of the African Wildlife Foundation, studied the elephants in Amboseli National Park in southern Kenya. During this time, she found elephant cows to be devoted mothers who more than tolerated the often unrelenting demands of their calves. For the first few months of its life, a calf seldom strays more than a few feet from its mother, often sucking on its trunk, like a human baby sucks on its thumb, and always eager to nuzzle. Moss found that little mouths were seldom turned away, whether they wanted the nipple for nursing or for comfort. And if a calf was rebuffed, a brief but bellicose tantrum of rumbling, ear flapping, and trunk tugging would be enough to get its mother to give in. For its first three months of life, a calf relies totally on its mother's milk. Although it can then begin foraging on its own, a calf may nurse until the next calf comes along—anywhere from three to six years later. Older siblings, especially the females, usually watch over the young when they leave their mothers' sides. But Moss says she has seen an older calf reluctant to give up its suckling rights. Although the mother will sometimes suckle both, this young calf's big sister appeared so annoyed by the lack of attention she was receiving, that when her mother's back was turned she gave her sibling a good swift kick to the tail. —B.D.S.

Photograph by Erwin and Peggy Bauer
**Authors**

Laurence Flanagan (page 48), who recently retired after thirty years as keeper of antiquities in the Ulster Museum, Belfast, became involved with the Spanish Armada in 1968, when nautical archeologist Robert Sténuit started excavating the wreck of the Girona off the coast of Northern Ireland. Flanagan offered the museum’s facilities so that artifacts could be properly conserved. He provided similar assistance when another wreck, *la Trinidad Valencera*, was later excavated under the direction of Colin Martin. Through Flanagan’s efforts, these finds, as well as the few artifacts surviving from a third wreck—which make up 95 percent of the authenticated Armada remains in the world—are now held by the Ulster Museum. With Colin Martin, he originated a 400th anniversary exhibition on view at the National Maritime Museum at Greenwich, England, until September 4 and scheduled to open in Belfast in October. Armada 1588–1988, with an introduction by M. J. Rodriguez-Salgado (London: Penguin, 1988), is the exhibition catalog. For additional reading, see Ireland’s Armada Legacy, by Laurence Flanagan (Gloucester: Allan Sutton; and Dublin: Gill & Macmillan, 1988); *The Spanish Armada*, by Colin Martin and Geoffrey Parker (London: Hamish Hamilton, 1988); and *Armada*, by Duff Hart-Davis (London: Bantam, 1988).

After doing research on public baths in Fez for more than a year, Maria Messina (page 40) began receiving invitations to henna parties from some of her female acquaintances. She soon learned that the application of henna as a cosmetic on the hands and feet provided an important spiritual occasion in the lives of many Moroccan women. Messina, shown above with a guide, is currently a doctoral candidate in anthropology at the State University of New York at Stony Brook. She is writing her dissertation on women, sexuality, and body symbolism in Morocco. For additional reading she recommends Patience and Power: The Lives of Moroccan Village Women, by Susan S. Davis (Cambridge: Schenkman Publishing Co., Inc., 1982), and Tuhami: Portrait of a Moroccan, by Vincent Crapanzano (Chicago: University of Chicago Press, 1980). The latter is a colorful ethnographic life history of a Moroccan man who believes himself to be married to a female jinni.
What do a wildlife refuge, a Navy bombing range, an Army supply depot, an industrial park, a potato farm, and a cattle ranch have in common? Each of these diverse settings is home for burrowing owls in Oregon’s Columbia Basin. Greg Green (page 58) grew up in this dry, steppelike region and has always been interested in its wildlife. He chose to study the owls because they would complement an ongoing long-billed curlew project in the understanding of the Columbia Basin ecosystem. Green has worked for the U.S. Forest Service, the Fish and Wildlife Service, and for the past three years as a consultant wildlife biologist at Envirospire Co., Bellevue, Washington. His present research includes aerial and shipboard surveys of sea otters and endangered whales in the Gulf of Alaska and the Bering Sea. When he’s home he enjoys riding his horses through the backcountry. Green cites Frederick G. Lindzey’s chapter in *Wild Mammals of North America*, edited by Joseph A. Chapman and George A. Feldhamer (Baltimore: Johns Hopkins University Press, 1982), as the best and most complete reference on badger natural history. A classic and still timely essay on the burrowing owl appears in Arthur C. Bent’s *Life Histories of North American Birds of Prey*, Part 2, first published in 1938 (New York: Dover Publications, Inc., 1961).
Although Thomas R. Laurion (page 66) served as a curatorial assistant in the University of Wisconsin-Madison’s Zoological Museum for six and a half years and was recently a research assistant in the University’s Department of Wildlife Ecology, he confesses it is hard for him to work indoors. “No matter what I’m doing,” he says, “I want to do it outside.” Nevertheless, at the urging of his project leader, Orrin Rongstad, Laurion is currently analyzing the data collected over three years of swift fox research. He would like to continue his fieldwork, which to date has been largely funded by the U. S. Fish and Wildlife Service and the U. S. Army, as well as an anatomical study of the fox, focusing on osteology. Also on his research wish list is work on the grasslands of East Africa, where he hopes he will be able to observe many of the same sorts of predator–predator and predator–prey interactions that must have been common on North American prairies 200 years ago. To learn about how the swift fox is faring in Canada, readers can turn to Canadian Geographic (“The Return of the Swift Fox,” by W. Lynch, vol. 107, 1987), and for information on canids in general, Laurion suggests The Wild Canids: Their Systematics, Behavioral Ecology, and Evolution, edited by M. W. Fox (Melbourne: Robert E. Krieger Publishing Co., Inc., 1975).

When moose roam free in your backyard, you have to go far to find really big game, so once a year or so, Erwin and Peggy Bauer (page 92) leave their Wyoming home for a photo safari in Africa. After following the elephant family for several days through Kenya’s Amboseli National Park, the Bauers began focusing in on an unusual case of sibling rivalry. The “Natural Moment” was taken from about a hundred feet, using a Nikon F-3 with a 400-mm lens. Erwin Bauer has published separate collections of his wildlife photographs of deer, bear, and the North American West. Wild Alaska, his newest collection, will be published later this year by Grolier Inc.
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Letters and Announcements

Meddling with Language

I was interested to read Jared M. Diamond’s comments about New Guinea expeditions, but disturbed by some of his tangential comments about linguistics (“The Last First Contacts,” August 1988). Diamond seems to be drawing the conclusion that contact with the “outside world” hastened the demise of many of New Guinea’s indigenous languages. That may or may not be the case. Languages become extinct for numerous linguistic and cultural reasons. Contact with other language groups may cause a tribe to give up its language and adopt the language of the other group. But that isn’t always the case. Sometimes the language of the group may become the language of a group of newcomers to the area; sometimes both languages may coexist; sometimes the two groups develop a pidgin for mutual benefit, in which case both original languages, within that area at least, are in essence lost. But languages sometimes change without outside contact. While European and American contact may have indeed interfered, we needn’t take pride in having the power to alter the linguistic history of an area or areas by our meddling. Interference phenomena are a natural part of the life of any language and only one directional motivation in language evolution.

Lesa Dill

Western Kentucky University
Bowling Green, Kentucky

The author replies:

No one questions that languages may change without outside contact (as happened on Polynesian islands) or that some languages may continue to coexist despite long and extensive contact (as with the four languages of modern Switzerland). However, the recent wave of first contact and tribal mixing in New Guinea has greatly accelerated the rate of language loss. Most New Guineans now speak English, pidgin English, or Indonesian as their second or even first language. Those have become the languages of government, schools, radio, and business. Couples from different tribes can now safely marry; they often use one of those widespread languages for communication, and their children may learn no tribal language at all.

For instance, one of my Tadavwe friends who married a Gimi girl told me that he learned only enough Gimi to say essential things, like “cook my sweet potatoes,” and he had to use his mother to translate anything else until his wife learned pidgin.

Langdon Named Museum President

George D. Langdon, Jr., has been named ninth president of the American Museum of Natural History. Robert G. Goelet, who served as president since 1975, has become chairman of the Museum’s Board of Trustees.

Langdon becomes president of the American Museum as it approaches its 120th anniversary in 1989. As full-time chief executive, he holds a position similar to that of a university president.

For the past ten years, Langdon, who is 55, was president of Colgate University in Hamilton, New York. A historian, he had previously been deputy provost and lecturer in history at Yale, as well as special assistant to the president and associate professor of history at Vassar College.

Langdon is the author of Pilgrim Colony: A History of New Plymouth 1620–1691, which was published by Yale University Press in 1966. He has also written articles on economic development and politics.
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during the American colonial period.

After spending a few weeks learning about the Museum’s 650 paid employees; 500 volunteers; 22 interconnected buildings, housing 40 exhibition halls viewed by some 2.6 million visitors a year; and 36 million artifacts and specimens, Langdon commented about his new job:

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“The challenges ahead will call for concerted effort from the Museum’s staff and research associates and its wide network of friends, including trustees, volunteers, members, and supporters everywhere.

“Every day we are reminded of the tremendous influences of human activities on the biosphere of the earth. We need to understand that all life is interconnected and that the future of the natural world is our future.

“The American Museum cannot solve the environmental problems of the world. But it can help us and future generations find solutions by educating the public and by continuing its basic scientific research into the organisms of the natural world, their interactions and evolution.”

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In Black and White

How have ordinary people, so often throughout human history, brought themselves to commit genocide?

by Jared Diamond

While the anniversary of any nation’s founding is taken as cause for its inhabitants to celebrate, Australians have special cause in this, their bicentennial year. Few groups of colonists faced such obstacles as those who landed with the first fleet at the future site of Sydney in 1788. Australia was still terra incognita: the colonists had no idea of what to expect or how to survive. They were separated from their mother country by a sea voyage of 15,000 miles, lasting eight months. Two and a half years of starvation would pass until a supply fleet arrived from England. Many of the settlers were convicts who had already been traumatized by the most brutal aspects of brutal eighteenth-century life. Despite those beginnings, the settlers survived, prospered, filled a continent, built a democracy, and established a distinctive national character. It’s no wonder that Australians feel pride as they celebrate their nation’s founding.

Nevertheless, one set of protests has marred the celebrations. White settlers were not the first Australians. Australia had been settled at least 40,000 years before by the ancestors of the people now usually referred to as Australian aborigines and also known in Australia as blacks. In the course of English settlement, most of the original inhabitants were killed by settlers or died of other causes, leading some descendants of the survivors to stage protests this year. The bicentenary celebrations focused implicitly on how Australia became white. This column focuses instead on how Australia ceased to be black and how courageous English settlers came to commit genocide.

Lest white Australians take offense at this piece, I should make it clear at the outset that I am not accusing their forefathers of having done something uniquely horrendous. My reason for discussing the extermination of the aborigines is precisely because it isn’t unique: it’s a well-documented example of a common event in human history. Genocide is such a painful subject that either we’d rather not think about it at all or else we’d like to believe that nice people don’t commit genocide, only Nazis do. But our refusing to think about it has consequences: we’ve done little to halt the numerous episodes of genocide since World War II, and we’re not alert to where it may happen next. Hence I’ll indicate briefly how frequent it is, why people do it, and what I learned from a friend of mine who joined in a genocidal massacre thirty years ago. Let’s begin by recalling the founding of white settlement in the state of Tasmania.

Tasmania, an island slightly larger than West Virginia, lies 200 miles off Australia’s southeast coast. When it was discovered by Europeans in 1642, it supported about 5,000 hunter-gatherers related to the aborigines of the Australian mainland and with perhaps the simplest technology of any modern peoples. Tasmanians made only a few types of simple stone and wooden tools. Like the mainland aborigines, they lacked metal tools, agriculture, livestock, pottery, and bows and arrows. Unlike the mainlanders, they also lacked boomerangs, dogs, nets, knowledge of sewing, and ability to start a fire.

Since the Tasmanians’ sole boats were rafts capable of only short journeys, they had had no contact with any other humans since the rising sea level cut off Tasmania from Australia 10,000 years ago. Confined to their private universe for hundreds of generations, they had survived the longest isolation in modern human history—an isolation otherwise depicted only in science fiction. When the white colonists of Australia finally ended that isolation, no two peoples on earth were less equipped to understand each other than were Tasmanians and whites.

The tragic collision of these two peoples led to conflict almost as soon as British sealers and settlers arrived in about 1800. Whites kidnapped Tasmanian children as laborers, kidnapped women as consorts, mutilated or killed men, trespassed on hunting grounds, and tried to clear Tasmanians off their land. Thus, the conflict quickly focused on Lebensraum, which throughout human history has been among the commonest causes of genocide. As a result of the kidnappings, the native population of northeast Tasmania in November 1830 had been reduced to seventy-two adult men, three adult women, and no children. One shepherd shot nineteen Tasmanians with a swivel gun loaded with nails. Four other shepherds ambushed a group of natives, killed thirty, and threw their bodies over a cliff remembered today as Victory Hill.

Naturally, Tasmanians retaliated, and whites counterattacked in turn. To end the escalation, Governor Arthur in April 1828 ordered all Tasmanians to leave the part of the island already settled by Europeans. To enforce this order, government-sponsored groups called roving parties, and consisting of convicts led by police, hunted down and killed Tasmanians. With the declaration of martial law in November 1828, soldiers were authorized to kill on sight any Tasmanian in the settled areas. Next, a bounty was declared on the natives: five British pounds for each adult, two pounds for each child, caught alive. “Black catching,” as it was called because of the Tasmanians’ dark skins, became big business pursued by private as well as official roving parties. At the same time a commission headed by William Broughton, the Anglican archdeacon of Australia, was set up to recommend an
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overall policy toward the natives. After considering proposals to capture them for sale as slaves, poison or trap them, or hunt them with dogs, the commission settled on continued bounties and the use of mounted police.

In 1830 a remarkable missionary, George Augustus Robinson, was hired to round up the remaining Tasmanians and take them to Flinders Island, thirty miles away. Robinson was convinced that he was acting for the good of the Tasmanians. He was paid $300 in advance, 700 pounds on completing the job. Undergoing real dangers and hardship, and aided by a courageous native woman named Truganini, he succeeded in bringing in the remaining natives—initially by persuading them that a worse fate awaited them if they did not surrender, but later at gunpoint. Many of Robinson’s captives died en route, but about 200 reached Flinders, the last survivors of the former population of 5,000.

On Flinders Island Robinson was determined to civilize and christianize the survivors. His settlement—at a windy site with little fresh water—was run like a jail. Children were separated from parents to facilitate the work of civilizing them. The regimented daily schedule included Bible reading, hymn singing, and inspection of beds and dishes for cleanliness and neatness. However, the jail diet caused malnutrition, which combined with illness to make the natives die. Few infants survived more than a few weeks. The government reduced expenditures in the hope that the natives would die out. By 1869 only Truganini, one other woman, and one man remained alive.

These last three Tasmanians attracted the interest of scientists, who believed them to be a missing link between humans and apes. Hence when the last man, one

William Lanner, died in 1869, competing teams of physicians, led by Dr. George Stokell from the Royal Society of Tasmania and Dr. W. L. Crowther from the Royal College of Surgeons, alternately dug up and reburied Lanner’s body, cutting off parts of it and stealing them back and forth from each other. Crowther cut off the head, Stokell the hands and feet, and someone else the ears and nose, as souvenirs. Stokell made a tobacco pouch out of Lanner’s skin.

Before Truganini, the last woman, died in 1876, she was terrified of similar post-mortem mutilation and asked in vain to be buried at sea. As she had feared, the Royal Society dug up her skeleton and put it on public display in the Tasmanian Museum, where it remained until 1947. In that year the museum finally yielded to complaints of poor taste and transferred Truganini’s skeleton to a room where only scientists could view it. That, too, stimulated complaints of poor taste. Finally, in 1976—the centenary year of Truganini’s death—her skeleton was cremated over the museum’s objections, and her ashes were scattered at sea as she had requested.

While the Tasmanians were few in number, their extermination was disproportionately influential in Australian history because Tasmania was the first Australian colony to solve its native problem and achieve the most nearly final solution. It had done so by apparently succeeding in getting rid of all its natives. (Actually, some children of Tasmanian women by white settlers survived, and their descendants today constitute an embarrassment to the Tasmanian government, which has not figured out what to do about them.) Many whites on the Australian mainland envied the thoroughness of the Tasmanian solution and wanted to imitate it, but they also learned a lesson from it. The extermination of the Tasmanians, carried out in settled areas in full view of the urban press, had attracted some negative comment. Hence the extermination of the much more numerous mainland aborigines was effected at or beyond the frontier, far from urban centers.

The colonial governments’ instrument of this policy, modeled on the Tasmanian government’s roving parties, was a branch of mounted police termed Native Police, who used search-and-destroy tactics to kill or drive out aborigines. A typical strategy was to surround a camp at night and to shoot the inhabitants in an attack at dawn. White settlers also made widespread use of poisoned food to kill aborigines. Another common practice was roundup in which captured aborigines were kept chained together at the neck while being...
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marched to jail and held there. The British novelist Anthony Trollope expressed the prevailing nineteenth-century British attitude toward aborigines when he wrote, "Of the Australian black man we may certainly say that he has to go. That he should perish without unnecessary suffering should be the aim of all who are concerned in the matter."

These tactics continued in Australia long into the twentieth century. In an incident at Alice Springs in 1928, police massacred thirty-one aborigines. The Australian parliament refused to accept a report on the massacre, and two aboriginal survivors (rather than the police) were put on trial for murder. Neck chains were still in use and defended as humane in 1958, when the Commissioner of Police for the state of Western Australia explained to the Melbourne Herald that aboriginal prisoners preferred being chained.

The mainland aborigines were too numerous to exterminate in the manner of the Tasmanians. However, from the arrival of British colonists in 1788 until the 1921 census, the aboriginal population declined from about 300,000 to 60,000.

Today the attitudes of white Australians toward their murderous history vary widely. While government policy and many whites' private views have become increasingly sympathetic to the aborigines, other whites deny responsibility for genocide. For instance, in 1982, The Bulletin, one of Australia's leading news magazines, published a letter by a lady named Patricia Cobern, who denied indignantly that white settlers had exterminated the Tasmanians. In fact, wrote Ms. Cobern, the settlers were peace loving and of high moral character, while Tasmanians were treacherous, murderous, warlike, filthy, glutinous, vermin infested, and disfigured by syphilis. Moreover, they took poor care of their infants, never bathed, and had repulsive marriage customs. They died out because of all those poor health practices, plus a death wish and lack of religious beliefs. It was just a coincidence that, after thousands of years of existence, they happened to die out during a conflict with settlers. The only massacres were of settlers by Tasmanians, not vice versa. Besides, the settlers only armed themselves in self-defense, were unfamiliar with guns, and never shot more than forty-one Tasmanians at one time.

I have already mentioned that the fate of Australian aborigines was typical of many episodes of genocide throughout human history in having been precipitated by a conflict over Lebensraum. In addition, Ms. Cobern's letter is a classic example of the usual response of a people charged with genocide. Typically, killers deny most responsibility for group murders; invoke self-defense or provocation, insofar as they acknowledge any responsibility at all; attribute ultimate responsibility to the victims; and denigrate the victims as subhumans implicitly deserving of death, whatever death's actual cause.

To appreciate that the fate of the Australian aborigines was hardly unique, we have only to recall our own not-quite-complete extermination of American Indians, another struggle over Lebensraum. History books usually portray this struggle as a series of military conflicts in our distant past between groups of armed adult males: the U. S. army versus mounted Indian warriors. In fact, much of the struggle consisted of sneak attacks and isolated murders in which white civilians killed Indians of any age and either sex. It was only in 1916 that the last "wild" Indian in the United States (the Yahi Indian known as Ishi) died, and frank and unapologetic memoirs by the killers of his tribe were still being published as recently as 1923. For instance, a rancher named Norman Kingsley explained how, in shooting a group of more than thirty unarmed Yahi that he had cornered in a cave, he discharged his .56 caliber Spencer rifle for a .38 caliber revolver when it came to shooting the babies, because "the rifle tore them up so bad." When Robert Anderson wrote about his own attack on a Yahi village, he mentioned that his friend Hiram Good suggested sparing the women while killing every man or well-grown boy, but "it was plain to me that we must also get rid of the women," who were then killed with some particular savagery not described in detail.

It used to be thought that humans were unique among animals in killing members of their own species. However, recent field studies have documented murder or group murder by many other species, including ants, hyenas, wolves, lions, monkeys, gorillas, and chimpanzees. Genocide by humans is at least as old as the oldest preserved written records. We all know the biblical account of how the walls of Jericho came tumbling down at the sound of Joshua's trumpets. Less often quoted is the sequel: Joshua obeyed the Lord's command to slaughter Jericho's inhabitants, as well as those of Ai, Makkedah, Libnah, Hebron, Debir, and many other cities. This was considered so ordinary that the Book of Joshua devotes only a phrase to each slaughter, as if to say: of course he killed all the inhabitants, what else would you expect? The sole account requiring elaboration is of the slaughter at Jericho itself, where Joshua did something really
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unusual: he spared the lives of one family (because they had helped his messengers).

We find similar episodes in accounts of the wars of the ancient Greeks, Crusaders, Pacific islanders, and other groups. Obviously, I’m not saying that slaughter of the defeated irrespective of sex has always followed crushing defeat in war. But that outcome, or else milder versions like the killing of men and the enslavement of women, happened often enough that they must be considered more than a rare aberration in our view of human nature. Since 1950 there have been nearly twenty episodes of genocide, including two claiming more than a million victims each (East Pakistan in 1971, Cambodia in the late 1970s) and four more with more than a hundred thousand victims each (the Sudan and Indonesia in the 1960s, Burundi and Uganda in the 1970s). A few cases attracted some international attention, but who protested the slaughter of Zanzibar’s Arabs in 1964 or of Paraguay’s Aché Indians in the 1970s?

What are the situations in which genocide is most likely? Historically, perhaps the commonest situation has involved one people attempting to usurp another people’s Lebensraum, as exemplified by the fate of Australian aborigines and Native Americans. Another common type of situation involves power struggles within a pluralistic society, as when Rwanda’s Hutu people killed Tutsi people in 1962–63 and when Burundi’s Tutsi killed Hutu in 1972–73. As for scapegoat killings of a helpless minority blamed for frustrations of their killers, one immediately thinks of slaughters of Jews by many peoples over many centuries and of Stalin’s killings of several ethnic minorities in Russia at the height of World War II. Most of these types of genocide also involved racial or religious persecution.

All human societies have sanctions against murder, which must somehow be overcome for genocide to happen. Overriding principles commonly invoked include self-defense, revenge, manifest rights to land, and possessing the correct religion or race or political belief. These are the principles that fan hatred and transform ordinary people into murderers. A further universal feature of genocide is an “us/them” ethical code that views the victims as lower beings or animals to whom laws of human ethics don’t apply. For instance, Nazis regarded Jews as lice; French settlers of Algeria referred to local Moslems as ratons (rats); Boers called Afrikaners bobbejaan (baboons); educated northern Nigerians viewed Ibos as subhuman vermin; and Ms. Coburn expressed a low opinion of Tasmanians.

Many books have been written on the psychology of genocide. It’s hard not to go numb while reading them. It remains hard to imagine how we, and other nice ordinary people that we know, could bring ourselves to look helpless people in the face while killing them. I came closest to being able to imagine it when a friend whom I had long known told me of a genocidal massacre at which he had been a killer.

Karinja is a gentle Tudawhe tribesman who worked with me in New Guinea. We shared life-threatening situations, fears, and triumphs, and I like and admire him. One evening after I had known Karinja for five years, he described to me an episode from his youth. There had been a long history of conflict between the Tudawhes and a neighboring village of Daribi tribesmen. Tudawhes and Daribis seem quite similar to me, but Karinja had come to view Daribis as inexpressibly vile. In a series of ambushes the Daribis finally succeeded in picking off many Tudawhes, including Karinja’s father, until the surviving Tudawhes became desperate. All the remaining Tudawhe men surrounded the Daribi village at night and set fire to the huts at dawn. As the sleepy Daribis stumbled down the steps of their burning huts, they were speared. Some succeeded in escaping to the forest, where Tudawhes tracked down and killed most of them during the following weeks. But the establishment of Australian government control ended the hunt before Karinja could catch his father’s killer.

Since that evening, I’ve often found myself shuddering as I recalled details of it—the glow in Karinja’s eyes as he told me of the dawn massacre; those intensely satisfying moments when he finally drove his spear into some of his people’s murderers; and his tears of rage and frustration at the escape of his father’s killer, whom he still hoped to kill some day with poison. That evening, I thought I understood how at least one nice person had brought himself to kill. The potential for genocide that circumstances thrust on Karinja lies within all of us. As the growth of world population sharpens conflicts between and within societies, humans will have more urge to kill each other, and more effective weapons with which to do it. To listen to first-person accounts of genocide is unbearably painful. But if we continue to turn away and to not understand it, when will it be our own turn to become the killers—or the victims?

Jared Diamond teaches physiology at UCLA Medical School and studies birds in New Guinea.
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A Web of Tales

Our stories—even our thoughts—are prisoners of ancient, persistent patterns

by Stephen Jay Gould

Every profession has its version: some speak of “Sod’s law”; others of “Murphy’s law.” The formulations vary, but all make the same point—if anything bad can happen, it will. Such universality of attribution can only arise for one reason—the principle is true (even though we know that it isn’t).

The fieldworker’s version is simply stated: You always find the most interesting specimens at the very last moment, just when you absolutely must leave. The effect of this phenomenon can easily be quantified. It operates weakly for localities near home and easily revisited and ever more strongly for distant and exotic regions requiring great effort and expense for future expeditions. Everyone has experienced this law of nature. I once spent two weeks on Great Abaco, visiting every nook and cranny of the island and assiduously proving that two supposed species of Cerion (my favorite land snail) really belonged to one variable group. On the last morning, as the plane began to load, we drove to the only unexamined place, an isolated corner of the island with the improbable name Hole-in-the-Wall. There we found hundreds of large white snails, members of the second species.

Each profession treasures a classic, or canonical, version of the basic story. The paleontological “standard,” known to all my colleagues as a favorite campfire tale and anecdote for introductory classes, achieves its top billing by joining the most famous geologist of his era with the most important fossils of any time. The story, I have just discovered, is also entirely false (more than a bit embarrassing since I cited the usual version to begin my essay of December 1985).

Charles Doolittle Walcott (1850–1927) was both the world’s leading expert on Cambrian rocks and fossils (the crucial time for the initial flowering of multicellular life) and the most powerful scientific administrator in America. Walcott, who knew every president from Teddy Roosevelt to Calvin Coolidge, and who persuaded Andrew Carnegie to establish the Carnegie Institute of Washington, had little formal education and began his career as a fieldworker for the United States Geological Survey. He rose to chief, and resigned in 1907 to become secretary (their name for boss) of the Smithsonian Institution. Walcott had his finger, more accurately his fist, in every important scientific pot in Washington.

Walcott loved the Canadian Rockies and, continuing well into his seventies, spent nearly every summer in tents and on horseback, collecting fossils and indulging his favorite hobby of panoramic photography. In 1909, Walcott made his greatest discovery in Middle Cambrian rocks exposed on the western flank of the ridge connecting Mount Field and Mount Wapta in eastern British Columbia.

The fossil record is, almost exclusively, a tale told by the hard parts of organisms. Soft anatomy quickly disaggregates and decays, leaving bones and shells behind. For two basic reasons, we cannot gain an adequate appreciation for the full range of ancient life from these usual remains. First, most organisms contain no hard parts at all, and we miss them entirely. Second, hard parts, especially superficial coverings, often tell us very little about the animal within or underneath. What could you learn about the anatomy of a snail from the shell alone?

Paleontologists therefore treasure the exceedingly rare soft-bodied faunas occasionally preserved when a series of unusual circumstances are coincident—rapid burial, oxygen-free environments devoid of bacteria or scavengers, and little subsequent disturbance of sediments.

Walcott’s 1909 discovery—called the Burgess Shale—surpasses all others in significance because he found an exquisite fauna of soft-bodied organisms from the most crucial of all times. About 570 million years ago, virtually all modern phyla of animals made their first appearance in an episode called “the Cambrian explosion” to honor its geological rapidity. The Burgess Shale dates from a time just afterward and offers our only insight into the true range of diversity generated by this most prolific of all evolutionary events.

Walcott, committed to a conventional view of slow and steady progress in increasing complexity and diversity, completely misinterpreted the Burgess animals. He shoehorned them all into modern groups, interpreting the entire fauna as a set of simpler precursors for later forms. A comprehensive restudy during the past twenty years has inverted Walcott’s view and taught us the most surprising thing we know about the history of life: the fossils from this one small quarry in British Columbia exceed, in anatomical diversity, all modern organisms in the world’s oceans today. Some fifteen to twenty Burgess creatures cannot be placed into any modern phylum and represent unique forms of life, failed experiments in metazoan design. Within known groups, the Burgess range far exceeds what prevails today. Taxonomists have described almost a million living species of arthropods, but all can be placed into three great groups—insects and their relatives, spiders and their kin, and crustaceans. In Walcott’s single Canadian quarry, vastly fewer species include about twenty more basic anatomical designs! The history of life is a tale of winnowing and stabilization of few surviving anatomies, not a story of steady expansion and progress.
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But this is another story for another time (see my columns of December 1985 through February 1986). I provide an epitome only to emphasize the context for paleontology's classic instance of Sod's law. These are no ordinary fossils, and their discoverer was no ordinary man.

I can provide no better narration for the usual version than the basic source itself—the obituary notice for Walcott published by his longtime friend and former research assistant Charles Schuchert, professor of paleontology at Yale. (Schuchert was, by then, the most powerful paleontologist in America, and Yale became the leading center of training for academic paleontology. The same story is told far and wide in basically similar versions, but I suspect that Schuchert was the primary source for its canonization and spread. I first learned the story from my thesis adviser, Norman D. Newell, still at the American Museum of Natural History. He heard it from his adviser, Carl Dunbar, also at Yale, who got it directly from Schuchert.) Schuchert wrote (in the Proceedings of the American Academy of Arts and Sciences, vol. 62, 1928, pp. 283–84):

One of the most striking of Walcott's faunal discoveries came at the end of the field season of 1909, when Mrs. Walcott's horse slid in going down the trail and turned up a slab that at once attracted her husband's attention. Here was a great treasure—a wholly strange Crustacea of Middle Cambrian time—but where in the mountain was the mother rock from which the slab had come? Snow was even then falling, and the solving of the riddle had to be left to another season, but next year the Walcotts were back again on Mount Wapta, and eventually the slab was traced to a layer of shale—later called the Burgess shale—3000 feet above the town of Field, British Columbia, and 8000 feet above the sea.

Stories are subject to a kind of natural selection. As they propagate in the retelling and mutate by embellishment, most eventually fall by the wayside to extinction from public consciousness. The few survivors hang tough because they speak to deeper themes that stir our souls or tickle our funnybones. The Burgess legend is a particularly good story because it moves from tension to resolution, and unfolds within its basically simple structure two of the greatest themes in conventional narration—serendipity and industry leading to its just reward. We would never have known about the Burgess if Mrs. Walcott's horse hadn't slipped going downslope on the very last day of the field season (as night descended and snow fell, to provide a dramatic backdrop of last minute chanciness). So Walcott bids his
time for a year in considerable anxiety. But he is a good geologist and knows how to find his quarry (literally in this case). He returns the next summer and finally locates the Burgess shale by hard work and geological skill. He starts with the dislodged block and traces it patiently upslope until he finds the mother lode. Schuchert doesn’t mention a time, but most versions state that Walcott spent a week or more trying to locate the source. Walcott’s son Sidney, reminiscing sixty years later, wrote in 1971: “We worked our way up, trying to find the bed of rock from which our original find had been dislodged. A week later and some 750 feet higher we decided that we had found the site.”

I can imagine two basic reasons for the survival and propagation of this canonical story. First, it is simply too good a tale to pass into oblivion. When both good luck and honest labor combine to produce victory, we all feel grateful to discover that fortune occasionally smiles, and uplifted to learn that effort brings reward. Second, it might be true. And if dramatic and factual value actually coincide, then we have a real winner.

I had always grasped the drama and never doubted the veracity (the story is plausible, after all). But last month, while spending several days in the Walcott archives at the Smithsonian Institution, I discovered that all key points of the story are false. I found that some of my colleagues had also tracked down the smoking gun before me, for the relevant pages of Walcott’s diary had been earmarked and photographed before.

Walcott, the great conservative administrator, left a precious gift to future historians by his assiduous recordkeeping. He never missed a day of writing in his diary. Even at the very worst moment of his life, July 11, 1911, he made the following, crisply factual entry about his wife: “Helena killed at Bridgeport Conn. by train being smashed up at 2:30 A.M. Did not hear of it until 3 P.M. Left for Bridgeport 5:35 P.M.” (Walcott was meticulous, but please do not think me callous. Overcome with grief the next day, he wrote on July 12: “My love—my wife—my comrade for 24 years. I thank God I had her for that time. Her untimely fate I cannot now understand.”)

Walcott’s diary for the close of the 1909 field season neatly dismisses part one of the canonical tale. Walcott found the first soft-bodied fossils on Burgess ridge either on August 30 or 31. His entry for August 30 reads:

"Out collecting on the Stephen formation (the unit that includes what Walcott later called the Burgess Shale) all day. Found many interesting fossils on the west slope of the ridge between Mounts Field and Wapta [the right locality for the Burgess Shale]. Helena, Helen, Arthur and Stuart [his wife, daughter, assistant, and son] came up with remainder of outfit at 4 P.M."
Walcott’s diary for August 31, 1909

Walcott drew on August 31. This reconstruction gains some support from a letter that Walcott wrote to Marr (for whom he later named the “lace crab Marrella”) in October 1909:

When we were collecting from the Middle Cambrian, a stray slab of shale brought down by a snow slide showed a fine Phyllopod crustacean on a broken edge. Mrs. W. and I worked on that slab from 8 in the morning until 6 in the evening and took back with us the finest collection of Phyllopod crustaceans that I have ever seen.

(Phyllopod, or “leaf-footed,” is an old name for marine arthropods with rows of lacy gills, often used for swimming, on one branch of their legs.)

Transformation can be subtle. A snow slide becomes a snowstorm, and the night before a happy day in the field becomes a forced and hurried end to an entire season. But more importantly, Walcott’s field season did not finish with the discoveries of August 30 and 31. The party remained on Burgess ridge until September 7! Walcott was thrilled by his discovery and collected with avidity every day thereafter. The diaries breathe not a single word about snow, and Walcott assiduously reported the weather in every entry. His happy week brought nothing but praise for Mother Nature. On September 1, he wrote: “Beautiful warm days.”

Finally, I strongly suspect that Walcott located the source for his stray block during the last week of his 1909 field season—at least the basic area of outcrop, if not the very richest layers. On September 1, the day after he drew the three arthropods, Walcott wrote: “We continued collecting. Found a fine group of sponges on slope [in situ] [meaning undisturbed and in their original position].” Sponges, containing some hard parts, extend beyond the richest layers of soft-bodied preservation, but the best specimens come from the strata of the Burgess mother lode. On each subsequent day, Walcott found abundant soft-bodied specimens, and his descriptions do not read like the work of a man encountering a lucky stray block here and there. On September 2, he discovers that the supposed shell of an ostracode really houses the body of a phyllopod: “Working high up on the slope while Helena collected near the trail. Found that the large so-called Leperditia-like test is the shield of a Phyllopod.” The Burgess quarry is “high up on the slope,” while stray blocks would slide down toward the trail.

On September 3, Walcott was even more successful: “Found a fine lot of Phyllopod crustaceans and brought in several slabs of rock to break up at camp.” In any event, he continued to collect, and put in a full day for his last hurrah on September 7: “With Stuart and Mr. Rutter went up on fossil beds. Out from 7 A.M. to 6:30 P.M. Our last day in camp for 1909.”

If I am right about his discovery of the main beds in 1909, then the second part of the canonical tale—the week-long patient tracing of errant block to source in 1910—should be equally false. Walcott’s diary for 1910 supports my interpretation. On July 10, champin the bit, he hiked up to the Burgess Pass campground, but found the area too deep in snow for any excavations. Finally, on July 29, Walcott reports that his party set up “at Burgess Pass campground of 1909.” On July 30, they climbed neighboring Mount Field and collected fossils. Walcott indicates that they made their first attempt to locate the Burgess beds on August 1:

All out collecting the Burgess formation until 4 P.M. when a cold wind and rain drove us into camp. Measured section of the Burgess formation—420 feet thick. Sidney with me. Stuart with his mother and Helen putting about camp.

(“Measuring a section” is geological jargon for tracing the vertical sequence of strata and noting the rock types and fossils. If you wished to find the source of an errant block dislodged and tumbled below, you would measure the section above, trying to match your block to its most likely layer.)

I think that Charles and Sidney Walcott located the Burgess beds on this very first day, because Walcott writes for his next entry of August 2: “Out collecting with Helena, Stuart and Sidney. We found a fine lot of lace crabs and various odds and ends of things.” “Lace crab” was Walcott’s informal field term for Marrella, and Marrella is the marker of the mother lode—the most common animal in the Burgess Shale. If we wish to give the canonical tale all benefit of doubt, and argue that these lace crabs of August 2 came from dislodged blocks, we still cannot grant a week of strenuous effort for locating the mother lode, for Walcott writes just two days later on August 4: “Helena worked out a lot of Phyllopod crustaceans from ‘Lace Crab layer.'” From then on, until the end of summer, they quarried the lace crab layer, now known as the Burgess Shale.

The canonical tale is more romantic and inspiring, but the plain factuality of the diary makes more sense. I have been to the Burgess ridge. The trail lies just a few hundred feet below the main Burgess beds. The slope is simple and steep, with strata well exposed. Tracing an errant block to its source should not have been a major problem—for Walcott was more than a good geologist; he was a great geologist. He should have located the main beds right away, in 1909, since he had a week to work after first discovering soft-bodied fossils. He was not able to quarry in 1909—the only constraint imposed by limits of time. But he found many fine fossils and probably the main beds them-
One island stacks up as the place for the happiest and most playful vacations. By day, play on miles of uninterrupted beaches or explore the many ways of enjoying the sea. On land, there is everything from prehistoric caves to shopping, tennis and other sports. At night, experience your favorite international cuisine or tasty local dishes and live shows. Then play some more at one or all of our six casinos. Or disco till the sun peeks in. We've got a Dutch heritage, but we speak fluent English. Know us yet? Look up. We spell fun in the Caribbean.

Aruba. One happy island. Come.
selves. He knew just where to go in 1910 and set up shop in the right place as soon as the snows melted.

Memory is a fascinating trickster. Words and images have enormous power and can easily displace actual experience over the years. As an intriguing testimony to the power of legend, consider the late memories of Walcott’s son Sidney. In 1971, more than sixty years after the events, Sidney wrote a short article for Smithsonian, “How I Found My Own Fossil.” (The largest Burgess arthropod bears the name Sidneyia inexpectans in honor of his discovery.) Sidney must have heard the canonical tale over and over again across the many years (think of him enduring mounds of rubber chicken and endless repetitions of the anecdote in after-dinner speeches)—and his actual experience faded as the conventional myth took root.

Sydney’s version includes the two main ingredients—serendipity in the chance discovery of a dislodged slab blocking the pathway of packhorses, and assiduous effort in the patient, week-long tracing of block to source. But Sidney places the packhorse incident on his watch in 1910, not on his mother’s the previous year:

Father suddenly told me to halt the packtrain. I signaled, and the horses started to browse at the side of the trail. Often on our summer camping trips I had seen father throw stones and logs out of the trail to make the going a bit easier for the horses. So it was no surprise to see him upend a slab, worn white by the shoes of horses slipping on it for years. He hit it a few times along its edge with his geological hammer and it split open. “Look Sidney,” he called. I saw several extraordinary fossils on the rock surface. “Let’s look further tomorrow. . . . We won’t go to Field tonight.” To our family, back in 1910, it seemed a miracle that Father’s simple act of thoughtfulness for the comfort and safety of a few packhorses led to this discovery.

A lovely story, but absolutely nothing about it can be true. Sidney knew the canonical yarn about slabs and packhorses, but moved the tale a year forward. We cannot believe that slabs could have blocked paths for two years running, with fossils always on their upturned edges, especially since an unanticipated discovery in 1909 precludes a similar surprise the next year. Moreover, Sidney could not have remembered an actual incident of the first season, and then mixed up the years, because he wasn’t there in 1909!

Sidney’s second ingredient, his tale of a week-long search for the mother lode (cited previously in this essay), is equally false from the evidence of Walcott’s diary, and similarly read into memory from the repetition of legend, not the recall of actual events.

Why am I bothering with all this detail? To be sure, truth has a certain moral edge over falsehood, but few people care much about corrections to stories they never heard, about people they never knew. If the only lesson in this little reversal of Burgess orthodoxy exhorts us to be careful lest a tendency to embellish or romanticize stifle the weakly flickering flame of truth, then this essay is as banal as the sentence I just wrote. But I would defend my effort on two grounds. First, the Burgess animals happen to be the world’s most important fossils, and the purely factual issues surrounding their discovery therefore demand more than the usual care and attention to accuracy. We might not challenge a family legend about Uncle Joe in the interests of domestic peace and benevolence, but we really would like to know how Jesus lived and died because different views have had such palpable effects upon billions of lives. Second, I believe that our tendencies to construct legends raise an issue far more interesting than watchdog warnings about eternal verity.

I would begin by asking why almost every canonical tale is false in the same way—a less interesting reality converted to a simple story with a message. Do we need these stories so badly because life isn’t heroic or thrilling most of the time? Sean O’Casey said that the stage must be larger than life, and few poets or playwrights can succeed by fidelity to the commonplace. It takes the artistry of James Joyce to make a masterpiece from one day in the life of an ordinary man. Louis Malle’s recent film, Au revoir les enfants (Good-bye children), succeeds because it consciously shuns the stuff of legend and tells an unembellished story as it might actually unfold with fallible people in earthly time. The Jewish boys hiding from the Nazis in a Christian school are caught. The pupils do not shout defiant praise to their beloved and arrested superior, but merely say a short and plaintive farewell. The Christian child and Jewish child do not form a deep bond of understanding, but meet with all the malaria and guardedness of their early teen-age years. But the very novelty of this ordinariness shows how rarely such a theme can work as art. Most of our existence is eating, sleeping, walking, and breathing. Even the life of a soldier, if expressed in real time, would be almost uninterrupted tedium—for an old motto identifies this profession as long periods of boredom interspersed with short moments of terror.

Astute scientists understand that politi-
...al and cultural bias must impact their ideas, and they strive to recognize these inevitable influences. But we usually fail to acknowledge another source of error that might be called literary bias. So much of science proceeds by telling stories—and we are especially vulnerable to constraints of this medium because we so rarely recognize what we are doing. We think that we are reading nature by applying rules of logic and laws of matter to our observations. But we are often telling stories—in the good sense, but stories nonetheless. Consider the traditional scenarios of human evolution—tales of the hunt, of campfires, dark caves, rituals, and toolmaking, of coming of age, and struggle and death. How much is based on bones and artifacts and how much on the norms of literature?

If these reconstructions are stories, then they are bound by the rules of canonical legendmaking. And if we construct our stories to be unlike life—the main point of this essay—then our literary propensities are probably derailing our hope to understand the quotidian reality of our evolution. Stories only go in certain ways—and these paths do not conform to patterns of actual life.

This constraint does not only apply to something so clearly ripe for narration and close to home as “the rise of man from the apes” (to choose a storylike description that enrolls biases of gender and progress into its conventionality). Even the most distant and abstract subjects, like the formation of the universe or the principles of evolution, fall within the bounds of necessary narrative. Our images of evolution are caught in the web of tale telling. They involve progress, pageant; above all, ceaseless motion somewhere. Even revisionist stories that question ideas of gradual progress—the sort that I have been spinning for years in this forum—are tales of another kind about good fortune, un-predictability, and contingency (the kingdom lost for want of a horseshoe nail). But focus on almost any evolutionary moment, and nothing much is happening. Evolution, like soldiering and life itself, is daily repetition almost all the time. Evolutionary days may be generations, but as the Preacher said, one passeth away and another cometh, but the earth abideth forever. The fullness of time, of course, does provide a sufficient range for picking out the rare moments of activity and linking them together into a story. But we must understand that nothing happens most of the time—and we don’t because our stories don’t admit this theme—if we hope to grasp the dynamics of evolutionary change. (This sentence may sound contradictory, but it isn’t. To know the reasons for infrequent change, one must understand the ordinary rules of stability.) The Burgess Shale teaches us that, for the history of basic anatomical designs, almost everything happened in the geological moment just before, and almost nothing in more than 500 million years since.

Included in this “almost nothing,” as a kind of geological afterthought of the last few million years, is the first development of self-conscious intelligence on this planet—an odd and unpredictable invention of a little twig on the mammalian evolutionary bush. Any definition of this uniqueness, embedded as it is in our possession of language, must involve our ability to frame the world as stories and to transmit these tales to others. If our propensity to grasp nature as story has distorted our perceptions, I shall accept this limit of mentality upon knowledge, for we receive in trade both the joys of literature and the core of our being.

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.

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Mofongo, a fritter of plantain purée and pork cracklings

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Back to the Roots

The cosmopolitan food of Puerto Rico is best sampled on the island itself

by Raymond Sokolov

I flew to Puerto Rico earlier this year in search of my roots as a New Yorker. This is no joke. My everyday life is pervaded by the presence of thousands of New Yorkers of Puerto Rican heritage. My hope was to experience as full a range as possible of their island’s multifarious, typical foods in their natural context and to try to get a balanced picture of the highly original cuisine whose transplantation to New York has inevitably been only a partial affair. From reading cookbooks, I already knew that no Manhattan restaurant was even scratching the surface of what was possible. Culantro (the broad-leaved coriander) was something I had never seen on my island, and I couldn’t recall encountering apio (Arracacia xanthorrhiza), a tuber of the carrot family native to northern South America. In Puerto Rico it is grown in the highlands and takes its name from standard Spanish, where apio means celery; it also goes by its South American vernacular name, arracacha.

Such confusing multiple names are typical of Puerto Rican foods. The Central American fruit most commonly known as sapodilla is usually referred to in Puerto Rican parlance as níspero. In Spain, níspero is the name of the European medlar, Mespilus germanica, and also the loquat, Eriobotrya japonica. Puerto Rican cooks have added still another layer to this nomenclatural palimpsest with a dessert called nísperos de batata, which is prepared from sweetened mashed sweet potatoes shaped to resemble sapodillas and given sapodilla “stems” made with a green thread tied around a whole clove.

Puerto Rican cookbooks written for English speakers include glossaries to help Anglos over the significant hurdle of all these exotic names. These handlists not only identify local flora and fauna such as the mabi, an indigenous tree whose bark is the basis of a fermented drink, but also lay out the local lingo for plants known by other names in other places. As one glances down these lists and discovers that the avocado is a palta in Puerto Rico, the true banana is a guineo, and the common orange a chîna, the realization grows that Puerto Rico is a place unto itself. Even the cooking vocabulary of so similar a place as the Dominican Republic, with its mangu (plantain purée) and mapuy (a variety of yam) and galleticas (cookies), is easily distinguishable from that of Puerto Rico.

Not only do Puerto Ricans enjoy a larder of unparalleled richness and cosmopolitan origins, thanks to their long Spanish colonial heritage, but they also have taken ingredients from all over the planet and combined them in a synthesis that could not have taken place except in the Spanish Caribbean. Here the climate was ideal for experiments in eclectic agriculture, and there was no powerful indigenous cuisine to compete with the spirit of invention that always arises in cooks confronting new foods in frontier situations. In Mexico, Aztec cookery was a strong shaping force that merged with the cuisine of the conquistadors to produce Mexican cuisine. In Puerto Rico and the other Spanish islands, a world empire added exotic ingredients to those already there and whipped up a menu unlike any that had existed before. For funche, cornmeal and coconut were mixed to make a tropical polenta. In the hot sauce called pique, acid Seville orange juice pickles native American chili peppers.

I hoped to experience these archetypal post-Columbian foods by roaming about in the hinterland of the island. I also hoped to avoid the deadening international food of the island’s major resorts and to observe the more traditional life of the western
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The Caribbean

highlands. It took more than three hours to reach Parador Hacienda Juanita, an inn set in mid jungle along the Ruta Panoramica, which winds by giant bamboo sprays and teams of men with machetes slashing away at vegetation to keep the shoulder clear.

Hacienda Juanita is part of a network of inns (paradores) maintained by the government. Apart from its lush gardens, it also offers examples of la cocina puertorriqueña in its dining room. For example, its menu features serenata, a "serenade" of flaked salt cod served cold as a salad on one plate and a combination of boiled tropical root vegetables served on another. Serenata is a strange adventure in connoisseurship, almost flaunting the unexpected differences between green and ripe plantains, yautias, yams, yuca, and breadfruit. These diverse root vegetables, many of them brought here from all over the world by Spanish galleons, have been naturalized and are now considered a separate, fundamental part of the diet, and specially classified as viandas hervidas, "boiled foods."

In her learned and thorough Rice and Beans and Tasty Things: A Puerto Rican Cookbook, Dora Romano lists some fifty recipes for roots and tubers—fritters, purées, salads, chips, and many more. The ingenuity is impressive, but it is the profusion of plants from around the world brought by Spanish colonists and African slaves to this one island that make Puerto Rican cuisine so special.

Hacienda Juanita turned out to be a rare example of a full-scale restaurant serving full-blown dishes of a traditional nature for consumption at a table. Demotic Puerto Rico does not lack for public eating opportunities. Far from it. But most of what I found of indigenous food in the western highlands, on roadsides, or in the village of Maricao and in the western port of Mayagüez was in locally rooted fast-food emporiums.

Along the western end of the Ruta Panoramica, one typically came upon a simple building that doubled as a bar and a stand-up, open-air restaurant with a small number of specialties, most of which were cuchifritos, those deep-fried oddments that range from mofongo (plantain purée and pork cracklings) to more straightforward pork omelets. One place served suckling pig. The "restaurant" I most lusted to try out was Willy's, a shack at a bend in the road between Mayagüez and Maricao. Willy's opened...
in the afternoon and advertised cuajito, pork stomach, as its especialidad.

Unfortunately, Willy did not serve cuajito on the day I passed by, only beer and coconut juice straight from the whole fruit. I did much better wandering around Mayagüez, dropping into storefront bar/snack bars, sampling the never redundant array of fritters of various description: the pionones, the cod empanaditas, and pasteles of this or that. Apart from the beer and the rum and the relaxed welcome, the common link between these places was hot lard sizzling in the background and handwritten signs that said: No hable malo. Respete que hay damas (Don’t use bad language. Respect the presence of women).

As I had expected from hearing many similar reports before I left, the height of this informal but diverse public Puerto Rican dining takes place at the beach. You will go far before you find a livelier food scene than the three restaurants competing at the western edge of the beach at Piñones Forest, just to the east of the San Juan airport. Here, with the dunes and the Atlantic on one side and a piney woods on the other, the glacializing hand of resort development has not yet squeezed out local culture. Food stand after food stand pops up along the road for miles. There are also graffiti threatening to fight the big builders. But for now the women next to the hot fat are peacefully grating yautia for the next batch of giant land crab alcapurrias and islanders constantly drop in and out for a beer and some solid nourishment.

The other main way to latch on to the lingering indigenous food culture is to wander among the stalls of the central market back in town, south of the University of Puerto Rico campus. Many San Juansians now live in suburbs and shop in supermarkets. But in the central market the fruit sellers will pour you refrescos, cold drinks made from guanábana (soursops), and the butchers have gandinga. And what is that? Gandinga is a mixture of cubed pork offal—liver, heart, and kidneys. The basic dish is a ragout. It has, shall we say, a strong taste. People on the island favor it for Christmas Eve dinner. I found it on the menu at El Obrero, a trucker’s restaurant down the street from the San Juan central bus station and a short walk from the central market. El Obrero is a local institution, not some dirty truck stop but a well-run restaurant with humorous place mats and militantly tradi-

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tional and unpretentious local food. El Obrero's *gandinga* comes with rice and beans. It isn't real Orloff, but that's the point. It is what it is, very gusty food that stands for the place it comes from. You won't find *gandinga* in Spain or in Mexico, but you will find it in serious Hispanic butcher shops in New York.

I felt a lot better about the future of the city when I found out about that. Hundreds of thousands of New York Puerto Ricans can still get *gandinga*. They don't have to settle for burgers. At the supermarket in my neighborhood they have their choice of yautia or its cousin arild, *malanga*. There are white sweet potatoes (*boniatos*) and true yams, plus plantains and bottled *raicito*, the *cilantro* condiment. Perhaps somewhere someone is flying in mangrove crabs. But even without them, I'm no longer down in the dumps about the future of Puerto Rican food in New York. There are no important restaurants because that is not the way it works back on the Isle of Enchantment either. The thing we ought to have, though, is a little place where you can get a beer and a plate of *cuajito*, on your way home from work, as you drive past the beach just to see what's happening.

Raymond Sokolov is a writer whose special interests are the history and preparation of food.

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### The Caribbean

Two recipes adapted from *Rice and Beans and Tasty Things: A Puerto Rican Cookbook*, by Dora Romano, Ramallo Bros.

**Printing, 227 Duarte St., Floral Park, Hato Rey, Puerto Rico, 00917**

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#### Cuajo (Pork Stomach)

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
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<tbody>
<tr>
<td>1½ pounds pork stomach</td>
<td></td>
</tr>
<tr>
<td>¼ cup vinegar</td>
<td></td>
</tr>
<tr>
<td>3 tablespoons salt</td>
<td></td>
</tr>
<tr>
<td>5 large <em>culantro</em> leaves</td>
<td>or 5 sprigs <em>cilantro</em> (coriander)</td>
</tr>
<tr>
<td>1 medium onion, peeled and quartered</td>
<td></td>
</tr>
<tr>
<td>4 garlic cloves, peeled</td>
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1. Trim off any fat from the pork stomach and rinse well under running water, scrubbing with a vegetable brush.
2. Cut into 2-inch squares and soak in 6 cups of cold water with vinegar for 15 minutes. Rinse.
3. Add salt to 2 quarts of water and bring to a boil. Add meat and return to boil. Skim. Then add *culantro* or *cilantro*, onion, and garlic. Reduce heat, cover, and simmer for 1½ hours or until tender. Drain.
4. At this point you can freeze the *cuajo* for later use or proceed directly to make *cuajo frito* (the prepared stomach is fried in a half inch of lard or vegetable oil until golden brown and slightly crisp) or *cuajo empanado* (breaded *cuajo*: dredge the stomach pieces in flour, beaten egg, and cracker or bread crumbs, then fry in lard or vegetable oil until golden brown). Serve with hot sauce.

**Yield:** Six servings

#### Funche con Leche de Coco (Coconut Polenta)

<table>
<thead>
<tr>
<th>Ingredient</th>
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<tr>
<td>3 cups coconut milk (see note below)</td>
<td></td>
</tr>
<tr>
<td>½ cup plus 1 tablespoon sugar</td>
<td></td>
</tr>
<tr>
<td>¼ teaspoon salt</td>
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Note: To make coconut milk, start with a whole fresh coconut. They are generally sold already husked, which means you start with a hairy brown sphere. Pierce the eyeholes with a pointed tool and drain off the liquid (reserve for a cool drink some other time). Smash the coconut with a hammer. Separate the meat from the shell with a heavy-bladed knife or screwdriver. Use a vegetable peeler to pare away the brown skin. Cut meat into 1-inch squares and process in a processor with the metal blade. Measure the grated coconut and return to the processor. A coconut with a diameter of 5 inches will yield about 4 cups of grated coconut. Add to the grated coconut half its volume of lukewarm water. Process two to three minutes. Let cool and squeeze through a clean dish towel. Four cups of grated coconut should yield about 2 cups of milk. If you need more, add water equal to that quantity to the already squeezed grated coconut. Squeeze again and add resultant milk to the first squeezing.
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Growing in the Wind

A Caribbean sampler yields everything from palm trees to cactuses

by Robert H. Mohlenbrock

Strong gusts greeted me as I walked across the parking lot of the Aruba Concorde, keeping me off balance until I reached the entrance of the hotel. Among the islands of the Caribbean, Aruba had to be among the windiest; but that was fine with me. This was one stop on my five-island sojourn—to Aruba, Curaçao, Barbados, Guadeloupe, and Saint Croix, all in the Lesser Antilles—to compare vegetation growing on the windward side of the islands with that on the leeward side.

In the Caribbean, as in much of the Northern Hemisphere, northeasterly winds blow from a tropical belt of high pressure toward the equator, where lower pressure prevails. They are known as trade winds because of their regularity (the phrase "to blow trade" meant to blow constantly in the same direction). Averaging eleven miles per hour, the trade winds whip against coasts, lashing out at the plants attempting to grow there and rapidly drying out the soil.

On Aruba, the winds have carved natural bridges, dunes, caves, and sandy coves. The stems of some of this island's plants, such as seaside samphire and purslane, lie flat on the rocky or sandy surface, keeping their branchlets from being blown about. This prostrate position also presses the plants against the soil, where there is more moisture. Erect shrubs, such as seaside temporana and saltwort, are anchored by deeply penetrating roots, which seek out needed water.

Although it carries moisture from the sea, the wind has a drying effect on plants. Species that grow on Aruba in the face of the wind are adapted in various ways to these conditions. Succulents, for example, have storage tissues that reserve water for periods of extreme dryness. For seaside samphire, the job is done by jellybean-shaped leaves, while cactuses hoard water in their stems.

Many plants, especially leguminous, or pod-bearing, trees such as mesquite, have tiny leaflets that expose little surface to the wind and hence reduce moisture loss. Some have spines instead of leaves: the cactuses, several leguminous trees, and as tintoillo fall into this category. Sea grape, matapal, and turrarae cope by having thick leaves with a heavy wax coating, while a dense covering of hairs protects the finger-like, silver gray leaves of the cocorobana. The white willow's leaves curl downward toward the main vein, shielding the openings in the leaf surface. The leaves of some species minimize the impact of the sun's rays by reorienting themselves through subtle movements. A mechanism in the leaf stalks of cat's claw, mesquite, and other leguminous trees makes them particularly adept at this.

The wind may affect the growth of young stems by suppressing buds on the exposed side, giving the plants a one-sided appearance. This is particularly true on Aruba and neighboring Curaçao, where some trees take on bizarre shapes: although the bases of the trunks remain erect, the upper trunk and branches are blown horizontal to the ground. These misshapen trees are popularly called divi-divi trees. In addition to the true divi-divi, or watapana, at least five other species on Aruba and Curaçao are so referred to: mesquite, or kwii; twisted acacia, or hubada; black willow, or huliba; West Indian cherry; and yuana, which has orange berries. These six divi-divi species develop on Aruba and Curaçao in the face of the strong trade winds. But when they grow in sheltered locations (the inner courtyard of a hotel, for example), their shape is symmetrical.

Divi-divi trees are readily found on the windward side of the dry hills near Matividi and in the adjacent Arikok region, both on Aruba's northeastern coast. Other trees in the thorny woods covering these hills are more symmetrical in growth, including two species of cat's claw, two kinds of beefwood, and two types of birch gums. All have hard, evergreen leaves or leaves reduced to spines, both of which are adaptations to living in dry, adverse environments. The under-story is sometimes sparse, sometimes nearly impenetrable with dense thicket of wild sage and bellyache-bush.

Another place to see divi-divi trees is on Hooiberg, a small, cone-shaped mountain that rises 541 feet above the plains in central Aruba. The windward side is scantily covered with scattered shrubs and solitary trees. Many divi-divi trees are found on this slope, along with a common agave, gumbo-limbo, beefwood, and the tall, sagurarolike candle cactus. The leeward side of Hooiberg is densely overgrown with various cactuses, along with campeche, yellow poui, wild sage, wild coffee, phyllanthus, and an endemic agave. A similar, although not as welldefined, contrast can be seen on 1,230-foot Saint Christoffel Berg, a mountain at the northern tip of Curaçao. The windward side consists of a dry, thorny forest with scattered divi-divi trees, while the leeward slopes are more densely clothed with vegetation and have very few divi-divis.

Although the effects of wind provide striking vegetational features, a search for undisturbed native habitats on densely populated Aruba and Curaçao is also a rewarding botanical quest. Most of Aruba, for example, has been under cultivation (its principal plant export at one time was Aloe vera). When unproductive fields are ultimately abandoned, they become overgrown by cactuses, euphorbias, and a variety of leguminous trees. Nonetheless, there are remnants of natural—or at least pre-European—vegetation.

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The Caribbean

Doug Perrine

“Water, water everywhere, nor any a drop to drink”;
prickly pears grow at Curacao’s West Point Bay.

In stark contrast, along Aruba’s northeastern coastline, to the northwest of
Fontein, the ground is bare, except for some annual grasses and small, scattered
shrubs. The soil is sandy, the result of the erosion of underlying rocks. The hills near
the coast have been eroded with gullies that often extend to the sea. Within these
sheltered, sandy gullies, scrubby woodlands of sea grape, button mangrove,
bontia, and cocorobana sometimes develop. These conditions intensify farther
west along the coast until, surrounding the California lighthouse at the north-
western end of Aruba, there is a desertlike community of thorny shrubs, huge prickly
pears, and tall candle cactuses.

Along the coast southeast of Fontein, the terrain is of limestone, laid down by
reef organisms during times that the is-
land was submerged beneath the sea. This
region supports scanty vegetation, which
has adapted to harsh, dry conditions.
Prickly pear cactuses are abundant, inter-
mingled with gnarled specimens of mes-
quite, twisted acacia, and wild sage.
Grasses scattered beneath the scrubby
woodly plants include bur grass and West Indian crabgrass, a species widespread in
the southeastern United States.

A walk inland from Boca Grandi (about
a mile southeast of Fontein) reveals the
change in vegetation with increasing dis-
tance from the sea. Along the rocky coast-
line, the creeping goat’s-foot morning-
glory makes an attempt to colonize the
water-swept shore. Behind this strand is a

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AIR FRANCE KLM

The Caribbean

Divi-divi trees reveal the direction of Aruba’s prevailing winds.

Behind this strand is a low sand ridge that is monopolized by seaside samphire. Next, in a 225-foot-wide strip, the tropical shrub known as seaside temporana grows above a sparse carpet of seaside samphire. Behind this zone the samphire disappears, and for the next 200 feet a woody-stemmed herb called broomweed covers nearly three-fourths of the soil. Finally, 1,000 feet inland, where limestone outcappings begin to appear, the shrubby forms of sea grape take over.

The vegetation of Curacao, fifty miles east of Aruba, is similar, but the higher mountains and a climate more favorable to plant growth permit a more vigorous development of vegetation in places. Saint Christoffel Berg, the island’s highest mountain, is the focal point of a national park and a good place to observe the plant life from sea level to 1,230 feet. A trail leading three-quarters of the way up the mountain to Rancho Grande passes by numerous barrel cactuses. The view of the sea from Rancho Grande is across the wind-swept slopes of the mountain. Fine examples of divi-divi trees can be seen from here, along with bastard locust, maytenus, and other trees. Several plants not known elsewhere on Curacao grow on the steepest slopes of Saint Christoffel Berg, including the double-toothed sword fern and climbing fern. On the cliff at the mountaintop are the handsome matapal, hog plum, golden fern, and pale peperomia.

Palms grow in the parish of Saint Andrew, Barbados

Doug Panehe
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Barbados, the easternmost island in the Caribbean, is also subject to the trade winds, although not as intensely as Aruba and Curaçao: some exposed plants do become slightly bent, but there are no divi-divi trees. Along the northern coast, however, the contrast between windward and leeward plant communities can be observed within one mile of each other. At blustery North Point, where waves batter the shoreline, the vegetation is scanty and low-growing. Clinging tenaciously to the rocky soil are seaside samphire, purslane, and duckweed (this last is not the familiar plant that floats on the surface of ponds, but a prostrate herb with small, yellow, daisylike flower heads). One mile to the west of North Point is Archer's Bay, a secluded, rocky cove protected from the winds by high cliffs. The vegetation at Archer's Bay is denser, and the trees grow taller. Whitewood and the silk-cotton tree are here.

Most of the native vegetation of Barbados disappeared following the arrival of the first colonists in 1627. Today, relatively few undisturbed areas are found. The windward beach at Long Pond has vegetation patterns typical of the northeast coast of the island. There is a sloping beach near the sea with an assortment of grasses and isolated patches of beach carpet, a tiny mat-forming species related to the North American pigwet. Moving inland, the sand is more stable and anchored by plants, notably the creeping goat's-foot morning-glory. Here, dead plant material in the soil retains water and provides nutrients.

Some of the highest dunes farther inland are covered by a shrub zone. Sea grape, stunted by the wind, is abundant, along with fat pork (a tree related to the rose), French cotton, the prickly horse nicker, and the highly poisonous manchineel. Behind the dune region is sandy brushland, a rather poor forest of dry-tolerant species whose leaves are protected by either a thick, waxy coating or a dense covering of hairs. In addition to the ever-present sea grape, these forests contain whitewood, manchineel, scarlet geiger tree, clammy cherry, seaside mahoe, and the nonnative tropical almond.

Turner's Hall Wood is the only example of presettlement forest left on Barbados. Located on steep land in the interior of the island, it is spared the desiccating winds; thus the vegetation is rich and lush. Four layers of plant communities can be readily detected. The upper layer consists of trees
up to 100 feet tall but which, because they are scattered, provide an open canopy. The principal trees in this layer are West Indian locust, silk-cotton, fiddlewood, and sandbox tree, all them deciduous. Two evergreen trees in this layer are jack-in-the-box and cabbage palm. Beneath the upper layer are trees ranging from thirty-five to sixty-five feet tall. The diversity of species is greater here, and most are evergreen. There is Spanish oak (not an oak but the leguminous *Inga laurina*), beefwood, fustic (the source of an important natural dye), leathercoat tree, and bastard locust. The density of the second tree layer casts so much shade that the shrub and herb layers beneath are relatively limited in species. Some of the herbs are close relatives of ornamentals popular in the United States; they include a dumb cane, a caladium, and a bromeliad known as pinguin.

Although Barbados receives about sixty inches of rainfall annually, compared with seventeen and a half inches for Aruba, there are many deciduous trees as a result of the dry season. During the dry season, from January to May, trees shed their leaves for a period of a few days to as much as four or five months, depending on the species. Despite the ample annual rainfall, no true rain forest has developed at Turner's Wood because rainwater runs off the steep slopes too rapidly.

Guadeloupe shares some of the same conditions found on Aruba, Curaçao, and Barbados, with northeasterly winds driving heavily into the coast. Located some 300 miles southeast of Puerto Rico, Guadeloupe is shaped like a butterfly, divided at its narrowest by a strait called the Rivière Salée (Salty River). The western lobe is dominated by a mountain range, whose vegetation retains much of its natural character (62,000 acres have been designated a natural park). The more heavily populated areas have inevitably seen more

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The Caribbean

alteration of their biological communities.

Grand-terre, the eastern half of Guadeloupe, is made up of limestone beds that were broken by tectonic action. The eastern coast, with its coral banks, includes the beautiful and rugged Pointe des Chateaux, its white sand beach washed by turquoise water. The pure sand may not appear capable of supporting much vegetation, but considerable plant life has developed a few feet inland. The woody seaside temporana, sea grape, and the very hairy leaved cucumbera grow vigorously. Here and there on the sand lies the ever-successful seaside samphire. At the spectacular Pointe de la Grande Vigne, the northernmost tip of Guadeloupe, a dry forest of legumes and sea grape lines the spectacular cliff high above the Atlantic Ocean.

The western half of Guadeloupe, known as Basse-Terre, is part of the eastern Caribbean volcanic axis. La Grande Soufriere, a volcano last active in 1976, rises 4,813 feet above sea level. The moisture-laden wind blows across Guadeloupe unimpeded until it approaches the mountainous western lobe. The windward slopes of the mountains force the air currents upward, where the collision with high-altitude cold air causes precipitation in the form of rain. Here, annual rainfall ranges from 315 to 395 inches, creating a tropical rain forest. After the air currents have dropped their moisture, they pass over the leeward side of the mountain range, which slopes down to the sea. Here rainfall is as little as 25 inches per year, just enough to support a dry thorn forest.

Similar to other tropical rain forests, the one on Guadeloupe contains numerous plant species. Most of the trees are evergreen and greatly swollen at their bases. The tallest trees are usually more than 100 feet tall. Common are gommer, a huge member of the tropical bursera family; two species of chataigniers; bois rouge carapate, a giant euphoria; and yellow mangue, a robust Saint Johnswort. Dozens of broad-leaved trees and a couple of mountain palms grow between 30 and 100 feet tall in the subcanopy. Their branches provide a home for epiphytic ferns, orchids, and bromeliads; high-climbing lianas reach to the top of many.

The dry plant community on the side of the mountains away from the rain forest includes many cacti, among them Turk's-cap cactus and several species of Cephalocereus and Opuntia. The many leguminous trees include species of aca-
Common components of the drier plant community are Turk’s-cap cactus, candle cactus, and prickly pear. Also common are agave, including the endemic Saint Croix agave. Along with the cacti and agaves there are lesser numbers of thorny acacias and cat’s claws. Unlike the situation on Guadeloupe, no true rain forest is to be found in the hilly western section of Saint Croix (although an area is called the “rainforest”). But gullies (or guts) protected from the wind do contain lush vegetation. West Indian locust, as well as the tyre palm, is found in these ravines. In the understory are strap fern, spider lily, and Christmas orchid. Wild tanier climbs the trees, while a large bromeliad (*Tillandsia utriculata*) clings to their branches.

Since shortly after its discovery by Columbus in 1493, Saint Croix has undergone a drastic alteration of flora. Today, after more than 200 years of sugar cane culture and other interventions by settlers and visitors, only remnants of the original landscape remain intact. But as in the case with other Caribbean islands, the persistent traveler can learn much about the affects of wind on vegetation and may even get a glimpse of what conditions were like before the arrival of Europeans.

This month, “This Land” columnist Robert H. Mohlenbrock takes a break from his usual beat—the 154 U.S. national forests—to survey five Caribbean islands, where trade winds are a constant factor in the growth of vegetation. Mohlenbrock is Distinguished Professor of Botany at Southern Illinois University at Carbondale.

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The islands of the Caribbean are often described as a two-thousand-mile-long jeweled necklace strung out in a sweeping curve from Florida to the northern coast of South America. It’s not a bad description, but it fails to convey the great difference between a necklace in a store window and the same necklace on, say, Elizabeth Taylor.

The Caribbean Sea, ranging in color from deep blue to emerald green, is the voluptuous backdrop for the bits of land that have drawn countless visitors, starting with their discovery by Columbus nearly five hundred years ago.

It is often a tranquil sea, clearer, warmer, and less salty than the adjacent Atlantic. Its tides are minimal. In these conditions, coral grows abundantly and a vibrant, wondrous web of life develops within and around the coral reefs.

In the next ten pages, five nature photographers, who have spent many days and some nights immersed in the Caribbean’s waters, present a few of their best images and their thoughts about photographing under water.
Years ago, while working as part of a NASA aquanaut crew off Saint John in the U. S. Virgin Islands, I was occasionally able to slip away to photograph marine life. Coming upon this boulder coral and admiring the symmetrical pattern of its polyps, I was delighted to find a tiny goby nestled there for protection. Another opportunity to take a picture came when a gray angelfish confronted me head-on. His bold stance is defensive as it presents a thinner target to a predator. He soon determined that I was not threatening and resumed grazing.

These pictures are part of a group that holds a special place in my collection. They represent the culmination of years of experiments to develop a camera system that would allow me to accurately record the wonders I had seen in twenty years of underwater photography. Since light and depth of field are always limited under water, most marine photographs are made at close range. So the wider the lens, the better. But underwater cameras used to be sealed into bulky, clumsy housings, with the lens flush up against a flat plate of glass. The problem was that when water came into contact with a parallel glass port, its refractive properties effectively turned the wide-angle lens into a normal one and also distorted the image and blurred the picture’s edges.

In the 1960s, with the late optical geometrist Gomer McNeil, I began to work on an underwater housing that would solve some of these problems. By 1971, when these pictures were made, we had just perfected the device that we called the “ocean eye” housing, which had a glass dome that corrected for the water’s refraction, as well as the other optical problems. For the first time, I was able to bring back sharp, distortion-free pictures of the underwater world.
The Caribbean

Juvenile queen angelfish, Barbados
I have spent most of my adult life studying the Gulf of California, but I also feel completely at home in the Caribbean. The reason, in part, is the strong relationship between the marine fauna of the Caribbean and that of the Gulf of California (as well as that of the tropical eastern Pacific).

The affinity between the two separate marine faunas is the result of the opening and closing of the Isthmus of Panama one to two million years ago. When the waterway between the Caribbean and the eastern Pacific was open, the two faunas were similar, if not identical. But the final uplift of the Panama land bridge isolated marine animal populations on both sides of the isthmus, resulting in divergence of most marine species.

Nonetheless, similarities between animals on both sides are clearly evident. Sibling species are everywhere. The juvenile queen and French angelfishes of the Caribbean, for example, are almost identical to the corresponding king and Cortez angelfishes of the Gulf of California. Twin species occur in all major fish families, as well as in invertebrates, such as nudibranchs, shrimps, crabs, and anemones.

The Caribbean differs considerably from the Gulf of California in its spectacular development of colorful sponges and corals. The rich coelenterate fauna (anemones, gorgonians, corals) harbors a multitude of small animals. Tiny shrimps, cowries, and crabs are often found clinging to their anemone or gorgonian hosts. When looking for photographic subjects, I carefully search every gorgonian, coral head, anemone, and sea star for the minute creatures associated with them. These animals are often so small that they go unnoticed by the casual observer. Photography unmasking details of form normally impossible for even the most attentive observer to see with the naked eye.

What troubles me is the growing human pressure on the Caribbean ecosystem. Whenever I dive or photograph the marine life, I always stop and scrutinize my surroundings. I see a harmony in this environment—fishes darting in and out of coral heads, small shrimps cleaning larger fishes, and sea fans in full bloom always facing the current. They seem oblivious to the dark cloud looming in the distance. I look carefully and savor the experience because I have a growing fear that the next time I return, it may not be the same.
Jay Ireland

Although I live in northern California, when I want to shoot in warmer waters, I return to the Cayman Islands, where I worked for nearly five years. And when I think of the Caymans, I think of Christmas tree worms, which are so prevalent in those waters. This one, its gill plates fully extended for feeding, was waving with the current when I took the shot.

This animal burrows into old coral and fashions a trap door to cover its entrance. It’s easy to miss these elusive and delicate little creatures because, as you approach, they quickly disappear down the hole and seem to pull it in with them.

Photographing them, as is the case with most marine animals, requires patience. Since a Christmas tree worm will retreat as you come near, you must lie very still for a few minutes and wait for it to slowly emerge. Then you can get off a few exposures before the worm decides it’s had enough. But don’t go away, for curiosity or hunger will get the better of the worm and it will return so you can shoot some more. Eventually it will become accustomed to your strobe and you can shoot all you want.

I discovered this young flaming sea scallop while looking for squid egg cases under pieces of old coral. There, curled up in one of the holes, was a little ball about the size of a thumbnail. Knowing what it was, I gently pried it loose, placed it in full view, and waited for it to open up. After a few minutes the colorful tentacles unfurled and the body extended as it prepared to scoot off to cover. I got a few frames before it jetted off, but I managed to retrieve it for another shooting session. Eventually I let it seek the cover it deserved.

As a boat captain and dive master in the Caymans, I observed a lot of vacationing amateur photographers and found that their most common mistakes were due to impatience. And they look for sharks and manta rays—which they are not likely to encounter on the coral reef—missing the colorful little fishes, worms, and plants that constitute most of the life on the reef.
The Caribbean

Flaming sea scallop, Cayman Islands
Parrotfish, Cayman Islands
The Caribbean

Compared with the fecund, junglelike reefs of the Indo-Pacific, the Caribbean is like a garden, a peaceful kingdom in a tiny, wondrously clear sea. It harbors vast underwater orchards of brown elkhorn coral and an extraordinary variety of sponge life—from the giant barrel sponges, which dwarf their Indo-Pacific cousins, to the red helmet sponges, which look like lumps of coal but turn brilliant red when photographed with a flash. The fish are more conservatively “dressed.” The queen angelfish, for example, has a particularly regal quality that stands up to its Pacific relatives.

Isolated in the center of the Caribbean, the Cayman Islands, where these photographs were taken, are surrounded by the deepest waters in this small sea.

Now fish may not have souls (except certain flatfish) but they do have expression, which is most pronounced when the camera looks straight into their eyes, as with this school of grunts. The school of grunts also has another compositional element—a rare thing in the ocean—a repeated pattern.

Fish have intimate moments as well. This parrotfish, in a wreck off Georgetown, exudes a perfect bubble of mucus at night. The bubble surrounds the fish like pajamas, protecting it from the sides of the wreck and possibly increasing the parrotfish’s sensory powers. What I like best is the perfection of the bubble.
The Caribbean, a 750,000-square-mile sea, is protected from the North Atlantic Ocean by the Greater and Lesser Antilles. Thus sheltered, the local inhabitants have evolved in relative isolation from the broader, global ocean currents. And like villagers whose ancestors have lived for centuries within a remote mountain valley, they display a character both colorful and unique.

The two-horned spider crab, looking like a refugee from the Mardi gras, is one such creature. Sitting on the tip of a red rope sponge formation, this crab displays the fascinating “decorator” behavior common to a number of crab species. Carefully covering its body with selected bits of sponge and algae, the crab’s camouflage strategy is to resemble a piece of randomly accumulated refuse.

The Caribbean must surely be the sponge capital of the world, and within these waters there exists an astounding variety of shapes, colors, and sizes of these most primitive animals. As I focused on a red boring sponge, I felt like I was peering into an open heart, looking at ventricles and arteries and such. The network of tunnels was merely the beginning of a vast labyrinth of passageways designed to carry nutrient-rich seawater throughout this filter-feeding organism. Without even knowing it, and certainly without having any say in the matter, the sponge itself is host to a large colony of zoanthids. If I were able to look closely enough, I would probably find that the tiny zoanthids serve as home to yet smaller creatures. And on and on. But that would take a new lens.

Two-horned spider crab on rope sponge, Honduras
Boring sponge, Cayman Islands
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A ruddy copper butterfly alights on an aster in a Great Basin meadow.

E. S. Ross
Islands in the Desert

Lush mountain habitats support life above a sea of sage and scrub

by Paul R. Ehrlich, Dennis D. Murphy, and Bruce A. Wilcox

An apparently endless sagebrush desert punctuated by unspectacular mountain ranges, the Great Basin of the western United States seems a desolate place to most visitors. The flora and fauna are neither particularly diverse nor interesting compared with the riches of the Rocky Mountains and the Sierra Nevada, which form the Basin’s borders.

But the Great Basin does have a charm of its own, a charm made up of little surprises: dwarf columbines growing amid a fallen but still-rooted centuries-old bristlecone pine; a prairie rattler coiled in the shade of a rock; a small herd of wild horses surprised in a subalpine meadow; and deep in the canyons of those otherwise sparsely forested desert mountains, oases of woodland, lush with vegetation, flourishing along the banks of rushing streams.

These relatively moist habitats at elevations above 7,000 feet in the Toiyabe, Ruby, Snake, Schell Creek, White Pine, Jarbidge, and other ranges are especially interesting to biogeographers since they form a terrestrial archipelago—isolated islands of moist montane habitat in a sea of desert. Charles Darwin made evidence from island biogeography central to his argument that evolution, not special creation, was responsible for the diversity of life. If, Darwin asked, species had been individually created to live in certain habitats, why then are not all island organisms similar to one another? Why, instead, do island species have their closest relatives on the nearest mainland? In particular, Darwin made the Galápagos archipelago famous, and ever since, biologists have been attracted to the isolated biological systems of islands and have come to realize that many “islands” are not surrounded by water.

Clumps of host plants can be thought of as islands colonized by herbivorous insects. Patches of soil may be islands for plant species adapted to the distinctive mineral balance of that soil. Likewise, the forested mountain ranges in the Great Basin serve groups of plants and animals that cannot survive in the sea of desert around them. But these ranges have only been isolated for about ten thousand years. In the cooler, wetter conditions of the glacial...
periods, the moist boreal or montane habitat occupied most of the Great Basin, mountain summits and valley floor alike. Forests similar to those north of the Basin and those now restricted to higher elevations stretched farther south and into considerably lower elevations than today. As the glaciers receded, the ranges of the montane animals and plants were reduced. The heather vole, which now lives solely in the northern and western fringes of the Basin, once inhabited the Toquima Range in central Nevada. And pika, those denizens of high talus slopes, lived at elevations as much as 3,000 feet lower than their current habitats.

One of the great challenges of biogeography has been to explain variation in the species diversity of islands. Why, for instance, will one island support more bird species than another, apparently similar island. Since virtually all organisms will soon be living in habitat islands—parks and other nature reserves—surrounded by seas of human disturbance, this question has taken on new importance.

In the 1960s, Robert MacArthur and E. O. Wilson hypothesized that the number of species on an island is determined by immigration of species from the mainland and extinction of species on the island. As species become established they are removed from the pool of potential immigrants. Should all the mainland species become established, the immigration rate would equal zero. As more and more candidates for extinction become established, the extinction rate should increase. At some point, the theory went, the rates of immigration and extinction would be equal, and the number of species on the island would reach an equilibrium. As some go extinct and others establish themselves, the array of species might change, but the total will remain roughly constant.

This theory has been tested with field data numerous times. For instance, twenty-five years after a volcanic explosion demolished the East Indian island of Krakatau in 1883, thirteen land bird species had returned to its once-lifeless shores. By 1921 twenty-eight species had returned; by 1934 another species had returned; by 1952 there were thirty-three species; and by 1985 there were thirty-five species. At present the rate of increase in the number of species appears to be slowing, and the system may be approaching equilibrium. Between 1952 and 1985 the total number of species increased by only two: this was the result of seven new species becoming established and five resident species going extinct.

The theory of island biogeography makes two other predictions. First, larger islands should have more species and larger populations than smaller ones. Chance events such as droughts, floods, fires, and landslides are less likely to exter-
minate large populations, as are chance demographic and genetic events. Second, islands closer to a source of potential immigrants should have a higher immigration rate and thus will equilibrate with more species than more distant islands.

Several years ago we became interested in knowing how these principles might apply to the montane habitat islands in the Great Basin. For more than twenty years, we had been studying butterflies in California and, in particular, the endangered bay checkerspot butterfly, which lives in patches of serpentine grassland on Stanford University's Jasper Ridge Biological Preserve. We had assumed that the preserve was adequate to insure the survival of the butterflies, but a two-year drought, from 1975 to 1977, convinced us otherwise. It so disrupted the delicate timing between the butterflies' movements and the life cycle of their annual food plants that a third year of drought certainly would have led to the extinction of the Jasper Ridge populations.

The near disaster focused our attention on the vulnerability of invertebrates to habitat fragmentation. What kinds of reserves would protect the diversity of what is possibly the largest group of animals—plant-eating insects? Would a reserve adequate for mammals or birds provide long-term habitat for butterflies? Although
most conservation efforts are made on behalf of warmblooded vertebrates, invertebrates make up a much greater part of the earth’s animal life.

About 600 butterfly species live in North America, and because of the interest of amateurs, an enormous amount is known about the insects’ distribution and choices of host plants. In most cases butterflies feed on only one or a few related plant species. While an insectivorous bird may eat any bug it can get its beak on, and a seed-eating rodent can live on a variety of seeds, a butterfly cannot survive without specific plants upon which it lays its eggs and its larvae feed. Plant distribution, therefore, ought to be a much stronger determinant of the distribution of butterflies than of most birds or mammals.

To find out we turned to the Great Basin. In contrast to the situation on Krakatau, the islands in the Great Basin are collapsing toward total extinction rather than gaining new species. As boreal habitats shrink, intervening areas are drying up. With the exception of large species such as white-tailed deer, coyote, and mountain lion, mammals cannot cross the large seas of desert separating mountain ranges. Jim Brown, of the University of Arizona, found that, without significant migration, rates of extinction are the dominant factors in determining the diversity of the mountain mammal faunas; island size determined the number of species. Large, rare, and specialist species were likely lost rapidly from the smallest islands, more slowly from the largest. Of the fourteen small boreal mammal species in the mountain areas, thirteen live in the 684-square-mile Toiyabe-Shoshone island, while only three remain in the 47-square-mile Panamint island.

Near Ely, Nevada, three mountain ranges within fifty miles of one another have very different mammal populations. The smallest range, at Spruce Mountain, has Uinta chipmunk, cliff chipmunk, golden-mantled ground squirrel, and the bushy-tailed wood rat. In addition to these species, the nearby Shell Creek Range has vagrant shrew, yellow-bellied marmot, long-tailed meadow mouse, and Nuttall’s cottontail. The nearby Snake Range has all of the above-named species, plus an additional two species, the water shrew and the short-tailed weasel.
Brown and Ned Johnson, of the University of California, Berkeley, also found that bird species, unlike mammals, appear to be in an immigration-extinction equilibrium. Wherever suitable habitat exists, the appropriate bird species are normally found in residence. This makes sense, because the arid stretches between ranges are easier to fly over than to walk across. Again, the relationship between area and species diversity was a key finding—although the tendency of large islands to have many more bird species than small ones was much less pronounced than in the mammals. Furthermore, the arrival of dispersing individuals can shore up dwindling populations that might otherwise go extinct—a phenomenon dubbed the “rescue effect.”

To see how the populations of butterflies fared, we carried out a five-year survey in eighteen of the insular mountain ranges of Nevada and Utah. We assembled data from museum collections and from the extensive field notes of George Austin of the Nevada State Museum, which allowed us to map the distribution of butterflies across the islands and compare it with the distribution of birds and mammals.

We immediately found that there were fewer species of butterflies on the Great Basin islands than in areas of comparable size on the “mainland” of the Rocky Mountains. Of the seven species of alpines, satyrine butterflies that live in tundra and subalpine conditions from New Mexico to the far Arctic, none reach the Great Basin. Of the seven species of satyrines called arctics that live in the high Rockies, only one, the arctic chryxus, penetrates the Basin. None of the alpine sulfur butterflies of either the Sierra Nevada or Rocky Mountains are found in the Basin. Those that do enter the Basin, such as two tailless relatives of swallowtails, do so just barely. The small Parnassian is found in the Ruby and Jarbidge ranges and on Spruce Mountain in the north and in the La Sal Mountains in the east; the American Parnassian is found only in the Stansbury and Oquirrh mountains, the northeastern islands closest to the mainland. Yet the butterfly faunas of the Basin ranges are not as impoverished as those of the mammals. The Snake Range, for example, supports a butterfly fauna of 70 out of a potential pool of perhaps 110 species in an area of some 400 square miles.

To further investigate this phenomenon, we categorized the butterfly species of the Great Basin according to their penchant for movement. At one end of the spectrum are sedentary species, such as coppers and Edith’s checkerspots, that complete their entire life cycle in a single canyon. At the other end are butterflies, such as the monarch and the painted lady, which migrate, and others, such as the buckeye and the cloudless sulfur, that expand their ranges each summer.

When we considered the sedentary butterflies, the pattern was very much like that of the mammals. (We theorize that even though some butterflies from high elevations in different ranges look alike,
Where streams run through aspen groves, below, the lush vegetation supports more birds than butterflies. Lower mountain meadows, opposite page (foreground), support many butterfly species. Conifer forests support many more bird species. On the upper slopes of 13,000-foot Wheeler Peak (background), only a few butterfly species can survive.

Dennis Murphy

the inability of many of these species to cross from one range to the next may mean that each high-elevation population evolved independently from low-elevation populations in the same range: a case of evolutionary convergence.) The most vagile butterflies, by contrast, showed distributions similar to those of birds; small island size and great isolation had less effect on species diversity in those organisms than in mammals.

Johnson found that when it came to predicting the number of bird species on a montane island, habitat diversity, not island size, was the determining factor. We found that neither the diversity of the habitat nor its size (which explained the diversity of mammals) explained much about the diversity of butterflies. Butterflies do not seem to be greatly influenced by either island size or by the kind of habitat diversity that affects the number of bird species. Very little terrain is needed to support a large butterfly population if larval host plants are available. Where conditions are suitable, even small Great Basin islands often support large populations of a single butterfly species, which reduces the risk of the species being wiped out by a climatic or other change. The area of appropriate habitat then, and not area per se, may be most important to butterfly persistence and persistence on a montane island.

Small differences in topographic exposure, of no significance to a bird or an adult butterfly, may make a crucial difference in the microhabitat in which a butterfly caterpillar develops. Temperatures on the mountains can vary by tens of degrees within a very few yards depending on the steepness and aspect of the slope: a host plant that may survive on a south-facing slope, for example, might not make it on a slope that faces north.

To differentiate the biogeographic patterns that distinguish butterflies and birds, we studied one particular type of habitat. Many of the mountain ranges have numerous corridors of riparian woodland with aspen alder and willow lining the banks of rushing streams. These open woodlands are rarely more than thirty to fifty yards across. The larger riparian islands support a greater diversity of bird communities than do the smaller ones.

When we subdivided these areas and surveyed them, the relationships of butterflies and birds to habitat diversity became clearer. While more bird and butterfly species inhabit the larger riparian habitats, those rich in bird species are rarely rich in butterfly species, and vice versa. Areas rich in trees and shrubs support many bird species, including yellow warblers, blue-gray gnatcatchers, warbling vireos, McGillivray's warbler, Swainson's thrush, and northern oriole, all found in the riparian islands. In contrast, butterflies are most diverse in open habitats of herbs and grasses such as senecio, aster, and buckwheat, where they feed on nectar and drink from standing pools of water.

In the Great Basin, the distances between riparian fragments are rarely much more than half a mile. Reserves designed to preserve most bird species preserve most butterfly species as well. But where human development has fragmented the butterfly's range, the loss and increased isolation of habitat eliminates potential stepping stones that allow a species to recolonize after a natural extinction. Habitat loss can also result in the disappearance of key habitat components, which may not occur in the very smallest habitat islands.

In the Great Basin, streamside habitat is frequently disturbed. Roads have been cut to reach the mineral rich mountains, and woodland has been leveled to provide broad meadows for cattle grazing. Overgrazing by cattle eliminates the understory, and with it much of the avian as well as the butterfly diversity.

Since the earth as a whole is being rapidly converted into a system of habitat islands surrounded by a sea of human disturbance, the Great Basin can be viewed as a model for the global conservation of biological diversity. As island biogeographic theory predicts, the process of fragmentation, with the associated shrinking habitat, increases the isolation of those areas and raises the extinction rate while lowering the immigration rate. Thus, the faunas of the Basin islands equilibrate with fewer species. Precisely the same thing is happening throughout the entire planet.

The Great Basin may now be nearing the end of a period when most Americans knew nothing of it, when transcontinental drivers whizzed through it as quickly as possible, and when biologists, undisturbed, could use it as a seedbed for ideas about the size and shape of nature reserves. The single square mile of Lehnman Caves National Monument has recently been expanded into 120 square miles of Great Basin National Park. The Forest Service, which must manage the land for timber, mineral mining, and rangeland must also manage its charge to provide for diversity of native plants and animals. The new park includes spectacular Wheeler Peak, the highest point (13,063 feet) in the Snake Range, and one of the few remaining stands of bristlecone pine trees, which are among the oldest of all living things. All of this should bring both notice and tourists to the Basin, which we hope will introduce many people to the fascinating biology of desert islands.
Navigators of the Night

Bats have been listening to FM broadcasts for ages

by Michael J. Novacek

Bats are the baritones, tenors, and sopranos of the ultrasonic world, whose rich vocal repertoires are largely beyond our hearing capabilities. Anyone who has experienced the utter silence of a windless desert night may find it hard to imagine the existence of a great cacophony of ultrasonic buzzes, squeaks, and calls. Scientists studying these sounds and their use in hunting and navigation have relied heavily on modern instrumentation and technology. Nevertheless, very erudite experiments conducted in the last decade of the eighteenth century anticipated, by more than one hundred years, the theory of echolocation in bats. Although these early experiments clearly demonstrated acoustic navigation in bats, the idea that bats “see” with their ears was so alien to common experience that it was rejected, even derided, by prominent zoologists of the nineteenth century.

One evening in 1793, Abbé Lazzaro Spallanzani was casually observing the flight of a captive owl in his laboratory. Flying too close to the candle illuminating the room, the owl extinguished the flame and immediately became wildly disoriented, crashing into walls and furniture. Intrigued, Spallanzani subjected other flying animals to the same conditions and found that bats, unlike birds, were not at all hampered by the darkness.

Spallanzani, a professor at the University of Pavia, in Italy, was well known for his straightforward, albeit primitive, methods of scientific inquiry. To investigate bat navigation, he first covered the heads of bats of several species with opaque hoods and found their flight performance to be variable, but generally poor. Dissatisfied because he suspected that the hood interfered with more than vision, Spallanzani resorted to permanently blinding the animals. After being allowed a recovery period, the bats demonstrated a retention of their flying skills.

Although unnecessarily cruel, the experiments gave the first indications of what we now know to be true about the sensory system of certain bats: vision does not play any significant role in their navigation. Unfortunately, Spallanzani’s methods failed to lead him to the correct explanation for his results. He concluded that bats were aided by a “sixth sense,” an as yet undiscovered receptor organ that freed them from the need for vision.

Following up on Spallanzani’s work, in 1794 the French surgeon and biologist Charles Jurine found that if the eyes of bats were left intact but the ears plugged, they were transformed into hopelessly in-eflyers, incapable of avoiding collision with even large obstacles. Jurine proposed that the “sixth sense” that Spallanzani had hypothesized was, in fact, hearing. Unable to accept this idea, Spallanzani repeatedly attempted to refute Jurine’s proposal. But his own experiments at last compelled him to accept the theory that had at first seemed preposterous.

Others were not so willing to accept the evidence with an open mind. Notable among the detractors was the eminent zoologist Baron Georges Cuvier. In 1800, he aptly noted that the experiments performed by Spallanzani and Jurine “were extremely cruel and have done much more than simply lessen the powers of hearing.” But Cuvier’s alternative proposal—that the powers of navigation in bats could be ascribed wholly to the organs of touch—was not based on empirical observations. Nevertheless, Cuvier’s opinions on the issue won the day or rather, one might say, the century. For the next hundred years, zoologists regarded the Jurine-Spallanzani theory as an absurd, unscientific claim.

In 1912, in a remarkable article, the American-born engineer Sir Hiram Stevens Maxim suggested that bats detected obstacles by “feeling” reflections or echoes of low-frequency sounds produced by their wingbeats. This was a variation on Cuvier’s tactile theory, but one that involved sound vibrations and the intriguing phenomenon of echolocation. Maxim even cited this phenomenon in bats to support his proposal that disasters such as the one that befell the Titanic could be avoided if ships were equipped with an echolocating device of his own design.

One problem with Maxim’s theory was its emphasis on low-frequency sounds. By that time, scientists knew that reflections of sound off very small objects would require much shorter wavelengths and therefore much higher, perhaps even ultrasonic, frequencies. Higher frequencies are those in the upper range of human hearing, sounds between 15,000 cycles per second (cps) and 20,000 cps, or 20 kilohertz (kHz). Ultrasonic frequencies are those above the 20 kHz hearing limit in humans. In 1920, the English physiologist H. Hartridge proposed that bats actually detected sounds at higher frequencies, but he did not specify whether these frequencies were above or below the upper range of human hearing nor did he test his ideas with experimentation. Nonetheless, Hartridge’s theory inspired a series of studies begun in 1938 at Harvard University. These experiments, conducted by Donald Redfield Griffin, who was later aided by Robert Galambos, capitalized on the developments of contemporary sonar technology. The Pierce sonic detector translated the ultrasonic frequencies emitted by a species known as the little brown bat into frequencies that were audible to the human ear. From this, Griffin and G. Pierce, the inventor of the device, discov-
tered diverse calls emitted by these bats above 20,000 cps.

By 1945, Griffin and Galambos had established the basic facts about bat echolocation. To echolocate, bats emit cries of ultrasonic frequencies, as well as sounds in the upper range of human hearing. These cries were estimated to be extraordinarily brief in duration (one-hundredth of a second or shorter), and the bats’ auditory systems were thought to act as “high-tech” receivers, capable of tuning in on specific high frequencies in the echoes of their own vocalizations. The discriminatory power of the echo also proved to be remarkable. Bats could accurately locate objects as thin as a 16-gauge wire (slightly thicker than the edge of a dime) at a distance of a few feet. Therefore, Griffin and Galambos concluded that echolocation is not only useful in avoiding obstacles, but is probably also employed to detect small prey, such as flying insects.

Today, through modern instrumentation, we know that, in addition to bats, some birds, shrews, tenrecs (the so-called spiny insectivores of Madagascar), toothed whales, and even blind humans use echolocation. But echolocation is not a universal trait in bats. All bats belong to the order Chiroptera, a group further divided into the suborders Microchiroptera and Megachiroptera. Although only a sampling of microchiropterans have been experimentally analyzed, all living members of this group, some 700 species, are probably capable of echolocation. The remaining 150 bat species, which belong to the suborder Megachiroptera, are visually oriented. Only one group of megachiropterans, the dog-faced bats (of the genus Roussettus), are known to echolocate. Vocalizations of the dog-faced bats and all nonbat echolocators are typically low-energy “clicks” that cover a broad band of frequencies unstructured in time. In other words, bursts of the same kinds of sounds are repeated at regular intervals. Microchiropterans, by contrast, emit high-as well as low-energy pulses of very specific frequencies (sometimes as high as 212 kHz) that change in structure over time. For example, the sound may be represented by a sweep from a higher frequency to a lower one—the so-called frequency modulated, or FM, sweep. For purposes of analogy, consider a singer who starts on a high note and in the same breath modulates to a lower tone. As the pulses of sound are repeated by a bat, the FM sweeps may change; they may drop more rapidly to the lower tone. Also, the repetition of the pulses may become more rapid as a bat closes in on its target.

The differences in bat performance, notably the acrobatics and skilled target perception of the echolocating bats, are thought to reflect a uniquely refined system for processing information from the incoming echoes. We now know that this information is extremely varied. Each bat species produces calls of its own distinctive flair. Some calls are comparatively long, constant frequency (CF) tones that end in a brief downward FM sweep. Other calls employ a very steeply dropping broad-band FM sweep or several harmonics of this same wave pattern. Still others are relatively shallow FM sweeps or short CF components terminated with a steeply dropping FM flick. Moreover, different species emphasize different frequencies within both the ultrasonic spectrum and high-frequency range, all in as little as one-hundredth of a second.

The purposes of different vocalization patterns are now apparent. Shallow, narrow-band FM signals are excellent for detecting a target, particularly at a longer range where sound energy must be focused over a few frequencies. Steep FM signals of broad-band width and short duration resolve fine-grained detail and gather information about the target. Bats using the less precise shallow FM pulses to search for a target often shift suddenly to broad-band FM signals as they close in on prey. Constant-frequency or shallow FM signals are prone to errors, particularly associated with the Doppler shift phenomenon. The Doppler shift, which involves the change in frequency of sound relative to the velocity of an object, can be explained by common experience. The pitch of a loud siren rises as an ambulance approaches us and lowers as it passes by. The sound has been “Doppler shifted” according to the distance between the approach-
The theory that bats “see” with their ears grew out of work conducted in the
1790s by Lazzaro Spallanzani, left, but the idea was rejected by the scientific
community for more than a century. One theory, depicted below, of just how
bats used a “sixth sense” to echolocate proposed that “nerve centers” in the
wing relayed vibrations and received echoes.

The echolocation system of bats is a sensitive detection system. Information from
vocalizations is leaked to prey, competing bats, or other predators with sensory sys-
tems tuned to these signals.

These drawbacks may partly explain the limited use of echolocation by mam-
imals. The vast majority of mammals retain an emphasis on visual, olfactory, and
tactile perception. Hearing is also important but is used primarily to assess im-
mediate surroundings or to communicate. Few other animals use the echoes of their
own sounds to provide sensory information on prey items or obstacles.

Echolocation has thus evolved under special conditions in only a few mamma-
lian lineages. Within bats, echolocation probably evolved at least twice. The
echolocating skills of the dog-faced bats are not present in other members of the
Megachiroptera nor are the broad-band clicks of these bats like the time-struc-
tured pulses of the Microchiroptera. Microchiropters and megachiropters differ
in ways other than their sensory systems, and some scientists believe that
the two groups arose from different mammalian lineages. They argue that mega-
chiropters are close relatives of the visually oriented primates, while microchiro-
pters are allied with the insectivores. These suspicions seem exaggerated in
light of the overwhelming evidence for a

The single origin of bats accepted by most zo-
ologists. All bats share a unique nexus of char-
acteristics associated with their flying abilities. The class Mammalia contains a
few passive gliders, but bats are the only mammals capable of active flapping, or
powered flight. The origin of true flight in mammals, therefore, seems coincident
with the origin of bats. In addition, all bats share a number of unique traits indepen-
dent of the flight apparatus. By contrast, echolocation by means of time-structured
calls was acquired only by the diverse microchiropters. Echolocation therefore
evolved after bats diverged from their nearest relatives.

These considerations set the stage for a basic question concerning the evolution of
bat echolocation. The acquisition of powered flight in bats obviously did not necessitate the use of echolocation. What factors, then, did favor development of
this sensory system? Clearly, echolocation enables bats to discriminate small objects
at close range. It is disadvantageous, how-
ever, in that it provides a less resolved image of more distant objects at the addi-
tional cost of sound production, elaborate signal processing, and information leakage. Nonecholocating megachiropters typically feed on fruit or nectar rather than on flying insects. Likewise, those microchiropters that are nectar and pol-
len feeders show a decreased emphasis on echolocation. Bats that pursue nocturnal
flying insects tend to use a sophisticated echolocating system.

A combination of factors, then, would seem most opportune for the development of
echolocation. This system works par-
ticularly well when it is used to hunt small
flying insects at close quarters under condi-
tions of low or unpredictable light. Al-
though many birds are insectivorous, they
are primarily diurnal in habits. Thus, noc-
turnal flying insects represent an enor-
mos resource for which echolocating bats face little competition. M. Brock Fenton, a noted authority on bat behavior and audition, has suggested that
echolocation in these animals may have evolved through three stages. The first
stage is the development of echolocation from signals used in bat-to-bat communi-

At close range, echolocation provides bats with information on a target's size, shape, distance, and escape velocity. Most echolocating bats, like the little brown bat feeding on a katydid, opposite, and the aptly named long-eared bat, below, prey on nocturnal flying insects. In contrast, nonecholocators tend to feed on nectar and fruit.

The second stage is the use of a broad-band, unstructured form of echolocation, which an animal uses to gather information about its surroundings—a stage apparently attained in most echolocators outside the Microchiroptera. The third stage is the refinement of echolocation for the purpose of detecting targets as well as for communication. Hence, the unique echolocating system of microchiropterans may be built on independently developed, second-stage skills that bats share with certain other vertebrates.

How can the history of the three stages be traced? All living species of microchiropterans that have been studied are capable of refined third-stage echolocation, and so do not provide direct clues to the earlier stages of the supposed transition. Moreover, direct historical evidence, namely fossils, rarely provides unambiguous evidence for a particular sensory mode or behavior. Instead, fossils usually preserve only the hard parts of the animal's anatomy. Fortunately, the earliest-known bats, which date back to fifty-million-year-old Eocene faunas from North America and Europe, are beautifully preserved, nearly complete skeletons that sometimes show impressions of wing membranes, hair, and even digestive contents. The conservative skeletal features in these fossils have led some scientists to claim that certain Eocene forms belong to a group more primitive than, and ancestral to, the living suborders of bats.

In 1984, I began a detailed anatomical study of these fossils in the hope of finding clues to their auditory capabilities. I was surprised to find that these extinct forms had structures that indicated an extremely refined auditory system. The cochlea, the bony capsule that encloses the inner ear, was strongly inflated, a feature unique to echolocating microchiropterans. Likewise, features of the tiny ear ossicles as well as the bony part of the hyoid apparatus (which supports the tongue and its muscles), indicated specializations for auditory reception and sound production compatible with the notion that these ancient bats were accomplished third-stage echolocators. This was supported by the structure of the teeth, which closely resemble those of microchiropterans that feed on aerial insects. In addition, West German paleontologists were able to identify parts of flying insects in the fossilized stomach contents of the European specimens. More recently, specialized echolocators, including forms capable of “flutter detection,” have been identified among the Eocene bat species from West Germany.

These observations have clarified certain aspects of the evolution of echolocation in bats. Even the most sophisticated version of this system has a very long history. As shown by the oldest-known fossil bats, it was present at least fifty million years ago. In fact, the anatomical structures preserved in the fossils indicate that these forms may have a more specialized auditory system than some living lineages of echolocating microchiropterans. This system was present even though some of these ancient bats retain a number of primitive skeletal traits in the flight apparatus, suggesting that although flight preceded refinement of echolocation in bat evolution, the use of this sensory mode in predation may have influenced further modifications of the flight apparatus. This scenario seems plausible in light of the extraordinary aerial acrobatics of insect-feeding microchiropterans.

At the same time, these findings may raise more questions than they answer. The advanced skull structure of the Eocene fossils indicates that the transition to echolocation, and for that matter the origin of bats, occurred incalculably earlier than the first records of the group. There is as yet no fossil evidence for less-refined stage one or stage two sensory systems in microchiropterans. Moreover, there are few clues to the divergence of the living bat suborders from a more primitive pattern. The answers to these questions may lie in much older, but as yet unexplored, fossil-bearing rocks. Or perhaps further studies of living bats will elucidate the pathway of evolution for the echolocating system. Whatever the direction of inquiry, the study of bat echolocation offers the same elements of surprise, mystery, and challenge that it did in Spallanzani’s dark laboratory nearly two centuries ago.
The billions of antarctic krill that live in the Southern Ocean are among the main consumers of the microscopic floating plant life known as phytoplankton. Pivotal to the antarctic ecosystem, krill are themselves food for a great array of other animals, including baleen and sperm whales, crabeater seals, fur seals, flying birds, such as the black-browed and gray-headed albatross, and Adélie, macaroni, chinstrap, king, and emperor penguins.
Fragile Life under the Ozone Hole

*Increased ultraviolet radiation may be weakening the primary link in the antarctic food chain*

by Sayed Z. El-Sayed

Twice within the century humans have threatened marine life in the Antarctic. In the early 1900s a greedy industry nearly annihilated the southern fur seal and baleen whales. Now, as the world seems poised to reap more of the Southern Ocean’s living resources, marine life is threatened once more, this time by an increased level of ultraviolet radiation. The culprits are chlorofluorocarbons (CFCs), the manufactured chemicals once hailed as miracle compounds and used extensively as coolants in refrigerators and air conditioners and as propellants in aerosol sprays. CFCs destroy the ozone in the stratosphere, increasing the amount of ultraviolet (UV) radiation reaching the earth’s surface.

Ozone, a triatomic form of oxygen, is rare in the lower atmosphere. Small but crucial amounts in the stratosphere (six to thirty miles above the earth’s surface) shield the earth from most solar ultraviolet radiation. Although the drastic thinning of the ozone layer apparently began about 1976, it was not until May 1985 that scientists with the British Antarctic Survey in Cambridge published the results of the observations they had been making since 1957. The ozone over Antarctica decreased dramatically each September and October and then gradually replenished itself by the end of November. Scientists monitoring the annual thinning of the ozone layer over Antarctica reported that in October 1987 the ozone reached its lowest recorded level ever, and the decline lasted into December, the longest period ever. More alarmingly, recent data indicate that ozone depletion is occurring on a global scale, although nowhere as extensively as over Antarctica. At its maximum, the antarctic “hole” was the size of the United States.

Ozone depletion over Antarctica is causing renewed concern about the consequences of increased levels of UV reaching the earth’s biosphere. Solar ultraviolet radiation is composed mainly of UV-A and UV-B, categories based on wavelengths. The shorter wavelength radiation, UV-B, is the more biologically injurious component of sunlight. In humans, UV-B causes sunburn and skin cancer, has been
In the Antarctic, phytoplankton live in the pack ice as well as in open water. Experiments conducted at Palmer Station on Anvers Island suggest that increased exposure to ultraviolet light decreases the productivity of these microscopic plants.

Joe Lelieveld

linked to cataracts, and can suppress the immune system. Studies have also shown that UV-B is harmful to many other forms of life, from bacteria to higher plants and crops. And recent investigations suggest that aquatic ecosystems may be especially vulnerable.

One area of concern involves the free-floating microscopic plants, known collectively as phytoplankton, which convert sunlight and chemicals into nourishment for themselves and for other organisms in the food chain. Numerous studies in recent years suggest that increased UV-B radiation at the ocean surface reduces phytoplankton productivity, that is, their rate of photosynthesis. Thus, by weakening the base of the food web, UV-induced changes could have extensive effects on the entire ecosystem.

Although the effects of ultraviolet radiation on marine phytoplankton in temperate and subtropical regions had been studied by several investigators, no such studies had been carried out on antarctic phytoplankton. In January 1987, an excellent opportunity to study the effect of UV on antarctic phytoplankton arose when Larry H. Weber, then a postdoctoral fellow at Texas A & M University, took part in a cooperative research cruise aboard the Polish vessel Professor Siedlecki off the Antarctic Peninsula. The main objective was to study the distribution of the shrimplike crustacean krill (Euphausia superba) and its relation to its food base, phytoplankton, but Weber was also able to conduct a short-term experiment to study the effect of ultraviolet radiation on phytoplankton productivity in these waters. Reducing UV radiation, he found, doubled or tripled the productivity of the phytoplankton, indicating that UV radiation inhibits primary production.

Recognizing the far-reaching implications of the findings on the Professor Siedlecki, I led a group that embarked in November 1987 on an in-depth study of the potential ecological effects of UV on antarctic marine phytoplankton. We selected the waters of Arthur Harbor, Anvers Island, as the site of our investigation, and since their short life spans may make them more sensitive to changes in ultraviolet radiation than are other components of the ecosystem, we studied phytoplankton, particularly ice algae populations.

Phytoplankton in the Antarctic live un-
The greatly thinned ozone layer (known colloquially as the ozone hole) over Antarctica has meant an increase in the amount of potentially harmful UV radiation reaching the earth. A satellite plotting of the Antarctic ozone hole for October 5, 1987, shows the lowest ozone value ever observed. On that day, the ozone hole covered nearly half the continent, or 2.5 million square miles.

NASA
under some highly specific conditions. Most unusual is the seasonal waxing and waning of the pack ice (from 12.5 million square miles—an area larger than Antarctica itself—at the end of the austral winter, to 2.5 million square miles in summer). This largest seasonal process in the world oceans has earned Antarctica the name of the “pulsating continent.” The formation and breakup of pack ice are important stages in the annual cycle of the marine ecosystem. At breakup, many planktonic species that live in the ice are released into the water; the speed of that breakup may affect the total seasonal production.

Since the rise and fall of productivity is in synchrony with the seasonal variation in solar energy, the variability of daylight, shifting from perpetual darkness in winter to continuous light in summer, also has a profound effect on marine plant life. A third special feature of the region is the Circumpolar Current, which connects circumantarctic waters into a single system, the Southern Ocean, transporting plankton and mineral nutrients, such as nitrates, phosphates, and silicates, throughout. In response to these unique physical features,antarctic plankton have developed characteristic features: circumpolar distribution, tolerance of near-freezing temperatures, and the ability to adjust to extreme variations in solar energy.

Unlike most phytoplankton, which float freely in the water, some types of microflora reside in the pack ice. Among these are the diatoms, dinoflagellates, silicoflagellates, and green flagellates. Of these, diatoms generally predominate. “This order [diatoms] occurred in such countless myriads as to stain the sea everywhere of a pale ochreous brown, in some cases causing the surface of the ocean, from the locality of the ships, as far as eye could reach, to assume a pale brown colour.” So wrote J. D. Hooker, the famed botanist-surgeon of the Erebus and Terror expedition (1839–43), under Sir James Clark Ross, in describing the ubiquity of the ice algae of the Southern Ocean.

We had originally planned to conduct our experiments in the open waters of Arthur Harbor. Unfortunately, unusually heavy sea ice, which covered almost all of

Diagram: Using solar energy, phytoplankton convert inorganic compounds such as phosphates, nitrates, and silicates into organic plant matter, thereby providing the food for herbivorous zooplankton and krill. These animals, in turn, are a major food source for the larger free-swimming animal life of the Southern Ocean. Among the important types of microscopic plants in the Southern Ocean are the diatoms, dinoflagellates, right, top. A mixture of plant and animal plankton, right, bottom, photographed in the waters east of the Antarctic Peninsula includes a star-shaped protozoan known as an acantharian, a chambered foraminifer, and the ubiquitous algae known as diatoms.

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Arthur Harbor during the entire period of our investigation, thwarted our research. We were therefore forced to modify our sampling strategy and to depend, for the most part, on the water pumped from a hole (cut through sea ice four to five feet thick) to the experimental site. We also collected brown melt ice, of the type described by Hooker, in the vicinity of Palmer Station’s ship dock, and from the nearby open waters at Bonaparte Point. The water from the ice hole was pumped to a mixing tank and was subsequently dispersed to flow-through chambers in four treatment tanks. The experimental setup was kept outside Palmer Station laboratory under ambient light conditions.

In an effort to create conditions as natural as possible, the treatment tanks were made either of transmitting or absorbing plexiglass (depending on whether the object was to eliminate, reduce, or enhance UV-radiation levels).

The water in tank No. 1 was exposed to ambient light, including UV-A and UV-B. Tank No. 2 was exposed to ambient light, but both UV-A and UV-B were excluded. Tank No. 3 was exposed to ambient light with a reduced level of UV-B. Tank No. 4 was subjected to ambient light, with an enhanced level of UV radiation supplied by sunlamps. The enhanced UV radiation was about 50 percent greater than ambient UV, a figure that roughly equals UV-B levels at 25 percent ozone depletion. We carried out similar experiments on the phytoplankton collected from the open waters off Bonaparte Point and with the samples of brown melt ice.

Our findings on photosynthesis corroborated the earlier results on the Professor Siedlecki: the phytoplankton was two to four times more productive in the tank from which both UV-A and UV-B were excluded. Conversely, photosynthetic rates were much lower under conditions of enhanced UV than under ambient conditions. This was the case in all our experiments, whether we used the phytoplankton from under the ice, ice algae, or phytoplankton found in the open waters off Bonaparte Point.

We also studied phytoplankton pigmentation and how it changed with exposure to varying levels of UV. In some phytoplankton, pigmentation increases in response to high levels of solar radiation. Alpha- and beta-carotene (orange) and zeaxanthin (yellow), for instance, are thought to play an important role in protecting some microflora from destruction at high light intensities. Our experiments suggested that short-term UV exposure may produce long-term increases in the concentration of the pigment dinonaxanthin, a possible adaptive mechanism for reducing UV stress.

In some cases, however, ultraviolet exposure seemed to weaken pigmentation. In tank 2, where both UV-A and UV-B were eliminated, the cells were bright gold and the total mass of cells was very great. The dominant species was the diatom Navicula glaci. In tanks 1 and 3, with ambient or reduced UV-B, respectively, the algae were not so abundant, but their color was still golden. In both of these tanks N. glaci also predominated, but in substantially reduced quantities. Few algal cells grew in tank 4, however, and those that did looked bleached. This, together with the relative abundance of empty diatom shells in the samples microscopically examined, seemed to point to the deleterious effect of UV radiation.

The impact of increased UV radiation on algal cells is not limited to a decrease in the rate of photosynthesis or to the change in pigment concentrations or to the production of protective pigments. High UV
levels also affect which species make up the algal community. Evidence from laboratory studies of other scientists indicates a differential sensitivity of algal cells to enhanced UV levels. In some of those experiments, irradiation with UV-B resulted in a decline in diatoms, while other types of algae survived with impunity.

The possible shift in the composition of the algal population was accompanied by a change in relative proportions of large and small species. Most easily harmed by enhanced UV were the nanoplanクトon (organisms less than twenty micrometers in diameter) and picoplankton (organisms less than two micrometers in diameter). Some researchers posit that protozoans feeding on antarctic nanoplankton and picoplankton form a major link between the primary producers (phytoplankton) and the herbivorous zooplankton and krill.

Recent studies have shown that nanoplankton and picoplankton make up a substantial proportion of the total phytoplankton biomass and primary production in the Antarctic. This finding, plus the possibility that these organisms are especially sensitive to UV-B, could have serious implications for the overall community structure and feeding relationships in the antarctic marine ecosystem.

So far I have discussed only the possible effects of UV-B radiation on surface and near-surface phytoplankton and on ice algae. But what about the phytoplankton that live well below the surface? Photosynthetic organisms are found throughout the water, down to the so-called euphotic depth, the depth at which only one percent of surface light penetrates—a figure that varies from a few feet to several hundred feet depending on the clarity of the water. Although turbidity may limit the penetration of light into coastal waters, in calm waters of the open ocean, UV light can penetrate to a depth of sixty feet or more. Thus, UV may also affect deepwater planktonic species and species that move up and down in the water column. In periods of very low mixing (in calm weather or when the ice melts during the austral summer), phytoplankton productivity increases, while mixing generated by wind lowers productivity. Accordingly, the residence time of deeper water organisms in the near-surface layer (and therefore their exposure to UV-B radiation) must be considered when assessing the total effect of UV on plankton production.

What about the effect of enhanced UV-B radiation on the organisms above the phytoplankton in the antarctic food web—the zooplankton (microscopic animal life) and the nektob (free-swimming organisms, including krill, fish, squid, and marine mammals)? We know very little about the reaction of these organisms to elevated levels of UV in the polar regions. However, there is abundant literature on the response of tropical, subtropical, and temperate marine organisms to increased UV levels. More than half a century ago, for example, investigations showed that the shorter UV wavelengths could kill *Calanus finmarchicus*, the most common copepod in temperate and subarctic regions. More recently, laboratory research on another marine copepod, *Acartia clausii*, indicated that UV-B radiation increased death rates and reduced fecundity in the survivors. We must still determine whether current solar UV-B affects antarctic copepods or not.

Furthermore, laboratory experiments in the Pacific Northwest a few years ago demonstrated that beyond certain levels, UV-B depressed the activity, developmental rates, and survival rates of shrimp, shrimplike crustaceans, and crab larvae. But we do not yet know if enhanced UV-B has a similar effect on antarctic krill.

Benthic, or bottom dwelling, organisms are also susceptible to UV-B radiation. About fifty years ago, researchers noted that UV-B retarded egg cleavage in the sea urchin. Other experiments carried out in the late 1960s and early 1970s on marine animals associated with coral reefs showed that shade-loving organisms such as sponges, bryozoans (creatures that form mosslike colonies), and tunicates (animals that develop covering mantles) were killed by exposure to solar UV radiation. On the other hand, a species of black sponge was unaffected, presumably because of its pigmentation. Several corals withstand high levels of UV-B radiation by producing the protective "pigment S-320." The function of S-320 is analogous to that of the melanin pigments that protect the outer skin layer in light-skinned humans exposed to the sun.

Plants and animals also cope with enhanced UV radiation by repairing the genetic damage caused by the exposure. Specific strategies used by antarctic organisms are currently being investigated at Palmer Station by Deneb Karentz, of the Department of Energy, Laboratory of Radiobiology and Environmental Health.
Penguins dot the antarctic ice. What direct effect, if any, increased ultraviolet radiation has on antarctic birds and mammals is not known. But if increased ultraviolet energy damages the vulnerable microscopic plant life of the Southern Ocean, the indirect effect on populations of higher animals would be devastating. 

Flip Nicklin

at the University of California, San Francisco. Karentz investigates bacteria, phytoplankton, zooplankton, seaweed, and some intertidal invertebrates whose shells may block out harmful UV radiation but whose gametes and larvae are exposed to UV in surface waters. According to Karentz, when DNA molecules are exposed to UV radiation, they change in structure. If the DNA molecules are not repaired, mutations in impaired cells may affect the genetic makeup of future generations. While some organisms have only one DNA repair mechanism, others may have two or three. The question now is, how effective are these pathways in antarctic organisms? Karentz's research may shed light on the subject.

Despite the preliminary nature of the results of our Palmer Station experiments, I believe they are sufficient to implicate elevated UV-B radiation in the decrease of the photosynthetic rates of antarctic phytoplankton, in bringing about a pigmentation change in algal cells, and in shifting the composition of the algal community. However, we do not yet know whether these findings can be applied to the phytoplankton and ice algae of the whole Southern Ocean. Considerable caution must be exercised in extending the results of our short-term laboratory experiments to the real world. In the latter, one has to contend with a host of complex, interrelated factors, among which are: the depth at which UV is attenuated; the depth of the water layer mixed by the wind; the residence time of the algal cells in the euphotic zone; seasonality of UV exposure; behavioral response of the targeted organisms to solar UV and their ability to repair damaged DNA molecules. As to whether the effect of UV-B on the algal population is short-lived, long lasting, or reversible, our limited data do not provide a final answer.

It would seem, however, that the ozone hole is not a transient phenomenon. After all, it took nearly fifty years for the CFCs to make their presence felt in the antarctic atmosphere. (CFCs were first manufactured in 1930 and were detected over Antarctica in 1976.) With the continuing release of nearly 362,000 metric tons of CFCs annually, and with a lifetime ranging from 75 to 100 years, the compounds will linger in the atmosphere to the end of the next century at the very least.

The question is, what will be the long-term effects of CFCs on the antarctic marine ecosystem? Given the long lifetime of these pollutants, and if our Arthur Harbor findings are an indication of what is in store for antarctic phytoplankton, the impact of elevated UV-B could be extremely damaging. Among the first casualties would be the herbivorous krill. And since krill provide the link between phytoplankton and higher organisms, namely, fish, birds, and mammals, their demise could trigger dramatic changes throughout the antarctic ecosystem.

In 1978, the United States banned the use of CFCs in certain aerosols, such as hair sprays. Now, after ten years of pleading by the United Nations Environment Program, representatives from twenty-four nations signed an agreement in September 1987, in Montreal, to regulate worldwide production of CFCs. The Montreal Protocol, although laudable, does not go far enough. It freezes CFC production at current levels and requires a 35 percent reduction in global CFC production by 1999. What is needed to stabilize the ozone layer at its present level is a reduction of more than 85 percent of the worldwide production of CFCs. Even then, it will take hundreds of years to stabilize the layer! The impending threats posed by stratospheric pollutants underscore the irony that, while governments plan to construct shields against nuclear missiles, the shield that protects us all from destructive UV radiation is threatened by man's own folly and shortsightedness.
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Millions of Mouths to Feed
by Jerome B. Grieder

In a small town library some years ago, I discovered Willa Cather's elegiac novel *Death Comes for the Archbishop*, which concerns the pioneering history of Catholic missionaries in the American Southwest, shelved (because of the title, one presumes) next to Agatha Christie among the whodunits.

By the same logic, it seems not improbable that E. N. Anderson's *The Food of China* may somewhere find its way into the section devoted to "Cookery (Chinese)." True, the reader will find here a scattering of menus and recipes (including some intriguing twelfth-century "barbarian" examples), a well-informed discussion of regional specialties, and an expert chapter on "basic cooking strategies." But *caveat lector:* this is not a cookbook or a treatise on Chinese cuisine or the Chinese diet or Chinese nutrition—although at the same time it is all of these. In brief, *The Food of China* is an uncommonly wide-ranging, imaginative, and knowledgeable essay on China's traditional material culture, with the history of agriculture at its center, but also taking into account the social, institutional, technological and scientific, and even the aesthetic and literary dimensions of this complex subject. There is a wealth of information and interpretive insight here for the specialist on things Chinese. For the general reader, I know of no better introductory overview to the intricate synthesis of human and natural resources that created and sustained traditional Chinese civilization.

One of the durable Western stereotypes concerning "Old China," attributed to Chinese peasants in their confrontation with nature, is a characteristic fatalism born of wisdom or bitter experience. "Man belongs to the soil, not the soil to man," wrote one early twentieth century European observer. This view reflects not merely Western romanticization of the exotic, primitive, and (allegedly) pure. It was also the explicit message of Chinese traditional high culture. In the classical Confucian canon, the emphasis is invariably on the importance of preserving the essential harmony between the natural order and the order created by humankind in response to its fundamental social instincts. Daoism, the philosophy of so much Chinese poetry and painting, urged human compliance with "The Way of Nature," not struggle against it, as the prescription for survival in an uncertain world. Mao Zedong's frequent exhortations to rise up against human subservience to the exigencies of nature are rightly viewed as a "modern" element in the revolutionary Chinese scheme of things.

But the Chinese had their own version of the parable of the Flood. The Chinese Flood was not a purifying act of judgment, but a catastrophe of nature; and the response was entirely practical and purposeful. The legendary emperor Yu—one of the cultural heroes upon whom the creation of Chinese civilization proverbially rests—did not build himself an ark and float hopefully upon the waters. Instead, he devised a system of canals and dikes that would lead the waters to their rightful destination in the seas and allow the crops to grow. The emperor Yu intervened against nature—and so the Chinese have been doing over the millennia since that remote age. It is this interventionist aspect of the Chinese tradition that establishes the premise of *The Food of China.* "Few peoples have transformed their countries' landscapes more thoroughly than the Chinese," Anderson writes.

Rather than geographic determination of human fate, China illustrates human determination of geographic fate. . . . Much of China is now a purely human creation. The Chinese were, and are, adept at making the land serve their ends rather than allowing it to constrain them. . . . [T]he landscape provides opportunities and shaping forces, but the actual fate of humanity in that landscape is determined by human choices that are constrained more by social and historic factors than by natural ones.

Anderson's approach, therefore, is logically historical/social. The first half of the book traces the development of Chinese agriculture—and of the social and political institutions that were erected on the foundations of the agricultural economy—from earliest times down to the end of the imperial system in the early twentieth century. Although the Chinese were not history's first recorded agriculturalists—earlier agrarian communities appeared in both the Near East and in North America—archeological sites dating from roughly 6000 B.C. onward attest to the existence of a sustained and increasingly complex agricultural society. By the first century B.C., at the height of the Early Han dynasty (that is, roughly speaking, by the beginning of the imperial age), Chinese agriculture, still largely the agriculture of the highlands and plains of North China, had developed remarkably sophisticated technologies for water conservation, drainage and irrigation, rice cultivation (although millet remained the staple grain for centuries), multiple cropping in many areas, and fertilization, including the pretreatment of seeds. Food had long since come to play a significant role in sacrificial religious rituals and in medicinal applications. And the idea of independent peasant households as the foundation of agricultural productivity had become established. Later allegiance to this ideal was, to say the least, sporadic, but the Chinese tended to return to it as the consequence of either policy or slow institutional evolution, as they have returned to it with dramatic results in the last decade. And the idea that government should play an active role in the promotion of agriculture, or at least to regulate and stabilize
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the conditions of peasant life, had similarly become an established axiom of imperial rule—although again, in later ages there was a wide disparity between theory and effective governmental practice.

According to Anderson, the second developmental stage in the history of Chinese agriculture encompassed the centuries between the fall of the Han (ca. A.D. 220) and Tang (618–907) dynasties, for at least two important reasons. First, it was during this time that China was receptive to foreign influences more than it had been previously or has been most times since. Buddhism was introduced, via central Asia, and exercised a slow but profound influence on the spiritual, philosophical, and aesthetic aspects of Chinese culture. This “opening to the West” brought new foods to China (the sugar beet, spinach, lettuce), it encouraged new styles in the preparation of wheat products, and to some extent it popularized grape wine as a supplement to earlier alcoholic beverages derived from wheat or rice. Buddhism, preaching respect for life in all its forms, may also have discouraged consumption of beef and other meats—certainly it contributed to the social demigam of butchers and craftsmen of leather and other animal products. Second, and more important, it was during these centuries that the Chang Jiang (Yangtze River), and the lands to the south, became fully incorporated into the Chinese political domain and economy, while the political center of gravity remained in the north. This allowed for economic and agricultural diversification even as it created the geopolitical tensions that characterized much of the history of the final imperial millennium.

Historians have long recognized the Song dynasty (960–1279) as the hinge upon which Chinese social and economic history turns. This is the period we must examine to trace the origins of late traditional (or even in some respects modern) Chinese civilization, characterized increasingly by mercantilism and the commercialization of agriculture and increasingly influenced by an urban-centered popular culture and a rigidly orthodox official ideology. It was also during the Song that what Anderson calls China’s “food system” assumed the character it would retain, with subsequent elaboration and variations upon basic themes, into our own time. Cultivation of cotton and sugar cane likely dates from the Song. (Although Anderson is primarily concerned with food crops, he does not ignore, where appropriate, the history of other agricultural products, such as silk and cotton, crucial to the development of traditional Chinese material culture.) Rice became the predominant food grain, and tea, which had been a rarity, became a lucrative commercial crop, although it remained more or less a luxury. At the beginning of the eleventh century, fast-ripening Champa rice was introduced and popularized by imperial decree, resulting in a vast increase in the area devoted to multiple cropping. Such innovations, together with the later introduction of new crops from the New World (for example, sweet potatoes, peanuts, and maize in the sixteenth century, probably via Manila), created the necessary conditions for the population explosion with which the Chinese have contended since at least the beginning of the Ming dynasty (1368–1644).

Chinese agriculture, and the Chinese diet, were thus historically diverse, dynamic, and cosmopolitan, directly or indirectly receptive to foreign influences and innovations. The government, when it was functioning well (as it did for long stretches of time), did indeed take agriculture seriously as more than an exploitable source of revenues. And Anderson argues persuasively that the Chinese peasant was far from being an unskilled laborer, a source of brute energy but not of expertise, akin to Edwin Markham’s “Man with the Hoe,” “bowed by the weight of centuries... the emptiness of ages in his face... stoict and stunned, a brother to the ox.” On the contrary, “the incredible industriousness of the Ming farmer is matched only by the amount he had to know” in the way of inherited practical or folk wisdom. “No country did more with its resources than did China,” Anderson concludes.

Yet the fact remains that despite peasant industry and ingenuity, a remarkably developed traditional technology, steadily expanding acreage under cultivation (but at a slower rate, as time goes on), a durable and occasionally effectively expressed governmental concern, and all the other factors that make the history of Chinese agriculture a success story, it is not—or was not, when China was compelled to enter the stream of modern world history—a story that ends on a note of triumph. On the eve of its recent revolutionary transformation, China was overcrowded and underfed, beset by entrenched social and economic inequalities in the countryside, suffering from institutional and technological stagnation. Why? It is a complex question, to which a number of answers have been suggested, ranging from the class struggle determinism of Marxist historiography to the comparably deterministic (if somewhat less rhetorical) hypotheses of demographic ecology. An-
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Jerome B. Grieder is a professor of history and East Asian studies at Brown University, where he teaches courses in nineteenth- and twentieth-century Chinese social and intellectual history. His most recent book is Intellectuals and the State in Modern China: A Narrative History (Free Press, 1981).
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Third Touch of Venus

by Thomas D. Nicholson

When two celestial bodies are aligned longitudinally in the sky, or along the same line of sight, they are said to be in "conjunction." Because the moon moves all the way around the sky about once a month, conjunctions of Venus and the moon are common. But they are not always close. Because of the tilt of their orbits, they can be separated by more than 13 degrees (more than twenty-six times the diameter of the moon) even at their closest during a conjunction. Then they separate rapidly. If they pass so close that the moon covers the planet, the event is called an occultation.

This year's calendar includes three occultations of Venus: January 21, April 19, and October 6. Unfortunately, North American observers couldn't see the moon cover the planet in January or April and will not be able to see the event in October either. Venus was a little too far north in January; the moon covered it only as seen from the Southern Hemisphere. In April the planet was too far south. Even though it was above our horizon when the occultation occurred, the moon missed Venus in our sky, covering it only over arctic regions. This month's occultation takes place during evening hours in North America, but Venus is a morning star now!

The syzygy (another name for conjunction) of January 21 placed Venus and the young crescent moon low in the southwest during evening twilight only four hours after they were closest. A good view if wintry skies were clear, but low because the moon and Venus were well south of the equator. The conjunction of April 19 was memorable: the moon and Venus were very high and easily visible in our sky at exactly the time of their closest approach and remained visible several hours after dark. All circumstances favored observers in North America.

The October 6 conjunction of Venus and the moon brings another opportunity to enjoy one of nature's most striking sky scenes, but only for early risers. Venus and the moon are morning objects, visible from about 2:30 A.M. (standard time) until dawn. They will be well up in the southeast at daybreak, with the moon above Venus on the morning of the 6th. The time of closest approach is about 10:00 P.M., EST, on the 6th, but when we see the pair again the morning of the 7th, the moon will have passed Venus and appear below it. The sight is worth getting up to see.

Events in the calendar below occur in local time unless otherwise indicated.

October 1: A waning gibbous moon rises about 10:00 P.M., EST, just after crossing from Taurus to Gemini. The red-dish star rising to the left is the Bull's Aldebaran, while Gemini's bright Castor and Pollux come up an hour later.

October 2: Last-quarter moon is at 11:58 A.M., EST. Jupiter in the east and Mars in the south, two brilliant current planets, are well up the sky by moonrise, just before 11:00 P.M.

October 4-7: Interest shifts to the dawn sky with the moon as a waning crescent rising after midnight and remaining past daybreak. Watch from day to day as it approaches and passes Venus and Leo's bright star Regulus.

October 4: Looking at Venus, you may wonder where Regulus went. It's there, next to Venus, only a quarter of a degree away, but the planet is so bright that its glare hides the star. Venus passes the star and moves east of it about 3:00 A.M., EST.

October 6: Notice the nearly perfect lineup of the moon, Regulus, and Venus before dawn. The moon passes and occults Regulus at about 3:00 P.M., EST, and Venus at about 10:00 P.M., EST. The occultation of Regulus occurs above our horizon, but in daylight. Venus is occulted after it sets, but the event can be seen in Asia and eastern Europe.

October 7: This morning, the crescent moon, at apogee (farthest from the earth), is underneath both Regulus and Venus.

October 10: New moon, in Virgo, is at 4:49 P.M., EST.

October 11: Mercury, at inferior conjunction (between the earth and the sun), becomes a morning star.

October 12: The young crescent moon is in the west at evening twilight. The moon was more than twenty-four hours old at sunset on the 11th, but conditions were not good for viewing it that early.

October 14: The waxing crescent moon and the ruddy star Antares form an attractive pair in the southwestern twilight sky. For observers in southern Australia and Antarctica, the moon will occult the star.

October 15-18: The evening moon moves through Sagittarius, into the lid of the Archer's Teapot. Saturn is above the moon on the 15th and to its right on the 16th, when it is the brightest starlike object nearby. First-quarter moon is at 8:01 A.M., EST, on the 18th.

October 19: Mercury ends its retrograde swing between the earth and the sun and will soon appear in the morning sky.

October 20: Meteor watchers will not appreciate having a bright gibbous moon as they search for Orionid meteors at today's maximum. This brief (about two days) shower produces twenty-five or more meteors per hour, but only the brightest will shine through the moonglow in the early morning sky, which is usually the best time to see meteors.

October 22: After leaving Sagittarius, the moon moves toward, and then beyond, brilliant, ruddy Mars, now fading but still a rival to Jupiter in brightness. Jupiter, visible in the east after dark, has been the brighter planet since early this month.

October 23: Now past Mars, the moon is at perigee (nearest the earth).

October 24: Full moon, the hunter's moon, is at 11:35 P.M., EST, in Aries.

October 26: Mercury is at greatest westerly elongation, rising in the morning before the sun.
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October 26–27: The moon passes Jupiter in Taurus; Jupiter is below the moon on the 26th and to the right of the moon on the 27th during evening hours. The red dish star below Jupiter is Aldebaran. Mars is still prominent in the south.

October 30: The waning moon rises after 9:00 P.M. in eastern Gemini but in line with Gemini's bright stars Castor and Pollux. Mars ends its retrograde motion and begins creeping up on Jupiter to the east. They make a handsome pair as they draw together in the next few months.

October 31: The waning gibbous moon is about a third of the way between Castor and Pollux (above) and Regulus (below) after it rises about 10:30 P.M. tonight. But Jupiter and Mars will be much higher to the right. Note the approximate line between each of these objects, and you can see why the Twins and Regulus are zodiacal stars; they are situated where the moon and planets travel.

The Fall Sky Map shows the constellations and stars for October, November, and December from 40° north latitude at the hours given below. To use the map, hold it vertically with south (S) at the bottom and match the lower half of the map with the stars you see when you face south. As you face other directions, turn the map to bring the corresponding compass direction to the bottom of the map. The stars move west continuously during the night. By morning (before dawn), stars on the western half of the sky will have set, those on the eastern half will have moved into the west, and new stars (those of the spring evenings) will have risen in the east. The map shows the sky at about 2:00 A.M. on October 1; 1:00 A.M. on October 15; midnight on October 31; 11:00 P.M. on November 15; 10:00 P.M. on November 30; 9:00 P.M. on December 15; and 8:00 P.M. on December 31. The map can be used for an hour or more before and after the times given.
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The United States South Seas Exploring Expedition of 1838-42 sailed 87,000 miles, circumnavigated the globe, surveyed hundreds of islands, mapped 800 miles of America's west coast, and produced nautical charts that were still in use as late as World War II. It established Antarctica as the seventh continent and collected more than 50,000 plants, 4,000 animal specimens, and 2,500 ethnographic artifacts, chiefly from the South Pacific and the northwest coast of North America. Many of these objects, however, were dispersed, destroyed by adverse conditions, or rendered worthless by subsequent mishandling. Although 2,000 new zoological species were described in the expedition's published reports, even more specimens (both new and known) were lost, spoiled, or misidentified.

More than 350 maps, paintings, drawings, artifacts, and samples of flora and fauna from the expedition have been reassembled for "Magnificent Voyagers: The U.S. Exploring Expedition, 1838-1842," an exhibition in Gallery 3 at the American Museum of Natural History from September 30, 1988, through January 1, 1989. The only major American exploring expedition in the age of sail embarked from Norfolk, Virginia, on August 18, 1838, with six ships: the Vincennes (the flagship) and the Peacock, both sloops of war; the pilot schooners Sea Gull and Flying Fish, outfitted as tenders; the brigantine Porpoise; and the storeship Rep
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An American exploring expedition had first been proposed in 1818 by John Cleves Symmes, Jr. (who sought to prove the earth was "hollow and habitable within"). With the United States emerging as a sovereign power, John Quincy Adams and other patriotic boosters wanted, in a single grand gesture, to establish American science on an equal footing with European science. But squabbles in Congress, the Navy, and successive administrations delayed the launching of an expedition for twenty years and thus diminished the prominent role originally envisioned for the natural sciences. When the squadron finally sailed under the command of Lt. Charles Wilkes, it carried a scientific corps of only nine men. The relegation of the scientific corps to inferior status became a source of tension between the naval officers and scientists. Secretary of the Navy James Kirke Paulding wrote in his instructions to Wilkes that the primary object of the expedition was "the promotion of the great interests of commerce and navigation," particularly, the American whaling industry. This goal was to be achieved principally through surveying, mapping, scouting, and the establishment of relations with natives.

Wilkes, a relatively inexperienced junior officer who had parlayed a scientific background into a position of leadership beyond his official rank, wanted only Navy men to fill the scientific posts. When none were found qualified, he reluctantly accepted a few civilians but remained steadfast in his determination that only American scholars participate. When the ships had completed their voyage, Wilkes remained in charge until the last report was published. Forbidding the members of the scientific corps to consult European
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Lt. Charles Wilkes, commander,
U. S. South Seas Exploring Expedition. Portrait by Thomas Sully
U. S. Naval Academy Museum

collections and reference libraries in preparing their reports, Wilkes demanded that only new species be described.

Hamstrung by bureaucratic indifference and lack of resources, several of the disappointed naturalist-explorers were unable to complete the work. Their reports were finished years later by “armchair” specialists, among them some of the most important names in American science—Asea Gray, Louis Agassiz, John Cassin, John Torrey. By then, however, some of the most noteworthy discoveries had been described elsewhere. Forced to compromise if the expedition’s findings were to be published while they still had any scientific value, Wilkes allowed these experts to take the collections to Europe for comparative study. Many mistakes in identification and description of both new and known species were corrected and the resultant advances in zoology, botany, and geology marked the beginning of a new phase in American science.

Expedition vessels twice ventured into antarctic waters in search of land. The
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Naturalist-artist Titian Peale's field sketch and oil painting of Kilauea, on the island of Hawaii

first effort, launched from Tierra del Fuego in February 1839, was hindered by storms, and the Sea Gull, with eighteen men aboard, was lost at sea off False Cape Horn. On the second try, in January 1840, the Porpoise, sailing from Sydney Harbour, unexpectedly encountered a rival expedition. The French corvette Astrolabe, under the command of J. S. C. Dumont d'Urville, was racing with the Wilkes expedition to claim the first definitive sighting of land beyond the ice floes. Although both expeditions were long believed to have sighted land on January 30, 1840, modern records give Wilkes credit for being first—by one day. (Dumont d'Urville had forgotten to change his calendar when he crossed the International Date Line.) The Americans explored 1,500 miles along the coast of the antarctic land mass, proving its continental character. Today, the eastern quadrant of Antarctica is known as Wilkes Land.

Wilkes had a penchant for capricious and excessive disciplinary action and was disliked by virtually all aboard. With his
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Of Ships & Sea

Sketch by Titian Peale of Wailua Falls, Kauai, was a study for a painting done in his studio.

AMNH

—

manship was frequently called upon whether the target was a new species of bird, game for the crew, or an unfriendly native.

Many of Peale's taxonomic classifications proved erroneous. His report, Mammalia and Ornithology, was riddled with errors and quickly suppressed by Wilkes. It was rewritten by John Cassin and published with thirty-two of Peale's original plates in 1858 as Mammalogy and Ornithology. Many of Peale's notes, specimens, and reference works had been lost when the Peacock was shipwrecked in July 1841. He complained that specimens had been carelessly opened and ruined or dispersed, their identifying tags lost or destroyed, and his efforts blocked by constant run-ins with Wilkes and other officers. Peale wrote to a friend of his dismay at finding "my two birds [male and female] made into one—the legs of one put on another body." He expressed his frustration in the entry in his journal dated August 29, 1839:

Reached the island of "Raraka,"... No Naturalist were permitted to land... The paucity of description and illustrations cannot with justice be charged to us. We are both willing and able to do our duty. It is our misfortune, not our fault, that both English and French are doing this kind of service in a much superior manner.

We have been close to this Island all day, could see it abounded in Scientific riches, & boats were swinging idly to their davits, men were looking at to a paradise, but no, a survey is made, nothing more is requisite, and time flies.

WHAT WAS A SCIENTIFIC CORPS SENT FOR?

The most enduring scientific contributions made by the Wilkes expedition be-
long to mineralogist James Dwight Dana. He took over the collection and study of marine invertebrates from Joseph P. Couthouy, a conchologist who left in midvoyage owing to ill health and conflicts with Wilkes. (Complaining of the smell below decks, Wilkes had limited Couthouy’s collection to one specimen per species.) Dana found many new types of coral (several are in the exhibition) and went on to produce a landmark study of corals and marine fossil invertebrates.

Like his contemporary Charles Darwin, Dana was both a geologist and a biologist, and his ocean voyage with Wilkes laid the groundwork for his later theories. Dana considered the Sandwich (Hawaiian) Islands “the key to Polynesian geology.” His studies of the active shield volcanoes Mauna Loa and Kilauea were critical steps toward a modern understanding of volcanism. By examining degrees of erosion, he was able to determine the sequence in which chains of volcanic islands were formed. Wilkes set up an observatory, Pendulum Peak (named after their largest instrument, which had its own tent), on the summit of Mauna Loa, where the encamped party took measurements and recorded meteorological data.

Dana saw coral atolls at every stage of their development on the voyage, confirming Darwin’s theory that atoll formation is a continuous sequence—from an island-building, underwater volcanic eruption to a sunken island fringed by a coral barrier reef. Realizing that coral reefs could not form if exposed to cold currents, but aware of fossil coral reefs well outside tropical latitudes, Dana reasoned that older corals had a higher tolerance for cold temperatures. Today, however, geologists consider his findings to be evidence of continental drift.

Botanist William Rich sailed as a last-minute replacement for Asa Gray, who had resigned from the expedition on the

---

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At the American Museum

Drawn from the Sea

"Drawn from the Sea: Art in the Service of Ichthyology," an exhibition of fish illustrations from the 1830s to the 1980s, will be in the American Museum’s Akeley Gallery from October 7 through December 11. More than twenty artists are represented, including Joseph Drayton, the official artist of the U. S. South Seas Exploring Expedition of 1838–42, and several Japanese watercolor and pen-and-ink artists. The exhibition was organized by the National Museum of Natural History and distributed by the Smithsonian Traveling Exhibition Service.

Caribbean Month

October is Caribbean Month at the American Museum. Programs include music and dance of Trinidad, Puerto Rico, Cuba, Jamaica, and the Dominican Republic, with performances by the Marie Brooks Caribbean Dance Theater, Los Amigos del Ritmo, Conjunto Melodia Tropical, De Drummers Dem and De Dawtas Dem, Bobby Sanabria and Ascension, Herman "Rock" Johnston and Family, and Son de la Loma. Films and lec-
Museum

Tales explore Caribbean art, folklore, and migrations. "Caribbean Jump-up," a special re-creation of Carnival in Trinidad, will include costumes and performances by the Satisfiers Steel Orchestra, the Alvin Forteau Caribbean Dancers, and Vibrations. For a full schedule call (212) 769-5315.

Appalachian Lives

The Museum hosts a two-day festival of Appalachian culture, featuring films, folk tales, and music, on October 14 and 15. A documentary on migration to and from Appalachia followed by a panel discussion opens the festival, which concludes with a concert by folk singer Jean Ritchie. Admission is free. For a full schedule of events call (212) 769-5305.

Fall Lecture Series

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Photograph by
Sharon Cummings
The Natural Moment
Bates Littlehales (page 46) began making underwater photographs in the 1950s for National Geographic. “But,” he says, “after years of photographing shipwrecks, underwater archeological sites, and all forms of marine life, I still felt that my pictures failed to convey my vision of underwater life. The delicate coral, the vibrant anemones, and the elegant angelfish that I saw through my face mask were not coming through in my pictures. To me, these natural wonders still seemed unnatural.” When he and a collaborator came up with the “ocean eye” housing in 1970, the next generation of amateurs and professionals were able to accurately record the wonders he had seen. “When I look at the work being done today by youngsters such as Chris Newbert and David Doubilet,” says Littlehales, “my mind boggles. And I admit to a sense of pride, too. They are the children of the ocean eye and we are all enriched by their talent.” After thirty-six years as a staffer with National Geographic, Littlehales (who in his spare time builds and restores five-string banjos) is about to embark on a second career—free-lance photography.

For Alex Kerstitch (page 48), art and science have long been intertwined. As an undergraduate at the University of Arizona, he earned his bachelor’s degree in fine arts, majoring in commercial design. An interest in marine biology, however, immediately asserted itself, and he had no sooner received his degree than he began graduate courses in marine ecology. He has always had an interest in scientific painting and illustration and took up photography as a necessary adjunct to his research on fish behavior and for Reef Fishes of the Sea of Cortez, written with Donald A. Thomson. A research associate at the University of Arizona for the last fifteen years, he also teaches marine biology at Sabino High School in Tucson, Arizona. Kerstitch discovered several species of underwater animals. Three of them—a cone shell (Conus kerstitchi), a shrimp (Dasycaris kerstitchi), and an olive shell (Oliva kerstitchi)—bear his name.
As a child in grade school in Fort Bragg, California, Jay Ireland (page 50) learned how to dive for abalone—an avocation that his entire family pursued with a passion—and his work and play have involved underwater environments ever since. Photography, however, was a skill acquired much later and on dry land. After working for five years as a dive master and scuba instructor in the Cayman Islands, Ireland has returned to northern California to pursue a full-time career in free-lance photography. For his underwater work, he uses a Nikonom with extension tubes and a Nikon F3 in aquatic housing.

David Doubilet (pages 45 and 52) started snorkeling at age nine in the cold waters off the New Jersey coast and was taking underwater black-and-white photos by the age of thirteen. Later, the desire to become a marine biologist was brought to a halt when he flunked freshman biology at Boston University. A contract photographer for National Geographic, Doubilet’s work over the last seventeen years has taken him to the Caribbean, Israel, Palau, Australia, New Guinea, Sri Lanka, and the Seychelles, as well as Scotland’s Loch Ness, the North Pacific, and the Atlantic. Doubilet’s wife, Anne, also a diver and photographer, is a partner in their stock photography library. Their four-year-old daughter, Emily, has already accompanied them on several assignments.

Since taking up underwater photography in 1972, Chris Newbert (page 54) has won more than thirty awards in international photo competitions. Even the most mundane creatures, he says, are transformed by the undersea environment into objects of exceptional delicacy and beauty. His 1985 book, Within a Rainbowed Sea, was reviewed in the March 1985 Natural History. Born in Massachusetts and now a resident of Kailua, Hawaii, Newbert began diving in the Caribbean only ten years ago, but has since made trips to Cozumel, the Cayman Islands, Belize, Jamaica, the U.S. Virgin Islands, and Roatan (Honduras). Newbert also conducts underwater photo expeditions around the world, but when on land, he loves skiing, horseback riding, and tennis.

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Three directors of Stanford University's Center for Conservation Biology teamed up to study the dynamics of life in the Great Basin of the western United States (page 58). Paul R. Ehrlich, above, has been a professor at Stanford since 1959 and is now Bing Professor of Population Studies. A member of the National Academy of Science, he has pursued his research interests throughout the world, studying reef fishes, birds, and butterflies. His thirty-year study of the ecology and genetics of the checkerspot butterfly serves as a model for long-term studies in population biology.
Ehrlich’s most recent book, *The Birder’s Handbook*, was written with David S. Dobkin and Darryl Wheye (New York: Simon and Schuster, Inc., 1988). Dennis D. Murphy, below, now acting director of the Center for Conservation Biology, has had a lifelong interest in butterflies. Murphy was awarded the 1988 Chevron Conservation Award for his work on the design of the Kirby Canyon Conservation Agreement, which protects endangered checkerspot butterflies from an expanding sanitary landfill. Bruce A. Wilcox, left, a former director of the Center for Conservation Biology, led the group’s field research team in the Great Basin. His research in biogeography includes studies of Nevada’s mountain birds and insects and island lizards in the Gulf of California. Wilcox is director of the Institute for Sustainable Development, a firm that works on international conservation. For further reading the authors recommend the Max C. Fleischmann Series in *Great Basin Natural History* (Reno: University of Nevada Press) and Conservation Biology: The Science of Scarcity and Diversity, edited by Michael E. Soule (Sunderland: Sinauer Associates, Inc., 1986).

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Micheal J. Novacek (page 66) hikes and climbs in the interest of science, specifically, in pursuit of fossils that may reveal the evolution of mammals since the demise of the dinosaurs sixty-five million years ago. Novacek did his undergraduate work at the University of California, Los Angeles, earning his bachelor’s degree in biology, and pursued his doctorate at the University of California, Berkeley. Chairman of the Department of Vertebrate Paleontology at the American Museum, Novacek has used the collected fossil evidence to trace the evolution of bats and their sensory systems over the last twenty million years. He has collected bat fossils from Baja California to the 11,000-foot peaks in the Andes of Patagonia. For more information on bat echolocation he recommends Listening in the Dark, by Donald R. Griffin (New York: Dover Publications, Inc., 1974).

Sayed Z. El-Sayed (page 72) has been a professor of biological oceanography at Texas A & M University for twenty-seven years. Born in Alexandria, Egypt, El-Sayed did his undergraduate work at the University of Alexandria and earned his doctorate in fisheries at the University of Washington. He became a naturalized U. S. citizen in 1965. Since 1961, El-Sayed has been on numerous cruises (about twenty) to study the antarctic marine food chain. The El-Sayed glacier in western Antarctica (lat. 75°40’ S, long. 141°52’ W) was named in recognition of his work in the region. El-Sayed became involved with the ozone hole when an environmental official asked him if he had noticed any decline in the productivity of the Southern Ocean because of it. His reply was, “We do not know, but we need to find out.” So he returned to Antarctica to study the effect of ultraviolet radiation on phytoplankton. Readers who may never go to Antarctica can learn more about the continent and its seas by browsing through Antarctic Science, edited by D. W. H. Walton (Cambridge: Cambridge University Press, 1987), or Beyond the Frozen Sea: Visions of Antarctica, by Edwin Mickleburgh (New York: St. Martin’s Press, Inc., 1988). A detailed description of the hole is in “The Antarctic Ozone Hole” (Scientific American, January 1988).

A professional free-lance wildlife photographer, Sharon Cummings (page 106) has explored all corners of the continental United States in search of subjects for her camera, which has been fine with her, as traveling is her next favorite pastime after bird watching and scuba diving. She also works close to home, which is Toledo, Ohio, photographing for the Toledo Zoo and running her own offset printing business. For several years she has observed the ring-necked pheasants in the Jermain Park nature reserve, five minutes away from her home. Although they live in the heart of the city, these birds are definitely wild, and wary by nature; they will flee at the first sight or sound of a human. So Cummings had to work from a blind to get the shot for this month’s “Natural Moment.” Fortunately, the cock’s crowing drowned out any noise from her camera, a Nikon F3 with an 80-200 zoom lens. Cummings captures all kinds of wildlife on film but feels most secure with birds because, she says, “they’re beautiful, come in endless sizes, shapes, and colors—and they don’t eat photographers!”
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Cover: George Hunt acquired this Bella Coola Indian mask for the American
Museum of Natural History in 1897. Photograph by Stephen S. Myers. Story
on page 50.
Remembering Margaret Mead

Margaret Mead spent more than a half century at the American Museum of Natural History. She was appointed an assistant curator in ethnology in 1926; when she died on November 15, 1978, she had been a curator emerita for nine years. Her loss was sorely felt by the Museum community. But perhaps no community felt the loss more than the village of Pere, on the island of Manus in Papua New Guinea, which Mead had first visited in 1928 and to which she had returned on six subsequent occasions, cementing ties of friendship and respect. Pere’s mourning culminated in a 1979 visit to the American Museum by John Kilepak (“JK”), the leader of the five teen-age boys who ran Mead’s house in 1928. JK presented a string of sixty kinas, the largest Papua New Guinea coins, as a token of Pere’s remembrance (see “Pere Mourns Margaret Mead,” by Barbara Honeyman Roll, *Natural History*, November 1979).

Regarded by the villagers of Pere as the last living link with the traditions of their past, JK himself died on May 20, 1987. In a letter to Barbara Roll and her husband, photographer Fred Roll, one young man from Pere paid JK the following tribute:

His association with Margaret Mead brought a lot of changes to Pere Village and to Manus as a whole. He also took Pere Village and Manus to the rest of the world. His interpretation of the people of Pere to Margaret Mead and to the rest of the world was true and realistic.

More recently, on a visit to Pere in March 1988, the Rolls spoke with a number of the young, educated men and women who are the product of Papua New Guinea’s modernization. These young adults felt, far more than their parents had, the importance of teaching their children about the “culture, belief, customs, and life of our ancestors,” so that they would not be deprived of the security of traditional roots.

Pere retains its fascination for anthropologists. Barbara Roll continues her studies of the inhabitants’ physiques and how they change in response to more medical attention and life in urban centers. Theodore Schwartz, who similarly has a long association with Pere, is observing the Paliau Movement, an opposition political party with strong religious and social goals. He is also concerned with how rapid culture change has affected the villagers’ thinking. Richard Shoup, a physical anthropologist, completed a doctoral dissertation on growth and aging in Pere, while Joan Schall is completing a dissertation on Pere health and migration.

In recognition of the community’s own needs, beginning in 1983 the Rolls and their friends established four scholarships for tuition and board at Manus boarding high schools to be awarded to the top graduates of Pere’s elementary school. There have also been gifts to the Institute for Intercultural Studies (a foundation set up by Margaret Mead) for renewing scholarships and maintaining the community center and village guesthouse, both named for Margaret Mead.

Meanwhile, at the American Museum, visitors to the Margaret Mead Hall of Pacific Peoples can view a model of a Manus village as it would have looked on Margaret Mead’s first visit, sixty years ago. Here, outrigger canoes still ply past houses mounted on pilings in a coral-reef lagoon. Flanking the entrance to the hall, two glass cases commemorate Mead’s contribution to anthropology. They contain some of her magazine articles and books, appointment calendars, and personal mementos. Among the honors displayed is the Medal of Freedom, posthumously awarded January 20, 1979, by President Carter, and the string of kina coins presented by the village of Pere. 

Margaret Mead, Papua New Guinea, 1938

Postscripts
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Two Bachelors of Lolgorien

Reputed to be unpredictable and dangerous, old African buffalo bulls are sometimes quite companionable

by Mark J. Młoszewski

It was a little after three in the morning; still dark, the air cool. The hilly, rolling grasslands of Kenya's western Narok District were all but invisible in the darkness. I did not expect to be able to discern animal shapes, but experience had taught me that if any animals moved across the background of bush and grass, the intensity of darkness would change, deepening and becoming lighter in turn—a sensation of movement lacking sharp outlines. I strained my night vision, hoping to avoid the commotion that a close encounter with an animal would be likely to cause. I knew that at any moment I might run into antelopes, one of the local rhinos, elephants, a big cat out hunting, or some buffaloes—as likely as not, the two I thought of as "my" bulls. Any disturbance now would spoil my efforts to remain undetected by that twosome.

Daylight would reveal the grasslands to be dotted with single trees and small clumps of bush and traversed by narrow strips of woodland growing along streams. But the country around Lolgorien had become so familiar to me that I no longer needed daylight to know where I was. Although marked on some maps with a dot signifying a town or village, Lolgorien did not fit into either category. It was a sparsely populated "location," mainly bush and grassland, without obvious boundaries—its "center," according to one's preference, was either the small isolated bush store owned by a Somali trader or the tiny police post standing alone farther along the track. From the twin thatched mud huts that served me as home, I had walked some three miles in the dark, largely cross-country, without even once switching on my flashlight. But any image of myself as a seasoned bush hand was sadly blotched by the reason for my coming to that spot at such a time. Mine was a tale of repeated failure. For weeks, I had been doing my futile best to approach a pair of old buffalo bulls that had moved into that portion of the Lolgorien area. In my previous experience, the task of spying out and approaching such animals was relatively easy or, at worst, moderately difficult—never hopeless. But with that pair of old buffaloes I was getting nowhere. I had repeatedly tried to stalk them in their daytime resting places among dense riverine bush, and had gotten close enough to hear the single deep, deliberate inhalation of a buffalo testing suspect scents on the air. Then, if I stood still, I could hear the discreet sounds of the bulls' departure, and my search ended in their now vacant resting spot. I tried alone. And I tried with Kula, my frequent bush partner, the product of a hunting culture and a tracker since childhood. And always with the same, depressing result. Now, not for the first time, I was trying another tactic—to catch sight of the bulls at first light, while they were still grazing in the open or on their way toward a woodland strip for the day, and follow them.

As the darkness reddened, the light increased. Everything turned orange. Nothing moved as I scanned the country by the weak dawn light. I was not surprised that the main buffalo herd, which would have made a big, black, restless patch on the landscape, was nowhere in sight. I expected it to be grazing elsewhere. But nothing else moved, either. Uncanny, how one morning an area could be full of animal activity and on another look so empty. Before leaving, I did one more scan of my surroundings. This time I spied two massive black lumps some distance away, slowly moving across the open grasslands toward a line of bush. There they were—my pair of bachelors. Checking the wind and keeping well out of the bulls' lines of sight, I started working my way toward where they would probably enter the bush. All seemed to be going well, with no hint that the pair might have caught wind of me. The bulls entered the bush where I expected they would, and I went on carefully working my way forward.

It was almost seven o'clock when at last I faced the undeniable: they were not there. I had lost them again—or they me.

Buffalo entered my life in the early 1960s. I am a geologist by profession, but I had studied biology and retained a keen interest in living things. When my work deposited me for many years in Africa, not without my own conniving, buffalo quickly became the focus of my biological interest. Why buffalo? Maybe because ever since I was tred by an irate Polish cow when I was five, the cattle tribe has fascinated me. And the buffalo is the only wild African cattle species now living. Well into historical times, the African buffalo's range covered most of Africa south of the Sahara, excepting only a few arid spots. Now the range has lost continuity and has become smaller, mainly because of extinctions caused by human activity. The so-called Cape buffalo, the large black or dark brown buffalo I met at Lolgorien, occurred throughout much of the great east-central African upland and its margins. It is generally considered a subspecies, Syncerus caffer caffer. A second, mostly smaller and more variably colored subspecies, Syncerus caffer namus, inhabits, or inhabited, forested basins within the great upland, as well as western Africa. It is often called the forest, or dwarf, buffalo. Neither of these names is always justified as some varieties are open woodland or savanna animals and some are almost the size of the Cape buffalo. In fact, one of the African buffalo's most interesting features is the great diversification within the species. I observed buf- faloes wherever my geological work took
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telex: 182471 will find them tomorrow morning.” And that is precisely what happened.

We met the dawn by the bachelors’ current grazing area, and as soon as there was enough light, we sighted them feeding well out in the open. They grazed their way progressively closer to woodland, stopped feeding by its edge, and then vanished among the trees and shrubbery. Stopping now and again to listen, we tracked them through the dense bush, across the stream bed, and through more dense bush. At the end of an hour or so, Runyati stopped to listen once more, his mouth half open as was his habit. His eyes found mine, and I lip-read the word *hapa* (here, in Swahili) as he indicated a direction with small head motions. The two bachelors stood shockingly close, visible through a lacework of branches and leaves. As simple as that. And it wasn’t a freak event. What neither I, with my pass-able bush skills, nor Kula, who was capable of tracking down an impala across hard, stony ground, could ever come close to achieving, even with much more effort, Runyati did every two out of three times on our subsequent outings. Despite all my years in Africa, I have not learned to believe in magic, but why he succeeded so easily where we failed so completely, I have yet to discover.

Thanks to Runyati’s assistance, I learned some details about those two bulls that until then I had known only in rough outline, from far away and in poor light. One was exceptionally massive—the biggest male buffalo I recall seeing in the Lolgorien area—dark chocolate brown, blunt faced, with very deeply curved horns. The other bull stood lower but may have been the more powerful of the two. He was black, with scarlike, hairless furrows across his face and a pair of great, angular, rugged gray horns, one with the tip broken off, sitting like a log across his head. The black bull always held his head low, as if under the weight of his horns, but the real reason was a long-healed injury, possibly from a bullet, which had left a scar between his neck and shoulder. The great brown bull was virtually blind, while his partner could detect movement at three hundred yards, but being unable to hold his head up, he seemed to find it difficult to smell distant danger.

I observed the bulls in three of their resting places, all in woodland growing along a stream. The blind bull was always posted where he could catch the breeze blowing through the riparian vegetation, but where visibility was very poor, while the other bull scanned the downwind direction in which, thanks to their choice of spots, visibility was always adequate.
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They seldom ran when retreating from threat but slipped away almost soundlessly, the blind bull following, with his chin or flanks in frequent contact with the other's rump or back. When they did run, they stayed within a few inches of each other, the blind one's head by the other's shoulder. When they were surprised in the open, the blind bull halted, waiting until the other brushed against him, thereby indicating the direction in which to move. Their protective strategy depended on joint early detection of threat, followed by a preferably unobtrusive retreat.

My persistent early failures offered plenty of evidence that their system worked well. That it was not foolproof, I also learned thanks to Runyati. I could have easily shot them at point-blank range had I wanted to. That pair, much the worse for the physical knocks of a long and unsheltered life but holding their own, are my personal symbol of undaunted, dignified old age.

Old bachelors' life styles differ from place to place, depending on prevailing conditions. Wherever there is sustained hunting or heavy predation, partnerships of two to five old buffalo bulls tend to be more common than single individuals. The reason could be that single males are more easily picked off by predators. My observations—from Kenya to southern Zimbabwe—leave me with no doubt that such bachelor partnerships enhance the chances of survival. No lion can afford to suffer serious injury in the course of bringing down its prey, for a wounded predator may have a dim future. A lion, or even two or three of them, will often think twice before tackling a group of surly, heavily-horned, thick-skinned, old but still powerful buffalo bulls, since the bulls may decide to face the lions collectively rather than expose their vulnerable rears in flight. A counterattack by a couple of bulls could result in the lion's being tossed into the branches of a tree or gored by massive horns. Consequently, when a party of bachelors does not run but instead stands watchful at the approach of lions, the big cats are apt to switch their attentions to a more convincingly senile and solitary old bull or a lame cow trailing the local herd. A male that grows old as a member of a bachelor group of the first class—a club of vigorous reserve bulls—may stay on, even though no longer able to compete for herd functions. Provided he ages gracefully, without trying to throw his weight around, such an old one is offered companionship and respect. Remaining with the club is apt to prolong his retired life since it affords him more protection against lions and hyenas than would his own waning powers. His main problem is keeping up with the others, for once he falls behind, he might never catch up. Thus, various penalties and advantages go with the different life styles.

Where there are few predators and little hunting, many old buffalo males may be able to survive on their own. This has distinct advantages. A solitary old bull can find all the grazing he needs within a small area, and if sufficient drinking water is also within easy reach, he can spend much time relaxing and soaking up the sun. He is, of course, more vulnerable to predators than if he belonged to a group, but even alone, he is hardly defenseless. A buffalo bull is powerful even when old, and so long as his senses remain fairly sharp, he is no pushover for a lion.

The rare bachelor bull lucky enough to survive into very old age (in the wild, this could mean between fourteen and thirty years), when his faculties have largely failed, buries himself in the densest and most impenetrable patch of low scrub he can find. There, the warming rays of the sun can reach him, but a marauding lion would find it very difficult. Ideally, there is only one narrow and easy-to-defend way into that patch of matted scrub, and while the bull must leave his sanctuary to graze and drink, he is quite safe during the long hours of resting and cud chewing. I drove several times past a place in the Samburu Game Reserve (in Kenya) before realizing that a woody looking item in the bush by the motor track was the badly worn and chipped boss, or basal thickening, of a buffalo's horns. If I looked long enough, I could see the horns move slightly, so I knew a live buffalo was attached to them. After that discovery, I made a point of looking whenever I traveled that stretch of the track, and always the almost motionless head or back of that ancient animal was visible as he dozed in his retreat.

Living in a game reserve and near a frequented motor track gave a measure of protection from hunters and could have been an important reason for that old bachelor's long survival. Anyone who has landed on the Keekorok airstrip in Kenya's Masai Mara Game Reserve may recall seeing solitary buffalo bulls, each standing or lying down peacefully in his own patch of open bush below, hardly reacting to the incoming plane, and indifferent to the close approach of the plane as it taxied nearby. Although with regard to human threat, the Keekorok neighborhood is very safe, that is not the case everywhere, and in most localities in that general area, old bulls must take greater precautions. This means, first of all, keeping well out of sight of both two- and four-
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The Ant and the Plant

In a chromosome-splitting contest, which kingdom has the best player?

by Stephen Jay Gould

As I write this column for November of a presidential election year, my thoughts stray from the proper high road of foreign and domestic policy toward my parochial reason for preferring Dukakis over Bush. Oh, I can give you reasons based upon Nicaragua, child care, and the “Massachusetts Miracle,” but I keep chuckling to myself with internal glees; if Mike Dukakis wins, we will finally have a president as short as I am.

Why do we care so much about size and number? My friend Ralph Keyes, who tips the charts with me at five feet seven and a half inches, wrote an entire book about our obsession with this supposedly irrelevant subject—The Height of Your Life (Little, Brown, 1980). He documented the extraordinary steps that short politicians and film stars often take to avoid discovery of their secret. (Ralph couldn’t even penetrate the subterfuges of Jimmy Carter’s staff to discover the height of our shortest recent President, who is at least an inch or two taller than Ralph and me, and therefore at, or not far from, the American average.) The most amusing item in Ralph’s book is an old publicity shot of a short Humphrey Bogart with two of his leading ladies, Lauren Bacall and Katharine Hepburn. They have just emerged from an airplane; Bogie is on the first step of the gangplank; the two women stand on the ground.

Why do we so stupidly equate more with better? Penises and automobiles, two objects frequently graded for size by foolish men, work just as well, and often more efficiently, at smaller than average lengths. Extremes in body size almost always entail tragic consequences (at least off the basketball court). Robert Wadlow, just shy of nine feet and the tallest human ever recorded, died at age twenty-two from infection caused by a faulty angle brace needed for supplementary support since his legs could not adequately carry his body. Moving beyond the pathology of extreme individuals, entire species of unusually large body size generally have short geological lifetimes. I do not think that their problem lies in biomechanical inefficiency, as earlier theories of lumbering dinosaurs held. Rather, large creatures tend to be anatomically specialized and form relatively small populations (fewer brontosaurus than boll weevils)—perhaps the two strongest detriments to extended survival in a world of large and capricious environmental fluctuation over time.

While most people do understand that large size does not guarantee long-term success, the myth of “more is better” still pervades our interpretations. I have, for example, noted with surprise, as I have monitored the impressions of students and correspondents over the past twenty years, how many people assume, as almost logically necessary a priori, that evolutionary “progress” and complexity should correlate with the amount of DNA in an organism’s cell—the ultimate base line for more is better. Not so. The very simplest creatures, including viruses at the low end, followed by bacteria and other prokaryotic organisms, do have relatively little DNA. But as soon as we reach multicellular life, based on eukaryotic cells with nuclei and chromosomes, the correlation breaks down completely. Mammals stand squarely in the middle of the pack, with $10^8$–$10^{10}$ nucleotides per haploid cell. The largest values, ranging to nearly 100 times more DNA than the most richly endowed mammals, belong to salamanders and to some flowering plants.

Many species of plants arise by polyploidy, or doubling of chromosome number. These doublings often run through several cycles among a group of closely related species, so the amount of DNA can increase greatly—and the high DNA content of some polyploid plants has never been much of a mystery. On the other hand, the extreme values for amphibians once puzzled zoologists sufficiently that they gave the phenomenon a name—“the C-value paradox.” However, since the discovery that so little of the total DNA codes actively for enzymes and proteins, this hundredfold difference between some mammals and salamanders seems less troubling. Most DNA consists of repeated copies; much codes for nothing and may represent “junk” in terms of an organism’s morphology. (I shall have to leave for another time the fascinating issue of how and why such junk DNA can accumulate. For one major reason, see my column of November 1981 on “selfish DNA.”) The hundredfold difference does not mean that salamanders have 100 times more active genes than mammals, for the disparity occurs chiefly in nonessential, or noncoding, regions. (We would still, of course, like to know why some groups accumulate more junk and more repetitions, but such differences do not merit special recognition as a formal paradox.)

This essay considers another expression of maximum and minimum, and another test of correlation between quantity and quality—numbers of chromosomes. We have voluminous data on average differences in number of chromosomes among groups of organisms, and some patterns surely emerge. Diptera (flies and their allies) tend to have few per cell; Drosophila, the great laboratory stalwart (and largely for this reason), harbors four pairs per diploid cell. Birds tend to have many. Instead of providing a compendium for these well-chronicled differences, I shall focus on the extreme cases of more and less among organisms. Extreme values may titillate our fancy, but they are also unusually instructive for recognizing and
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specifying generalities. Exceptions do prove rules. (And as I have pointed out before, the etymology of that cliché, usually mistaken for a reversed meaning, is not "prove" in the sense of verify, but "prove" in the sense of test or challenge. This definition, from the Latin probare, is not entirely archaic in English—consider printer's proof, or a proving ground for testing weapons.)

Until two years ago, the lowest number of chromosomes, a commandingly minimal one pair, had been found for only a single organism—a nematode worm, appropriately honored in its subspecific name as Parascaris equorum univalens. This minimal complement had been discovered long ago, in 1887, by the greatest cytologist (student of cellular architecture) of the late nineteenth century—Theodor Boveri. Boveri (1862–1915) was a great intellectual in the European tradition—a complex and fascinating man who lived for the laboratory, but who also played the piano and painted with professional competence. His short life was scarred by fits of depression, and he died in despondency as the First World War enveloped Europe. The two greatest of Boveri's many scientific discoveries centered on chromosomes. First, he established their individuality and shifted attention from the nucleus as a whole to chromosomes as the agent of inheritance (all in years before the rediscovery of Mendel's laws). Second, he demonstrated the differential value of chromosomes. Before Boveri's experiments, many scientists had conjectured that each chromosome carried all the hereditary information, and that organisms with many chromosomes carried more copies of this totality. Boveri proved that each chromosome carried only part of the hereditary information (some of the genes, as we might say today), and that the full complement built the organism through a complex orchestration of development.

Boveri took great interest in his discovery of an organism that carried but one pair of chromosomes per cell—and therefore did place all its hereditary information into one package. But Boveri quickly discovered that P. equorum univalens, though no impostor in its claims to minimalism, was not entirely consistent either. Only the cells of the germ line, those destined to produce eggs and sperm by meiosis, kept all the hereditary material together in a single pair of chromosomes. In cells destined to form body tissues, this chromosome fractured several times during the first cleavage divisions of early embryology, leading to adult cells with up to seventy chromosomes!

Finally, in 1986, Australian zoologists Michael W. J. Crosland and Ross H. Crozier reported a remarkable new species within a closely related group of ants, previously united into the overextended species Myrmecia pilosa (see their article in Science, March 14, 1988, p. 231). This name falsely amalgamates several distinct species sharing a similar body form, but carrying different numbers of chromosomes in their cells. Species with nine, ten, sixteen, twenty-four, thirty, thirty-one, and thirty-two pairs of chromosomes have been described. Obviously, this complex of forms has evolved some way of speciating in concert with substantial changes in chromosome number.

On February 24, 1985, on the Tidbinbilla Nature Reserve near Canberra, Crosland and Crozier collected a colony of winged males and females, plus a mated queen with pupae and more than 100 workers. All workers tested from this colony carried but a single pair of chromosomes in their cells—all of them, not just cells of a particular type. An unambiguous example of chromosome minimalism had finally been discovered, almost exactly 100 years after Boveri found only one pair of chromosomes in the germ line cells of Parascaris.

But the story of M. pilosa is even better, deliciously so. If you were out searching for absolute minimalism, you would have to root for finding your single pair of chromosomes in an ant, bee, or wasp—for the following interesting reason: The Hymenoptera, and just a few other creatures, reproduce by an unusual genetic system called haplodiploidy. In most animals, all body cells contain chromosomes in pairs, and sex is determined by maternal and paternal contributions (or noncontributions in some cases) to a single pair. But haplodiploid organisms specify sex by a different route. Reproductive females usually store sperm, often for long periods. Genetic females (including the functionally neuter workers) arise from fertilized eggs, and therefore contain chromosomes in pairs. But males are produced when the queen fails to fertilize a developing egg with stored sperm (in most other animal groups, of course, unfertilized eggs are inviable). Thus, the cells of male ants, bees, and wasps do not carry chromosomes in pairs and bear only the single set inherited from their mother. These males have no fathers, and their cells contain only half the chromosomes of females—a condition called haploid, as opposed to the diploid, or paired, complement of their sisters. (The entire system therefore receives the name haplodiploid, or male-female in this case.)
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Haploidyploidy implies, of course, that males of the Titubinilla colony of *M. pilosula* have a truly and absolutely minimal number of one chromosome per cell. Not even a single pair — just one. The only lower possibility is disappearance. Crossland and Crozier checked just to be sure. The males of their colony contained a single chromosome per cell.

If we have reached a limit in the search for less, the other extreme seems more open-ended. How many chromosomes can a cell contain and still undergo the orderly divisions of mitosis and meiosis? Can hundreds of chromosomes line up neatly along a mitotic spindle and divide precisely to place an equal complement into each daughter cell? At what point do things become so crowded that this most elegant of biological mechanisms breaks down?

Maximal numbers are most easily reached by polyploidy, or doubling of chromosomes. This process occurs in two basic modes with differing evolutionary significances. In autopolyploidy, a cell doubles its own complement, forming, initially at least, a cell with two sets of identical pairs. Thus, the new autopolyploid usually looks like its parent. Autopolyploidy is not a mechanism for rapid evolution of form, though the redundancy introduced by doubling does permit considerable evolutionary diver- 
generation afterward — as one member of the duplicated pair becomes free to change. Alloploidy, on the other hand, can produce viable hybrids between distant species and can serve as a mechanism for sudden and substantial changes in form. Hybrids, with different forms and numbers of maternal and paternal chromosomes, will usually be sterile because chromosomes have no partners for pairing before meiosis — the "reduction division" that produces sex cells with half the genetic information of body cells. But if the precursors of sex cells undergo alloploidy, then each chromosome will find a partner in the duplicated version of its own form.

Since polyploidy is so much more common in plants than animals, we should search for maximalism in our gardens, not our zoos. The numerical importance of polyploidy in plants can best be appreciated in a wonderful graph that I first encountered, when a graduate student, in Verne Grant's *The Origin of Adaptations*. This graph is a frequency distribution for chromosome pairs in monocot plants. Once you go beyond the lowest complements, from ten on without exception, all peaks are for even numbers of chromosome pairs.

At first inadequate sight, this pattern doesn't make sense in the deepest possible way. Biology is not numerology; its regularities do not take the form of such abstractions as "cleave to even numbers." Such a graph will not be satisfying until we figure out a biological mechanism that, as a side consequence and not because evens are better than odds per se, produces an imbalance of species with chromosomes in pairs of even numbers. The resolution is elegantly simple in this case. Polyploidy is very common in plants, and every number, odd or even, when doubled, yields an even number. The peaks therefore indicate the prevalence of polyploidy in plants. Estimates range as high as 50 percent for the number of angiosperm species produced by polyploidy.

Since polyploidy can continue in cycles — doubling followed by redoubling — chromosome numbers, like the pot in the poker game with table stakes, can rise alarmingly from small beginnings. The champions among all organisms are ferns in the family Ophioglossaceae. The genus *Ophioglossum* exhibits a basic number of 120 chromosome pairs, the lowest value among living species. (Such a high number must, itself, be derived from earlier incidents of polyploidy among species now extinct. The basic number for the entire
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family, 15 pairs, may have been the starting point.) In any case, cycles of polyploidy have proceeded onward from this already large beginning of 120 pairs. The all-time champion, not only in Ophioglossum, but among all organisms, is Ophioglossum reticulatum, with about 630 pairs of chromosomes, or 1,260 per cell! (The total need not be an exact multiple of 120, because doubling may be imperfect, and secondary gains or losses for individual chromosomes are common.)

The very idea of a nucleus with 1,260 chromosomes, all obeying the mechanical need for alignment and division as cells proliferate, inspired G. Ledyard Stebbins, our greatest living evolutionary botanist, to a rare emotion for a scientific paper—rapture. (Since Ledyard and I share a passion for Gilbert and Sullivan, I will write, for his sake, “modified rapture”—and he will know the reference and meaning): “At meiosis, these chromosomes pair regularly to form about 630 bivalents, a feat which to cytologists is as remarkable a wonder of nature as are the fantastic elaborations of form exhibited by orchids, insectivorous plants, and many animals” (Science, June 10, 1966, p. 1468).

In fifteen years of writing essays for this magazine, I have specialized in trying to draw general messages out of particulars. But this time, I am stumped. I don’t know what deep truth of nature emerges from the documentation of minimal and maximal chromosome numbers. Oh, I can cite some clichés and platitudes—surely an acceptable stance for an election month; quantity is not quality; good things can come in small packages. I can also state the obvious conclusion that inheritance and development do not depend primarily upon the number of distinct rods holding hereditary information—but this fact has been featured in textbooks of genetics for more than seventy years.

No, I think that every once in a while, we must simply let a fact stand by itself, for its own absolutely unvarnished fascination. Has your day not been brightened just a bit by learning that a plant can orchestrate the division of its cells by splitting 630 pairs of chromosomes with unerring accuracy—or that an ant, looking much like others, can gallivant about with an absolute minimum of one chromosome per cell? If so, I have earned my keep, and can go cultivate my garden. I think I’ll try growing some ferns. Then I might take some colchicine, which often induces polyploidy, and maybe, just maybe.

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.
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An all-weather road winds westward for six miles from Los Alamos to a popular ski area in north-central New Mexico's Jemez Mountains. From the ski area, abandoned forest road 282 now serves as a mountain trail into a verdant section of the Santa Fe National Forest. After about a mile, the trail leads out of the dense forest and into a clearing of grassland perched on a southwest-facing slope. This is the Cañada Bonito grassland, which extends from an elevation of nearly 9,000 feet to a 9,860-foot ridge crest on a slope that has as much as a 40 percent grade in places.

At its base, the grassland merges imperceptibly into the forest, while at the crest there is a sharp transition to a dense forest of Engelmann spruce. Some woody plants encroach along the edges of the grassland, but only a few have succeeded in establishing themselves within it. Biologists consider the grassland unique in the Santa Fe National Forest because it has not been subjected to grazing by domestic livestock since 1943, when it was removed from public access with the establishment of the nearby nuclear laboratory. Other isolated mountain grasslands in the area are heavily grazed and have a mowed appearance, with numerous gullies eroded into the terrain.

In the generally semiarid region, the Jemez Mountains stand as an island of cool, moist forests. The area receives little precipitation between April and June, but frequent summer thunderstorms and winter snows, which pile up to ten feet or more, provide adequate moisture for the rest of the year. Several grassy slopes, including Cañada Bonito grassland, have developed, usually on predominantly southern exposures. Geographer Craig Allen refers to these areas as montane grasslands, reserving the term meadow for usually moist, low-lying level areas.

Although the high elevation limits the growing season to about a hundred days, the vegetation is dense. The grasses, which grow nearly waist high, are mostly Thurber fescue and Parry danthonia, but botanists have recorded fifteen other kinds, including two other fescues, two June grasses, bluegrasses, bromes, bentgrasses, and even Virginia wild rye, which is wide-
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Adjacent to the grassland, below 9,000 feet, is a mixed conifer forest dominated by a few large Douglas firs and an abundance of smaller white firs and Rocky Mountain maples. Aspen and Engelmann spruce are also present, but they are relatively small and show little evidence of recent reproduction. On the ridge crest and down the even steeper north-facing slope, Engelmann spruces form a closed forest, with a scattering of cork-bark fir, white fir, Douglas fir, quaking aspen, and Rocky Mountain maple.

Beneath the vegetation of the Cañada Bonito grassland, a thick, nearly continuous blanket of sod and litter has developed, bare only where pocket gophers have been at work. Allen reports that the fine loamy mixed soils beneath the grasses contain at least one percent organic matter to a depth of as much as three feet. In contrast, the soils beneath the mature Engelmann spruce and mixed conifer forests are comparatively thin and stony, extending only inches below the surface, except in areas where the trees have recently encroached on the grassland. In both grass-
trees becoming established between 1928 and 1953. Only four of the trees—two Douglas firs and two ponderosa pines—are large and earlier in origin. These large trees have probably been the seed source for the recent invasion.

Allen postulates that Cañada Bonito arose following a catastrophic crown fire in what was a spruce-fir forest. Because forests of Engelmann spruces and cork-bark firs do not recover after a fire, the burned-out forest may have been invaded by herbs. The steep, south-facing slopes provided a dry habitat more suitable for the growth of grasses than trees, whose reproduction was hampered by the early dry season and the lack of shade. Engelmann spruce and cork-bark fir would not have regenerated in conditions such as these, and the more drought-tolerant Douglas fir and ponderosa pine would not have been able to do much better. In addition, there may not have been enough ponderosa pine and Douglas fir in adjacent forests to provide an adequate source of seeds. Furthermore, if grasslands persist long enough, they will develop a thick cover of sod and litter, and with the thicker cover, establishment of conifer seedlings becomes even more difficult.

The most powerful force that deters woody invasion of a grassland is fire, as suggested by Wisconsin ecologist John T. Curtis in 1959. Since grasslands occur on dry slopes, fire could spread rapidly. The abrupt change at the ridge crest from

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grassland to spruce forest might also be explained by fire. Ground fires burn upslope with ease, but they usually peter out at the ridgetop because of the difficulty in burning downhill on moist slopes.

Fires once occurred with great regularity in the grasslands and forests due to the annual buildup of dry plant litter, which provided a ready source of fuel. The intensity of grassland fires killed any tree seedling that might have germinated. Before settlement by modern inhabitants of the West, Indians may have purposely set fire to the grasslands to improve hunting or perhaps for other reasons. Lightning strikes undoubtedly set many fires (weather records kept at nearby Los Alamos show that of the sixty-two days of July and August, there is an average of forty-six days with thunderstorms). When shepherds and goatherders began to occupy the Jemez Mountains during the 1800s, they too burned the grasslands for pasture until the end of the second decade of the twentieth century. According to Richard J. Vogl, a biologist at the University of Arizona, other settlers burned the grasslands to clear the area for agriculture, reduce undergrowth for better visibility, and promote heavy vegetation growth for ground-dwelling animals.

About 1920, however, the United States Forest Service, convinced that fire was a force of destruction, began a policy of fire suppression. This suppression coincided with an invasion of tongues of forest into the grasslands, such as the invasion documented at Cañada Bonito by Craig Allen. As long as this policy of fire suppression continued, the forest advanced slowly into the grasslands.

The policy has also permitted dangerously large quantities of dry plant material to accumulate in the grasslands and the forests. Natural fires allow this dry plant material to be recycled into the soil in the form of ash. Now, however, it has accumulated to such an extent that devastating forest fires break out every year across our nation.
In the last several years, as ecologists have begun to realize that fires can be beneficial, the Forest Service has been amenable to altering its policy. In fact, burning a grassland to maintain its integrity has become a standard management technique. Although the Forest Service has not practiced this technique in Canada Bonito, fire could be used to maintain the grasslands.

Because Canada Bonito is one of the few remaining Thurber fescue grasslands that have not been subjected to recent livestock grazing, it has been designated as a Research Natural Area by the Forest Service to permit the study of this ecosystem, to maintain its genetic pools, and to preserve this grassy island in the heart of a coniferous forest.

"This Land" highlights the biological phenomena of the 154 U.S. national forests. Robert H. Mohlenbrock is Distinguished Professor of Botany at Southern Illinois University at Carbondale.

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Lessons from Biology

"It is astonishing how one simple incorrect idea can envelop the subject in a dense fog"

by Francis Crick

Even a cursory look at the world of living things shows its immense variety. Although we find many different animals in zoos, they are only a tiny fraction of the animals of similar size and type. The geneticist J. B. S. Haldane was once asked what the study of biology could tell one about the Almighty. "I'm really not sure," said Haldane, "except that He must be inordinately fond of beetles." There are thought to be at least 300,000 species of beetles. By contrast, there are only about 10,000 species of birds. We must also take into account all the different types of plants, to say nothing of microorganisms such as yeasts and bacteria. In addition, there are all the extinct species, numbering in all perhaps as many as a thousand times all those alive today.

The second property of almost all living things is their complexity and, in particular, their highly organized complexity. This so impressed our forebears that they considered it inconceivable that such intricate and well-organized mechanisms would have arisen without a designer. Had I been living 150 years ago I feel sure I would have been compelled to agree with this Argument from Design. Its most thorough and eloquent protagonist was the Reverend William Paley, whose book, Natural Theology, was published in 1802. Imagine, he said, that crossing a heath one found on the ground a watch in good working condition. Its design and its behavior could only be explained by invoking a maker. In the same way, he argued, the intricate design of living organisms forces us to recognize that they too must have had a Designer.

This compelling argument was shattered by Charles Darwin, who believed that the appearance of design is due to the process of natural selection. This idea was put forward both by Darwin and by Alfred Wallace, essentially independently. Darwin wrote up a "short" version of his ideas (he had planned a much longer work) as Origin of Species. When this was published in 1859, it immediately ran through several reprints and did indeed produce a sensation. As well it might, because it is plain today that it outlined the essential feature of the "Secret of Life." It needed only the discovery of genetics, originally made by Gregor Mendel in the 1860s, and, in this century, of the molecular basis of genetics, for the secret to stand before us in all its naked glory. It is all the more astonishing that today the majority of human beings are not aware of all this. Of those who are aware of it, many feel (with Ronald Reagan) that there must be a catch in it somewhere. A surprising number of highly educated people are indifferent to these discoveries, and in Western society a rather vocal minority are actively hostile to evolutionary ideas.

*****

Perhaps the first point to grasp about natural selection is that a complex creature, or even a complex part of a creature, such as the eye, did not arise in one evolutionary step. Rather it evolved through a series of small steps. Exactly what is meant by small is not necessarily obvious since the growth of an organism is controlled by an elaborate program written in its genes. A small change in a key part of the program can make a large difference. For example, an alteration in one gene in Drosophila can produce a fruit fly with legs in the place of its antennae.

Each small step is caused by a random alteration in the genetic instructions. Many of these random alterations may do the organism no good (some may even kill it before it is born), but occasionally, a particular chance alteration may give that particular organism a selective advantage. This means that in the last analysis the organism will, on average, leave more offspring than it would otherwise. If this advantage persists in its descendants then this beneficial mutant will gradually, over many generations, spread through the population. In favorable cases, every individual will come to possess the improved version of the gene. The older version will have been eliminated. Natural selection is thus a beautiful mechanism for turning rare events (strictly, favorable rare events) into common ones.

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We were driven to a clearing in the woods, where we waited in long boots and rain jackets to be received by the orangutans. After the tour guide gave us some idea of what to expect, we were driven to the clearing, and the orangutans were released. We were amazed by their intelligence and the way in which they interacted with each other. The orangutans showed great curiosity and were very friendly, often reaching for our hands or trying to take our cameras. It was a truly extraordinary experience.

What gives biological research its special flavor is the long-continued operation of natural selection. Every organism, every cell, and all the larger biochemical molecules are the result of a long intricate process, often stretching back several billion years. . . . Physics, either in its more basic forms, such as the study of the fundamental particles and their interactions, or in its more applied branches, such as geophysics or astronomy, is very different from biology. It is true that in the latter two branches we have to deal with changes over comparable periods of time and what we see may be the result of a long historical process. The layers upon layers of rock exposed in the Grand Canyon would be an example. However, while stars may "evolve," they do not evolve by natural selection. Outside biology, we do not see the process of exact geometrical replication, which, together with the replication of mutants, leads to rare events becoming common. Even if we may occasionally glimpse an approximation of such a process, it certainly does not happen over and over again, until complexity is added to complexity.

Another key feature of biology is the existence of many identical examples of complex structures. Of course, many stars must be broadly similar to each other. Many crystals in geological rocks must have a basically similar structure. But in neither case do we find masses of stars or crystals that are identical in many small details. One type of protein molecule, on the other hand, usually exists in many absolutely identical copies. If this were produced by chance alone, without the aid of natural selection, it would be regarded as almost infinitely improbable. Physics is also different because its results can be expressed in powerful, deep, and often counterintuitive general laws. There is really nothing in biology that corresponds to special and general relativity or quantum electrodynamics or even such simple conservation laws as those of Newtonian mechanics: the conservation of energy, of momentum, and of angular momentum. Biology has its "laws," such as those of Mendelian genetics, but they are often only rather broad generalizations, with significant exceptions to them. The laws of physics, it is believed, are the same everywhere in the universe. This is unlikely to be true of biology. We have no idea how similar extraterrestrial biology (if it exists) is to our own. We may certainly consider it likely that it, too, will be governed by natural selection or something rather like it, but even this is only a plausible guess.

What is found in biology are mecha-
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nisms: mechanisms built with chemical components that are often modified by other, later mechanisms added to the earlier ones. While Occam's razor is a useful tool in the physical sciences, it can be a very dangerous implement in biology. It is thus very rash to use simplicity and elegance as a guide in biological research. While DNA could be claimed to be both simple and elegant, it must be remembered that DNA almost certainly originated fairly close to the origin of life when things were necessarily simple or they could not have got going.

Biologists must constantly keep in mind that what they see was not designed, but rather evolved. It might be thought, therefore, that evolutionary arguments would play a large part in guiding biological research, but this is far from the case. It is difficult enough to study what is happening now. To try to figure out exactly what happened in evolution is even more difficult. Thus evolutionary arguments can usefully be used as hints to suggest possible lines of research, but it is highly dangerous to trust them too much. It is all too easy to make mistaken inferences unless the process involved is already very well understood.

All this may make it very difficult for physicists to adapt to most biological research. Physicists are all too apt to look for the wrong kinds of generalizations, to concoct theoretical models that are too neat, too powerful, and too clean. Not surprisingly, these seldom fit well with the data. To produce a really good biological theory one must try to see through the clutter produced by evolution to the basic mechanisms lying beneath, realizing that they are likely to be overlaid by other, secondary mechanisms. What seems to physicists to be a hopelessly complicated process may have been what nature found simplest, because nature could only build on what was already there.

The genetic code is a good example of what I mean. Who could possibly invent such a complex allocation of the sixty-four triplets [all the possible three-way combinations of the four bases that make up DNA]? Even so, there is a simplicity of a sort in the genetic code. The units of coding all have just three bases. The Morse code, by contrast, has symbols of different lengths, the shorter ones coding the more frequent letters. This allows the code to be more efficient, but such a property may have been too difficult for nature to evolve at that early time. Arguments about efficiency are thus almost always to be mistrusted in biology since we don't know the exact problems faced by myriads of organisms in evolution. And without know-
ing that, how can we decide what form of efficiency paid off?

There is a more general lesson to be drawn from the example of the genetic code. In biology, some problems are not suitable or ripe for a theoretical attack for two broad reasons. The first is that the current mechanisms may be partly the result of historical accident. The other is that the "computations" involved may be exceedingly complicated. This appears to be true of the protein-folding problem (the physical laws governing how each polypeptide chain folds itself into a unique three-dimensional structure).

Nature performs these folding "calculations" effortlessly, accurately, and in parallel, a combination we cannot hope to imitate exactly. Moreover, evolution will have found good strategies for exploring many of the possible structures in such a way that shortcuts can be taken on the paths to the correct fold. The final structure is a delicate balance between two large numbers—the energy of attraction between the atoms and the energy of repulsion. Each is very difficult to calculate accurately, yet to estimate the free energy of any possible structure we have to estimate their difference. That it usually happens in aqueous solution, so that we have to allow for the many water molecules bordering the protein, makes the problem even more difficult.

These difficulties do not mean we should not look for the broad principles involved (for example, a protein that exists in aqueous solution folds to keep many of its water-hating side groups out of contact with the water), but it does mean that it may be better to try to go around such problems and not try to tackle them head-on at too early a stage.

A number of other lessons can be drawn from the history of molecular biology, although it would be easy to find examples in other branches of science as well. It is astonishing how one simple incorrect idea can envelop the subject in a dense fog. My mistake in thinking that each of the bases of DNA existed in at least two different forms is one such case. Another, more dramatic in some ways, was the assumption that the ribosomal RNA was the messenger RNA. And yet how plausible this mistaken idea was. Jean Brachet, the embryologist, had shown that cells with a high rate of protein synthesis have large amounts of RNA in their cytoplasm. My colleague Sydney Brenner and I knew there had to be a messenger to convey the genetic message of each gene from the DNA in the nucleus to ribosomes in the cytoplasm, and we assumed that this had to be RNA. In this we were right. Who would have been so bold as to say that the RNA we saw there was not the messenger, but that the messenger was another kind of RNA, as yet undetected, turning over rapidly and thus probably there in small amounts? Only the gradual accumulation of experimental facts that appeared to contradict our base idea could jolt us out of our preconception. Yet we were acutely aware that something was wrong and were continually trying to find out what it was. It was this dissatisfaction with our ideas that made it possible for us to spot where the mistake was. If we had not been so conscientious in dwelling on these contradictions we should never have seen the answer. Eventually, of course, someone else would have spotted it, but the subject would have advanced less rapidly—and we would have looked very silly.

Unless one has experienced it, it is not easy to convey the dramatic feeling of sudden enlightenment that floods the mind when the right idea finally clicks into place. One immediately sees how many previously puzzling facts are neatly explained by the new hypothesis. One could kick oneself for not having had the

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idea earlier, it now seems so obvious. Yet before, everything was in a fog. Often it becomes clear that to prove the new idea a different kind of experiment is needed. Sometimes these experiments can be carried out in a remarkably short time and, if successful, serve to put the hypothesis beyond reasonable doubt. On such occasions one can go from muddled puzzlement to virtual certainty in the space of a year or even less.

I have discussed earlier the importance of general, negative hypotheses (suggesting, if one can, what class of theories are unlikely to be true), the mistake of mixing up a process with the rather different mechanisms that control it, and especially the importance of not mistaking a minor, subsidiary process for the main mechanism one is interested in. However, the principal error I see in most current theoretical work is that of imagining that a theory is really a good model for a particular natural mechanism rather than being merely a demonstration—a "don’t worry" theory. Theorists almost always become too fond of their own ideas, often simply by living with them for so long. It is difficult to believe that one’s cherished theory, which really works rather nicely in some respects, may be completely false.

The basic trouble is that nature is so complex that many quite different theories can go some way toward explaining the results. If elegance and simplicity are, in biology, dangerous guides to the correct answer, what constraints can be used as a guide through the jungle of possible theories? It seems to me that the only really useful constraints are contained in the experimental evidence. Even this information is not without its hazards since experimental facts are often misleading or even plain wrong. It is thus not sufficient to have a rough acquaintance with the experimental evidence; rather a deep and critical knowledge of many different types of evidence is required, since one never knows what type of fact is likely to give the game away.

It seems to me that very few theoretical biologists adopt this approach. When confronted with what appears to be a difficulty, they usually prefer to tinker with their theory rather than seek some crucial test. One should ask, What is the essence of the type of theory I have constructed, and how can that be tested?—even if it requires a new experiment to do so.

Theorists in biology should realize that it is extremely unlikely that they will produce a useful theory (as opposed to a mere demonstration) just by having a bright idea distantly related to what they imagine to be the facts. Even more unlikely is that experimentalists ignore their work. Let theorists produce just one theory of the type sketched above and the world will jump to the conclusion (not always true) that they have special insight into difficult problems. They may then be embarrassed by the flood of problems they are asked to tackle by those very experimentalists who previously ignored them.

Francis H. Crick is Kieckhefer Distinguished Research Professor at the Salk Institute in La Jolla, California. He shared the 1962 Nobel Prize for Physiology or Medicine with James Watson and Maurice Wilkins for working out the structure of DNA.

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39
Two forms, sedentary and migratory, of the planthopper Prokelisia feed on a blade of grass. The wings of the sedentary form (left) are greatly reduced, rendering it flightless.

Planthoppers on the Move

*Are good times just a hop, skip, and jump away? If not, these little fortunetellers of the marsh take wing*

Text by Robert F. Denno • Photographs by Dwight R. Kuhn

On a still, sultry day in June, with the hazy skyline of New Jersey's Atlantic City barely visible on the horizon, I was fishing off a high bridge for blue crab, nearly hypnotized by the shimmering surface of the marsh water below. Suddenly, I saw what must have been millions of small creatures silhouetted against the water. The air was filled with them, all flying in the same direction. I swatted a few and discovered that they were planthoppers: small, aphidlike insects (about three-sixteenths of an inch long) that feed on a variety of plants, most often grasses.

In the summer, the air over the Atlantic Coast salt marshes is often filled with swarms of mosquitoes, no-see-ums, and greenheads (biting flies familiar to vacationers from Cape Cod, Massachusetts, to Jacksonville, Florida). I knew all too well the intent of these pesky flying insects: to bite and, in the process, irritate me. The planthoppers' activity was both less annoying and more mysterious: Where were they coming from? Where were they going? And, above all, why were they on the move? After learning that such mass movements are an annual occurrence, I was off in pursuit of answers to these questions, which, for the last fifteen years, have brought me back to the intertidal marshes of New Jersey.

The insects migrating on that June day were salt marsh planthoppers, *Prokelisia marginata*. As I found out early in my study, adults of this species occur in two forms: migratory and sedentary. The fore and hind wings of the former are fully developed, while those of the latter are greatly reduced, especially the hind pair, rendering these insects flightless. Long-winged forms can fly hundreds of miles, while short-winged adults can hop just a few yards—thus the name planthopper. Migratory individuals of this species outnumber flightless ones by a wide margin: 9 to 1. In sharp contrast, a survey of fifteen other planthopper species living on these intertidal salt marshes revealed that, on the average, 96 percent of all adults had short wings.

Why the difference? The answer, I found, lay in the hoppers' host plant, cordgrass (*Spartina alterniflora*). Several species of grasses, rushes, and other plants grow on the marsh. Some, like high tide bush, groundsel tree, and sea oxeye, grow along the upper fringes of the marsh in areas reached only by the highest tides. Others, with a greater ability to tolerate salt and withstand occasional submergence, are found lower in the tidal range; these include salt meadow hay, salt grass, and needle rush. In most cases, while a plant species may cover a huge expanse of marsh, its distribution is restricted to areas with specific conditions. Cordgrass, however, is an exception. It grows not only on the high marsh, near the high-tide mark, but also along the margins of tidal creeks and bay edges, which I refer to as the streamside environment. Furthermore, cordgrass grows very differently in the two environments. On the high marsh, near the mean high-water level, the plants grow in dense meadows of short rosettes no more than four to fifteen inches tall. Along the stream sides, however, cordgrass can reach well over six feet in height, but may still become completely inundated during the highest of tides.

Cordgrass grows tallest along the margins of tidal creeks.
Prokelisia planthoppers are thus presented with two very different habitats with perhaps different consequences for their survival and reproductive potential. This began to suggest why the adults migrate en masse every year, but it was only when I realized how dramatically the two habitats—high marsh and streamside—change with the seasons that I felt I was zeroing in on an explanation.

Like most planthoppers on the marsh, *P. marginata* is totally dependent on its host plant: it feeds on it (drawing up phloem sap through strawlike mouthparts called stylets), mates on it, deposits eggs in it, and nestles down in it for the winter. Thus it behooves the hoppers to be able to tell a good stand of cordgrass from an inferior one, and indeed they can. Laboratory studies have demonstrated some aspects of how the insects respond to different food conditions. Given a choice, for example, hoppers in the lab go out of their way to feed and deposit eggs on the most nutritious cordgrass plants they can find. Their pickiness pays off: hoppers fed on fertilized plants with high levels of soluble nutrients grow much larger and lay many more eggs than do hoppers fed on poor quality plants.

Despite laboratory findings, years of fieldwork were needed to ferret out how these planthoppers deal with changes in their natural environment. To begin with, I needed to understand the insect’s life cycle. The female deposits her eggs into cordgrass toward the base of the leaf blades, using her sawlike ovipositor to insert the eggs into the leaf tissue. Eggs hatch into nymphs, which wriggle to the surface of the leaf and begin feeding immediately. The nymphs molt through five stages, or instars, before emerging as adults. The entire cycle—from egg to adult—generally takes about one month, and more than one generation occurs in any given year. However, the development of young produced toward the end of the breeding season (which lasts from April through September) is interrupted, and the hoppers spend the winter in the nymphal stage, emerging as adults the following spring. Unlike many other kinds of insects, in which overwintering young, usually eggs or pupae, are concealed and immobile, these overwintering hopper nymphs are both active and relatively exposed. To survive, they hide in the loose thatch of blades and stems that remain after the cordgrass dies back in the fall.
Winter on the marsh can be violent, especially in the streamside environment. Winds, waves, and shifting ice knock over the tall grass stems and eventually shear them off altogether, leaving exposed creek banks with little dead plant material for the hoppers to hide in. Conditions are less severe on the high marsh, where much thatch remains and nymphs stand a better chance of successfully passing the winter deep in the tangles of dead stems and leaf blades.

As a consequence, planthopper populations are restricted to the high marsh during the winter season. With the onset of spring, new shoots of cordgrass appear in both streamside and high-marsh habitats. Along the creeks and bays, however, plants frequently remain inundated by tidewater and inaccessible to the hoppers until late spring, when the grass has grown tall enough to outstrip the high tides. Therefore, the first generation of adults (both long- and short-winged forms) that emerge in May from overwintering nymphs stay on the high marsh to mate and deposit their eggs. At this time, high-marsh cordgrass is nutritious, and there are relatively few hoppers to compete for it (even on the high marsh, a large proportion of nymphs fail to survive the winter).

But with the approach of summer, the high-marsh meadows become a less favorable place to develop. The nutrient quality of the cordgrass decreases and the marsh gets crowded, sometimes with more than 2,000 hoppers to a square yard. Under crowded conditions, nymphs take as many as ten days longer to develop into adults, probably because they eat less or are rele-
gated to poor feeding sites. During this extended nymphal stage, hoppers may be vulnerable to predacious spiders and beetles and parasitic wasps.

Not surprisingly, then, most of the offspring of first-generation adults molt into migratory adults and join in a mass exodus to the streamside in late spring. A few short-winged adults do develop at this time, however, primarily on the flooded mud pans that are found here and there in the extensive meadows of the high marsh. On these pans, cordgrass is shorter and stockier than on the rest of the high marsh and flowers very profusely in the fall. Significantly, the grass also grows more sparsely in the pans, and because it has more nutritional value than meadow plants, it offers a few hoppers summer refuge on the high marsh.

As waves of migrants from high-marsh meadows colonize streamside cordgrass, which by now has grown very tall, hundreds of hoppers can be seen on a single plant. Mating ensues and shortly thereafter females begin stabbing their eggs into the blades of grass. In some years, more than a million eggs are deposited in about one square yard of grass. After only ten days, most of the colonizing adults have died, but soon their eggs begin to hatch and build into standing room only aggregations of nymphs, each vying for a place to tap into the phloem.

The adults that develop in streamside populations during early summer are larger and more fecund than those that emerge from nymphs feeding in meadows on the high marsh at the same time. In the summer, streamside cordgrass contains more soluble protein than high-marsh vegetation, probably because of greater oxygenation of roots in the more porous mud along creek banks and the abundant nutrients delivered by tidewater to this frequently flooded habitat.

Another advantage of the streamside habitat in the summer is the relative lack of some predators and competitors. Three other species of planthoppers feed on cordgrass on the high marsh, but none accompanies *P. marginata* to the streamside. Furthermore, the wolf spiders that take such a toll on planthoppers on
The female, left, stabs her dark, sawlike ovipositor into a blade of cordgrass, deposits an egg in the leaf tissue, then pulls out the ovipositor and moves on to stab again. During the course of her life, a female may deposit up to one hundred eggs. Ovipositing damages the cordgrass, as does the hoppers' feeding style: sucking up phloem sap with strawlike mouthparts. When hopper populations are dense, the cordgrass begins to show signs of "hopper burn," turning yellow and then brown, below.

the high marsh are virtually absent along stream sides.

This paradise for planthoppers is short-lived, however, and the insects themselves may be largely responsible. As the developing nymphs suck up nutrients, the grass blades begin to show signs of "hopper burn," turning yellow and then brown. Weakened, the plants' ability to photosynthesize and manufacture nutrients is drastically reduced. If planthopper populations are dense enough, a once favorable habitat for planthopper development will deteriorate rapidly.

With the cooler temperatures of fall, the complexion of the marsh changes yet again. Cordgrass begins to flower and produce vegetative shoots, or tillers, after which the aboveground culms turn yellow and senesce. Associated with flowering
Teased out of the leaf tissue by the photographer, the planthopper eggs below have distinct eye spots, indicating that they are almost ready to hatch. After hatching, nymphs wriggle out to the surface of the leaf and begin feeding immediately. Opposite: Different stages of planthoppers may live on the same cordgrass plant. Here, two nymphs (lower left) share a blade with both long- and short-winged adults.

and tillering is a rise in the amino nitrogen content of the vegetation, especially on the high marsh. As a consequence, fall lessens the discrepancy between the nutritional value of streamside and high-marsh plants.

During September and October, the planthoppers migrate to winter refuges on the high marsh. These fall migrations, of third- and sometimes fourth-generation adults, are triggered by the tremendous density of hoppers developing in the streamside vegetation. By now the tables have turned, and the high marsh is the place to be for overwintering and a chance to develop into large, fit adults the following spring.

Planthoppers thus use a “developmental switch,” which comes into play while nymphs are still young, that allows them to maximize the quality of life for their offspring. If the future looks promising where they are, they molt into short-winged forms and stay. If hard times lie ahead—signaled by crowded conditions and less nutritious food—they molt into escape artists, the long-winged form.

If migration is so advantageous for *P. marginata*, why don't more salt marsh planthoppers do it? One reason may be that in some environments, such as the windy salt marshes of the Atlantic Coast, long wings can be a serious problem. Most planthopper species feed on plants that, no matter how extensively they may grow, are relatively uniform in nutritional value and structure, compared with cordgrass. Moving from one part of the range to another would not be likely to improve the hoppers' lot, and any insects that actually wandered or were blown off the range would probably be doomed. So unless a planthopper has someplace better to go, it is best to stay put.

Another aspect of long wings, more subtle but perhaps equally important, demands consideration. Planthoppers have a limited energy supply. If an individual must build wings and wing muscles and fuel flight, then it has less energy to spend on producing eggs. Migration itself can also be an ordeal. Some individuals make short trips, but most must move hundreds of yards or even several miles before reaching a suitable stand of cordgrass. For these reasons, long-winged females reproduce later in life and lay fewer eggs than do their short-winged counterparts. For flightless females, leaving more offspring behind to withstand the rigors of the harsh marsh winter may be a highly adaptive strategy.

So, to fly or not to fly? For some planthoppers in the marshes of New Jersey, the answer—like so much in life—is a trade-off. Greener pastures may indeed lie ahead for the migrant, but at least for the short term, leaving home has its costs: fewer offspring. Over the long term, however, the move may pay off handsomely for the planthoppers; if they have predicted the future correctly, then their offspring will fare well in their new habitat and will, in turn, produce more young.
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The Man behind the Indian Masks

George Hunt, son of a white trader and a Tlingit noblewoman, traded in treasures between two worlds

Text by Aldona Jonaitis • Color photographs by Stephen S. Myers

The frontispiece of the American Museum of Natural History's 1896 Annual Report contained a colorful map showing the locations of the various peoples who lived in northeast Siberia and on the Northwest Coast of America. The Report had a short piece by Museum president Morris Jesup describing a topic of great current interest to anthropologists and other scientists: the theory that America was populated by migratory tribes from the Asiatic continent.

Jesup had become intrigued by an ambitious project proposed by anthropologists Frederic Ward Putnam and Franz Boas: a major expedition to North Pacific regions to determine, once and for all, whether Native American peoples developed entirely in North America or whether they came from Asia via Siberia. Putnam and Boas felt that by sending a team of scientists to the Northwest Coast and to northeast Asia to collect data and artifacts, much could be learned about the prehistoric and historic relations between peoples on both sides of the North Pacific Ocean. As it turned out, the Jesup Expedition supported research in British Columbia from 1897 to 1902, and sent men not only to Siberia but to Washington State as well. It did not, however, have any fieldworkers in either Alaska or the Aleutians.

The expedition team was hand-picked by Boas. During the first year of the expedition, Boas went to British Columbia, "courtesy of the Northern Pacific Railroad," with Harlan Smith of the American Museum and Livingston Farrand of Columbia University. There...
George Hunt, right, was one of the most valued members of the Jesup Expedition team and continued to contribute to the Museum collection when the expedition was over. Below: A Kwakiutl wooden bowl collected by Hunt in 1899 represents a man crouching beneath a whale and was probably used in ceremonial feasts.
they met up with James Teit of Spences Bridge, a Scotsman turned Indian expert, and George Hunt, the son of a Tlingit woman and a Hudson's Bay Company official, who had been raised among the Kwakiutl.

George Hunt was not only Franz Boas's most valued Kwakiutl informant, but in many ways, he was also his most prized ethnological assistant. Born in Fort Rupert in 1854, Hunt functioned as a Kwakiutl. Several anthropologists and collectors who had worked on northern Vancouver Island before the Jesup Expedition sought out this intelligent, bilingual man for his intimate knowledge of Kwakiutl culture. By the time Hunt met Boas during the latter's 1888 field trip, he was accustomed to dealing with whites who wanted artifacts and ethnographic information.

Boas trained Hunt in ethnographic field methods, which Hunt learned extremely well. But despite high regard for Hunt's abilities, the anthropologist had occasional difficulties with his assistant. Although Hunt was indispensable to Boas during his 1894 winter field trip to the Northwest Coast, the anthropologist complained to his wife that Hunt was sometimes less than cooperative.

I wish I were away from here. George Hunt is so hard to get along with. He acts exactly as he did in Chicago. He is too lazy to think, and that makes it disagreeable for me. I cannot change this, though, and have to make the best of it. He left at noon with some excuse and returned only after several hours. He knows exactly how dependent I am upon him.

In the early months of the Jesup Expedition, Boas had sent Hunt a letter that he was to translate into Kwakiutl and then read to the assembled village at a feast for which Boas would pay. In this letter, Boas described the intent of his project, and assured the Kwakiutl that he would try to show "to the white men in Victoria that your feasts and your potlatches are good . . . that your ways are not bad ways." He regretted that so many young Kwakiutl no longer celebrated their traditions.

It is good that you should have a box in which your laws and your stories are kept. My friend, George Hunt, will show you a box in which some of your stories will be kept. It is a book that I have written on what I saw and heard when I was with you two years ago. It is a good book, for in it are your laws and stories. Now they will not be forgotten. Friends, it would be good if my friend, George Hunt, would become the storage box of your laws and of your stories.

Hunt then presumably showed the Kwakiutl Boas's 425-page book, The Social Organization and the Secret Societies of the Kwakiutl Indians, and perhaps even shared with them a translation of Boas's acknowledgment in the preface: "The great body of facts presented here were observed and recorded by Mr. George Hunt of Fort Rupert, British Columbia, who takes deep interest in everything pertaining to the ethnology of the Kwakiutl Indians and to whom I am under great obligations."

In 1900, the Kwakiutl of Alert Bay held a winter ceremony to which they invited Hunt, a member of the Hamatsa, a secret society also known as the Cannibal Society. To their dismay, Canadian government officials raided the ceremony and arrested several people, including Hunt. An Indian agent, R. H. Pidcock, accused Hunt of "assisting in the
Hunt and Boas procured this wooden sun mask from the Bella Coola Indians in the first year of the Jesup Expedition.

mutilation of a dead human body,” the corpse of a woman who had died several years earlier. To defend himself, Hunt claimed to be obtaining information for the agent to act upon, an argument Pidcock did not buy.

Shortly after his arrest, Hunt was in contact with Boas:

I am writing to let you know that I am in trouble. I am taken Prisoner in Alert Bay for going to see Lawtises tribe winter Dance, a Hamatsa eating Daid corps and I was sent to Vancouver to be tried. But I got a lawyer and he sent me Home to get some more witnesses and I am to be tryed on the 13th of next month.

In a March 1900 letter to collector Charles Newcombe, Boas expressed indignation at such wrong-headed interference with “nearly extinct” rituals. Then he asked Newcombe to present to the court one of Boas’s books acknowledging Hunt: “It would seem to me that to any sensible judge or jury it will make all the difference in the world why a man should take part in affairs of that sort.” In the end, Hunt was acquitted of all charges.

Hunt collected voluminous texts (for $.50 a page), which he copublished with Boas as volumes in the “American Museum of Natural History Memoirs” series; he also purchased about 2,500 works of art for the Museum, many of which are its most precious examples of Kwakiutl art. Boas insisted that Hunt collect old and complicated pieces with good documentation on associated myths and inheritance rights.

Hunt’s collection not only expanded the American Museum’s holdings considerably but also greatly increased the public’s understanding of British
Long-nosed "fool dancers" served as the unofficial policemen of the Kwakiutl Winter Ceremonial, an elaborate presentation of mythic events that included the initiation of young people into secret societies. Hunt acquired this mask in 1897 at Fort Rupert, a village whose population was wholly Kwakiutl.

Columbian Indian ceremonials. When, during a potlatch, a Kwakiutl chief wished to add a dramatic touch to the festivities, he directed his guest's attention to the wooden statues that were either set up outside atop tall poles or erected within the communal house. These figures, which might depict the chief himself, his speaker, his rival, or members of his rival's family, were used to enhance the chief's position at the expense of his rival by insults and mockeries. For example, one chief made an unusually explicit representation of a twisted-faced woman exposing her genitalia to ridicule a rival whose daughter had become a prostitute in Victoria. In another example, the figure of a chief's rival was placed before the fire and then offered some grease from a ladle. After pretending to listen to what the statue said, the chief's attendant smiled and announced publicly, "I thought so. He came to warm himself at our chief's fire because he is cold in his house and has never tasted grease." The attendant then covered the artwork with grease. To accuse his rival of insufficient food and grease was a terrible insult; a chief indicated his wealth by throwing grease away. Chiefs insulted in this fashion typically retaliated energetically and with equal aggressiveness, often by displaying their own statues mocking their rivals.

In addition to art used in a secular context, Hunt sent to the Museum a collection of pieces, including masks, used during the Winter Ceremonial, an elaborate masquerade reenacting encounters of a variety of mythical beings. Some masks were cleverly animated, such as that depicting the three avian attendants of Cannibal-at-the-North-End-of-the-World. The birds surround what seems to be the face of the Cannibal himself. By pulling strings, the dancer could open and shut the beaks of these birds in syncopated beat.

Even more dramatic were the transformation masks that revealed two or sometimes more faces in succession. One such mask, perhaps the most remarkable piece in the Hunt collection, is a triple transformation mask: when shut, it illustrates a smiling bull's head; when first opened, a sea raven; and when fully opened, an exquisitely and sensitively modeled white human face accentuated with red nostrils and mouth. Other pieces, such as the family of ghosts (No'tEngils), have articulated limbs and were used as puppets during the performance of dramatic rituals.

Although Boas was by and large extremely pleased with the objects Hunt sent back to the Museum during the years of the Jesup Expedition, he occasionally questioned the judgment of his Kwakiutl collector. One such occasion concerned the purchase of the great Dzonokwa bowl, now considered one of the Museum's treasures. This remarkable, more than six-foot-long dish represents the child-eater Dzonokwa, who is also known to bestow immense wealth on families. The artwork is a celebration of cavities for holding food: Dzonokwa's belly constitutes the principal bowl, while her naval and breasts are little dishes. One can even remove her aggressively carved mask to reveal yet another bowl hidden under her face.

Boas was most unhappy with Hunt about this purchase. On learning of the $65 bill for this carving, Boas wrote Hunt, "The price that you had to pay for the Dzonoq'wa dish is very high; and although
The “death bringer,” a wooden figure covered with fur, below, was also acquired from the Bella Coolas, and was used in ceremonial dances.

I presume you were very much interested in this specimen, I do not think the purchase was a very good one.” Hunt responded by explaining that the owner had refused another collector’s offer of $100 for the same or a very similar bowl, and wrote, “The owner would not sell it for that price so I thought I got it very cheap for if we write about the ways the Indians Handle it in the large feast I think you would like it” [4 July 1902].

Although the Jesup North Pacific Expedition came to an official end in 1902, Hunt continued to collect for the Museum and, in 1904, acquired one of its most treasured collections, the Nootka Whalers’ Washing Shrine, from Friendly Cove on Vancouver Island. This complex of figures was erected in an open shed, in which certain privileged individuals, usually chiefs, prayed and purified themselves in order to attract beached whales. Four times each day for four days, the whaler would go to wash in this shrine. Twice a day he had also to rub on his skin one hundred branches of hemlock, which he then tossed outside the shrine. Since by the end of any one whaler’s washing ritual eight hundred hemlock branches had been used, this shrine ended up surrounded by thousands upon thousands of piled-up hemlock branches.

Hunt sent Boas a photograph of the shrine to solicit his advice on whether it was advisable to acquire it. Hunt had some difficulty gaining access to this shrine to take the photo, for when the Nootka chief learned of Hunt’s interest in the shrine, he asked if he were a shaman. Hunt responded affirmatively, “for they say that I could not go to see the Whalers Praying House unless I was [a shaman].” To test whether Hunt really did have
healing powers, the chief brought him a sick man to cure; luckily, the patient recovered and Hunt was brought to the shrine.

In January 1904, Boas wrote Hunt giving him permission "to attempt to purchase the whaling-house of which you sent me a photograph." Boas then requested that Hunt take as many photographs of the house as possible, so that they could reconstruct the whole structure when it arrived in New York. In his letter to Hunt, he described his plan: "To build a whole house just like the one in which the carvings are, in one of our halls, and to put trees and vines and bushes made of wax around it, so as to make the whole thing look just as it looks now." [26 January 1904].

On June 9, 1904, Hunt described to Boas how he had encountered "trouble" in buying the Whalers' Washing Shrine—a true understatement, as it turned out. First of all, two different high-caste men claimed ownership of the assemblage. One threatened that if Hunt tried to buy it from the other, he would file a charge for selling stolen property, while the other asserted that if he did not get his proper share, he would "bring trouble among his people." These men not only wanted dollars, and a good many of them; they also wanted some of Hunt's Kwakiutl Cannibal Society songs. Although one of the men finally agreed to sell the shrine for $500 and ten Hamatsa songs, he reversed his decision the very next day. He had become frightened by his people's warnings that they would die soon if he sold the shrine.

Despite these obstacles, on June 22 Hunt finally reported that he had managed to bring the two vying chiefs together on friendly terms, and get each to agree to take $250. They in turn made Hunt promise not to touch the house until all the people left the area, and to bring it to the steamer at night. On July 27 Hunt wrote proudly to Boas that the shrine was "the best thing that I ever bought from the Indians." Unfortunately, the shrine was never erected as Boas had envisioned. Properly set up in a tree-covered, open-air shrine, the sixty-odd wooden figures, the fifteen human skulls, and the two large wooden whales would simply have taken up too much space in the Museum; instead, a small model of the Nootka Whalers' Washing Shrine was set up in the Hall of Northwest Coast Indians, while all the contents still remain in storage.

In 1943, Claude Lévi-Strauss was living in New York City, a refugee from the Nazis. One of his favorite places to spend time was the American Museum's Hall of Northwest Coast Indians, which he described as "a magic place where the dreams of childhood hold a rendezvous, where century-old tree trunks sing and speak, where indefinable objects watch out for the visitor, with the anxious stare of human faces, where animals of superhuman gentleness join their little paws like hands in prayer."

The great French anthropologist's poetic musings on this fabulous collection, published in the Gazette des Beaux Arts, included deeply appreciated responses to many of the pieces George Hunt had collected. The aesthetic experience Lévi-Strauss had during the war years is not dissimilar to that of the two and a half million people who visit the Museum each year and look at the great bowls, the articulated masks, the dynamic figures, the ghostly puppets, so vibrantly painted and excellently carved. These visitors, past and present, owe much to George Hunt, a brilliant and sensitive collector who contributed considerably to the glories of the American Museum's Northwest Coast Indian art collection.
A Kwakiutl transformation mask (pictured here both open and closed) reveals two entirely different beings. When shut, it is a simple and elegant representation of a raven. When open, the mask reveals the "Raven of the Sea," surrounded by depictions of sharp-toothed creatures facing inward.
Cape gannets crowd Bird Island near Lambert's Bay, South Africa, where seabirds vie with fur seals for breeding space.
A Fate Unsealed

Hunted nearly to extinction, fur seals now flourish on the southwest coast of Africa

Text and photographs by Fred Bruemmer

Europeans discovered fur seals and penguins on February 3, 1488, when the Portuguese explorer Bartolomeu Dias, sailing down the coast of southern Africa, sailed into a bay he called São Brás, now Mossel Bay. “Within this bay is an islet on which are many very large seals . . . and birds that . . . cannot fly [and have] the voice of an ass braying.” Eleven years later, Vasco da Gama, en route to India, stopped at the same seal island, counted 3,000 seals, and “for our amusement . . . fired among them with our bombard.”

Reports over the next four centuries told of intermittent but intensive hunting of the largest of all fur seals and the only pinniped of southern Africa. The Dutch took 45,000 seals from islands near the Cape of Good Hope in 1610; French sealers from La Rochelle haunted the coastal islands; and in the nineteenth century, sealers came from the United States and Great Britain. Benjamin Morrell, an American, wrote voluminously, if not always truthfully, about his sealing trips. In 1828–29 he hunted along the coast of southern Africa and reported that he took 7,320 skins, but he also reported that seals were scarce and had already been eradicated on many islands.

Morrell landed at Ichaboe Island, near the present-day town of Lüderitz in Namibia, killed a thousand seals, and noted the presence of a twenty-five-foot-thick layer of guano that had been laid down by enormous flocks of seabirds, mostly Cape gannets, jackass penguins, and Cape cormorants. Morrell called the island guano “the richest manure in the world,” and his report started southern Africa’s guano boom. By December 1844, 460 ships lay at anchor near Ichaboe, while nearly 8,000 men mined the “white gold.” The business was lucrative but messy. Wrote one shipmaster, “Here I am in the father of all dunhills, an enormous mass of bird’s manure . . . looking like bad snuff mixed with rotten kittens.” But in England the stuff was worth £10 a ton at a time when a 300-ton ship could be bought for £2,700.

The guano harvest was so valuable that when Britain agreed at the 1884 Confer-
ence of Berlin that Germany could annex South-West Africa (now Namibia), which was three times the size of Italy, as its protectorate, she specifically reserved sovereignty over the islands off Namibia for herself; they now form a part of the Republic of South Africa.

The guano accumulation of centuries was quickly removed and shipped to Europe and the West Indies. Workers stripped 200,000 tons from Ichaboe, and hundreds of shiploads came from other islands. Soon only the yearly dung layer remained to be harvested, laboriously scraped from the islands’ rocks—some 2,000 to 6,000 tons are now produced annually by the breeding birds. Although workers took large numbers of penguin eggs, other, less numerous guano-producing seabirds received some protection. Disturbed by the guano workers, the seals that had survived the slaughter left most of these islands.

By this time their numbers had been reduced to fewer than 100,000 and they had been eliminated from twenty-three of the forty-seven islands off southern Africa where they once bred. South Africa ended the ruthless free-for-all in 1893 and began a carefully managed seal harvest—similar to the harvest of northern fur seals on Alaska’s Pribilof Islands—that yielded 2.5 million pelts between 1900 and 1983. Fur seal numbers increased steadily. But when the Canadian hunt for harp seals was filmed in the 1960s, showing the clubbing of the cute, white-furred pups to a horrified world, an emotional campaign led to a worldwide boycott of most seal products. The Inuit could no longer sell ringed seal skins; the two-centuries-old fur seal harvest on Alaska’s Pribilof Islands ended; and the once highly prized South African fur (or Cape) seal pelts, harvested for five centuries, became worthless. A 1983 European Communities directive banning the import of harp seal and hooded seal pup pelts virtually ended the market for all seals.

In southern Africa the resurgent animals settled on bird islands and so trampled and harried the guano-producing seabirds that on some of the islands the invaders were repelled by men patrolling the perimeter. The seals then established rookeries on the mainland of South Africa and Namibia, and as a result, seal populations soared to their present level of about 1.3 million.

Jean-Paul Roux, a seal biologist with Namibia’s Sea Fisheries Department, believes that successful mainland colonization by fur seals must be undertaken suddenly and by many seals. Although lions, which once made mainland seal colonies an impossibility, are now gone from the mainland, two other predators of seals remain, the black-backed jackal and the brown hyena. If only a few females arrive, hyenas and jackals will eat the pups as soon as they are born. With a mass invasion, natural mortality would satisfy these predators, which act mainly as a cleanup crew. They kill pups when the females first arrive, but are soon content with eating placentas and the stillborn.
According to South African sea mammal specialists Peter B. Best and Peter D. Shaughnessy, who made a detailed study of the voyages of Benjamin Morrell and some of his successors, the first mainland seal colony in southern Africa probably formed at Cape Cross, Namibia, between 1848, when the guano-ship captain W. Messum landed there and saw no seals, and 1884, when Captain Hoffman of the German cruiser Mōwe came ashore and found many seals. The seals most likely emigrated to the rocky, islandlike promontory of Cape Cross to escape the guano workers on one of the islands. From there the colony spread, and the rookery now stretches for more than three miles along the beach.

Seals probably formed the mainland rookeries at Wolf and Atlas bays just south of Lüderitz in similar fashion. A half mile from shore lie the Long Islands, which, despite their name, are small. In 1828, when Morrell passed, they had a “dense population of fur-seals with which they were literally covered.”

Where the small number and size of the islands off southern Africa limited population growth, this check was removed when the fur seals moved to the mainland. And there they acquired a mighty protector, De Beers Consolidated Mines, the world’s foremost producer of gem diamonds.

In April 1908, Zacharias Lewala, a native worker, gave his boss, the German railroad inspector August Stauch, a
Strange pebble he had found near the railroad track at Kolmanskop, a few miles inland from Lüderitz. It was a diamond. Shortly after, Stauch and two companions made a prospecting trip. In a letter, now preserved in the Lüderitz Museum, one of them wrote to relatives in Germany that they had gone far into the desert and were short of provisions when, late one evening, they came into a Märchental (an enchanted valley). As they ate a frugal meal, the moon rose und im Mondlicht glitzerten die Diamanten (and the diamonds glittered in the moonlight).

Such reports naturally resulted in a diamond rush, a free-for-all that did not suit the German colonial authorities. They assigned to the Deutsche Kolonial-Gesellschaft für Südwestafrika the exclusive mining and prospecting rights in the 21,182-square-mile Sperrgebiet (forbidden region), soon hemmed by signs that said Verboten!

After World War I, De Beers acquired the diamond rights; the Sperrgebiet became its fief; and sometime in the 1940s the fur seals settled there. Rarely disturbed, they increased rapidly. In Namibia, diamonds are a seal's best friend. At Wolf Bay and nearby Atlas Bay, some 380,000 seals live in the restricted diamond area, a diamondiferous coastal zone nearly twice the size of Belgium. Surrounded by diamonds, the fur seals are left to pup in peace.

The largest mainland fur seal colony,
with a peak population of 360,000 animals, is at Kleinsee in South Africa’s Namaqualand, a diamond region controlled by De Beers and off limits to the general public. In 1976, the mainland seal population was three times larger than the island herds. Today, of the 1.3 million South African fur seals, nearly one million live on the mainland. They breed at twenty-four colonies, from the Black Rocks in South Africa’s Algoa Bay near Port Elizabeth to Cape Cross in Namibia, a coastal distance of about 1,600 miles. (In California, northern elephant seals increased from fewer than 100 in 1892 to more than 100,000 at present and have reoccupied islands where they once bred. Año Nuevo Point, an eight-acre promontory near Santa Cruz, became too crowded in the 1970s, and the seals, uninhibited by grizzlies, wolves, mountain lions, or humans, colonized the mainland.)

The tremendous increase in fur seals has been bad for seabirds because not only do the seals compete with them for food and vital island space, they also eat them, primarily the hapless jackass penguins. Phil Uys, lighthouse keeper at Dias Point near Lüderitz, told me he has seen a fur seal come up beneath a swimming penguin, grab its belly, and with several violent shakes, tear the entire underside out of the bird. (The subantarctic fur seal kills rockhopper penguins in a similar manner, and theantarctic fur seal eats macaroni penguins.) The losses may not be great, but the habit of eating portly little penguins has done nothing to enhance the fur seal’s reputation.

Overfishing by humans, however, is the main cause for the recent decline in seabirds. Fish catches in the immensely rich Benguela Current off southwestern Africa soared in the 1950s and 1960s and collapsed in the 1970s. Hardest hit were the pilchards, the main food fish of the jackass penguins, and these birds declined from a high of at least 1.5 million in 1900 to 100,000 at the present.

Human fishing has less effect on the adaptable seals. They eat a wide variety of food, including squid, and Jeremy David, of South Africa’s Sea Fisheries Institute, points out that off Namibia, where most seals live and feed, 52 percent of their diet consists of the noncommercial pelagic goby. David has computed that the human fishery around southern Africa takes 1.6 million tons a year and that the seals consume 1.4 million tons of food. Some of this they get from the fishermen. Peter Best reports that off Namibia “the seals have adopted a behavior pattern of waiting until a purse seiner has encircled a shoal of fish, then jumping over the corkline into the net and feeding wildly on the enclosed fish.” Not surprisingly, fishermen hate the fur seals.

Fur seals in search of lebensraum can be pushy and extremely persistent. In the 1970s, they increased rapidly on Hollam’s Bird Island and Albatross Rock, islands off the coast of Namibia that were crowded with seabirds. Now most of the birds are gone and the seals rule the islands. Despite a wall built to keep them
out, seals came ashore on Sinclair Island and harried the already endangered penguins. These invasions can be rapid and overwhelming. In 1980 the first seals in this century appeared on Mercury Island, an important bird sanctuary north of Lüderitz. By 1985, they numbered 14,000, including 3,600 pups born on the island. Now patrols repel the seals on Mercury and also on Bird Island in Lambert’s Bay, where 5,000 seals recently arrived and the housing shortage among seabirds is already so acute that Cape cormorants nest on oil tanks and abandoned trucks.

The South African fur seal is embarrassingly successful and no one knows what to do about its burgeoning numbers. Popular sentiment is not opposed to a controlled harvest but balks at the suggestion of a massive cull—of reducing the population by large-scale killing. Since breeding space is no longer a limiting factor, and as David has pointed out, “no epidemic diseases are known to have affected the seals historically... food would seem the most likely ecological factor to exert control over the... number of seals.”

At present, free of enemies, endowed with secure and unlimited breeding space on the mainland, and apparently amply supplied with food, southern Africa’s fur seals continue to flourish.
A fur seal pup, far left, can run quickly and nimbly on its oversized flippers. Below: Fur seals mass at Cape Cross, Namibia, breeding without threat from humans or other predators. Overcrowding may be the seals' worst problem. To avoid being trampled by bulls, the pups form pods at the edge of the colonies where the females come to feed them.
Drawn from the Sea

In the most artful of scientific illustration, science comes before art

by Michael Smith

John Ridgway, a prominent teacher of biological illustration, wrote that "a finished fish drawing probably represents more real work per square inch of surface than any other kind of drawing." Fish are among the most difficult of all natural history subjects to depict with scientific accuracy. Every patch of surface contains details that may have taxonomic importance. Their surfaces are usually covered with scales, often thousands of them, whose shape, size, and arrangement are all potentially useful in identification or in inferring relationships among species. Even the number of rays in the fins or pores on the sensory surfaces must be depicted accurately. Good technical illustrations can be a scientific tool, conveying detailed information about the physical makeup of a specimen that cannot otherwise be expressed.

The earliest practitioner of fish illustration as a rigorous form of scientific imagery was Jacob Heckel, inspector of the Imperial and Royal Natural History Cabinet in Vienna during the early nineteenth century. Prior to his work, fish illustrations were often beautiful, but rarely precise, which, combined with the inexact nature of most nineteenth-century taxonomic description, often kept scientists from recognizing differences between species. Consequently, they concluded that there were few species left to discover.

To bring mathematical precision to fish illustration, Heckel, in 1837, designed and built a machine he called a goniometer (from the Greek gōnion, "angle"). The device, made of pivoting metal arms, allowed him to determine the Cartesian coordinates of every major feature on the form of a fish and to draw an exact body outline. Heckel's work, much of it still unsurpassed, allowed him to develop a quantitative method for the analysis of fish morphology. In later papers he added color to the illustrations, and in an 1840 paper on Brazilian fishes, he took the technique to the ultimate of abstraction by publishing, not the illustrations of the fish, but only the formulas for their outlines.
Nicholas Pike painted these watercolors of wrasses during his tenure as U. S. consul to the island of Mauritius from 1867 to 1874. In order to complete the drawings when he returned from the field, Pike kept exacting notes and sometimes dried fish parts. The gill bar and patch of skin on the page reproduced above came from a Mauritius sea bass.
To accurately depict a fish's color—a feature that fades quickly after its death—ichthyological artists sometimes accompanied expeditions into the field. William Belanske, both naturalist and artist, served as illustrator on an oceanographic expedition to the Galápagos in 1926. Most of his illustrations are watercolors, but he used powdered mica to reproduce the metallic sheen of silvery species such as the hatchetfish—a technique developed two centuries before by Japanese artists producing the woodblock prints known as *ukiyo-e*.

Nicholas Pike was not only a naturalist and artist but also

**Drawn from the Sea: Art in the Service of Ichthyology** will be on view at the American Museum through December 11.
U. S. consul to the island of Mauritius in the late 1800s. From the tropics, he reported on weather, geology, flora, and fauna, and produced hundreds of watercolors of fish. Because Pike intended these paintings to be color notes for more formal illustrations, each was accompanied by scale counts, numbers of fin rays, and marginal notes and sketches. To insure that surface textures would be depicted accurately, Pike dried and pressed scales and patches of skin from the original specimens and pasted them to the margins of his color sketches. His paintings, never published, fill six heavy volumes in the collection of the American Museum of Natural History.

Unlike traditional art, scientific illustration, from its beginnings, was intended for mass distribution. Its development, then, was tied to the progress of printing technology. Early illustrations (from about a.d. 1400 in Europe) were reproduced by means of woodcuts. A copy artist redrew an illustration on a wooden plank and then carved away the surrounding areas to leave the lines of the drawing in relief. The image appeared as black lines on a white background, but the lines were too heavy to be able to convey the fine details needed to discriminate among related species.

A liberating change came in the late 1500s with the development of engraving on metal plates (intaglio printing, or gravure). The engraver cuts the image into the surface of a metal plate, inks the plate, and then wipes it clean, leaving ink only in the incised lines. When put on a press the paper is squeezed into the cut depressions to meet the ink. Since much finer lines can be cut into metal than into wood, more delicate details can be reproduced. The method was developed in time to show off the glories of Renaissance artists such as Albrecht Dürer, and later made it possible for ichthyologists like Jacob Heckel to achieve new levels of precision in conveying the characters of fish. These more precise figures allowed ichthyologists to rely on published work for species identification when they had no access to museum specimens.
G. H. Ford’s lithographs, such as this moray eel from the 1866 Fishes of Zanzibar, were models of scientific illustration.

AMNH
By 1850 the copperplate gave way to the lithograph as the best medium for scientific illustration. Here the image is drawn with grease pencil on a surface of smooth stone (the best of which comes from the Solenhofen quarries, which also yielded the beautifully preserved fossils of the extinct and aptly named *Archaeopteryx lithographicus*). The unmarked portion of the surface is wetted so it repels the ink, which adheres only to the drawn image, to which paper is then pressed. The process allows even more subtle reproduction of shading and details than does engraving, but most important, an artist could now draw the image directly on the stone, cutting out the middleman engraver who might introduce errors between the artist's work and the printed illustration.

Preeminent among nineteenth-century lithographers was G. H. Ford of the British Museum (Natural History), whose work can be seen in the major ichthyological monographs produced in England in the 1860s and 1870s. While ichthyologists appreciate the accuracy of his illustrations, art lovers can appreciate the work's liveliness and beauty.

Biological illustrators are often asked why photography hasn't put them out of business. While a photograph can capture a moving animal or give immediate corroboration of an identification, the camera does not distinguish between incidental qualities of light and the characteristics of a specimen that a scientist finds useful. Some features, for instance, may only be seen under certain light and magnification. Many fishes have transparent layers of tissue that a camera "sees" through, recording internal features as part of the external form. Some features of interest may actually be part of this transparent surface and invisible to the camera. An illustrator can draw these features without showing the organs behind them.

Both artists and scientists use drawing as a discipline, to gain a better understanding of the structure and design of organisms. From this understanding often comes an appreciation of their beauty. □
The lionfish, top, a pen-and-ink, watercolor, is by Kumataro Ito, who served as artist on the U.S. steamer Albatross during an expedition to the Philippines between 1907 and 1910. The black-and-yellow rockfish, bottom, was painted about the same time by Henry Raschen, who worked on the fishes of the west coast of the United States for the U.S. Fish Commission.

Smithsonian Institution
A Spotty Record?

The approaching sunspot maximum may be one of the largest ever

by Stephen P. Maran

On the morning of March 18, as I gazed at the eastern sky above the Java Sea, the dark silhouette of the moon slid across the bright disk of the sun, blocking it from view and producing one of the most spectacular total solar eclipses I have ever seen. Several brilliant red prominences appeared at the edge of the moon, although they were, in fact, in the two outer layers of the sun's atmosphere—the chromosphere and corona. Even more impressive were the long, pearly white streamers that extended almost vertically up and down as seen from my vantage point on the helicopter deck of the QE2.

Elongated in the east–west direction, the corona had a shape typical of the solar minimum, the interval during the sunspot cycle when there are the fewest spots (see "The Sun also Surprises," Natural History, November 1987). The most recent solar minimum occurred in 1986, and already the word is out among astronomers that the coming maximum of the sunspot cycle is likely to be very large and to occur sooner than some experts had anticipated.

Solar activity produces magnetic storms, powerful disturbances of the earth's magnetic field. The storms, in turn, interfere with radio communications, telegraph lines, transoceanic cables, and electrical power transmission lines and are often accompanied by auroral displays. For several days in early May, one such storm enveloped the globe, causing, according to the Washington Post, "radio and telephone disruption and a bright blue-and-white aurora borealis." Many more magnetic storms and more profound interference with terrestrial activities, as well as even bigger and brighter auroras, can be expected as solar activity increases over the next few years of the current sunspot cycle, cycle 22.

Solar astronomers worldwide are planning extensive studies of the coming solar maximum (that is, the period of peak sunspot numbers). Among the projects is "Flares 22," a three-year international study of solar flares—powerful eruptions that are thought to be triggered when magnetic structures in the solar atmosphere bump into each other. To gear up for that work, an International Solar Month (ISM) began in September. It will involve major facilities of both the United States and the U. S. S. R., including two Soviet spaceprobes, Phobos 1 and Phobos 2, that were launched July 1988. Although the Phobos craft are on a mission to Mars, Phobos 1 carries an instrument that is making images of the sun at five-day intervals and measuring solar radiation as well. Other images will be obtained by NASA's earth-orbiting craft, the Solar Maximum Mission (Soviet Max, for short), and the sun will be mapped in radio waves by the very large array radiotele-

An enormous solar eruption, extending half a million miles, was photographed in 1973 from Skylab. The white area is an active sunspot region.
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In New Mexico. By combining images taken from different directions in space, solar astronomers hope to produce stereoscopic views of the solar corona.

In past years, solar disturbances have been implicated in the breakdown of electronic equipment at pumping stations along the Alaska pipeline and even with interference in the flight of homing pigeons. The pigeons seem able to sense the direction of the earth's magnetic field and use that information, at least in part, to steer their way home. Yet after a large solar flare in June 1972, many homing pigeons that had been released by the University of Chicago reportedly became lost.

Patrick McIntosh, a solar astronomer and forecaster with the National Oceanographic and Atmospheric Administration (NOAA) in Boulder, Colorado, expects peak sunspot activity about the end of 1989 or the first quarter of 1990. There are many solar forecasters and they have made at least three dozen different predictions of the size of the next sunspot maximum. Most of them admit that there is no known physical basis for predicting the date of a sunspot maximum. All we know is that, based on the statistics of past sunspot cycles, large maximums tend to occur earlier than small maximums.

Unlike the date of the sunspot maximum, its size can be forecast. Some astronomers believe that powerful magnetic fields in sunspots are produced by gas flows that wind up and intensify already present, weak magnetic fields, somewhat like the ever thicker knots that develop when you wind the propeller in a model airplane powered by a rubber band. Therefore, these experts use measurements of the magnetic field at sunspot minimum to forecast the size of the next sunspot maximum. This method is hard to depend on, however. For one thing, because it was proposed fairly recently, there has not been enough time to confirm it by repeated testing. Since a sunspot maximum occurs about every eleven years, we need several eleven-year intervals before we will know if the predictions made by this method or any other are reliable. Worse yet, the estimated precision of most such predictions is quite poor, so that even if they are believable, they may not be very useful. A prediction that there is a 70 percent chance of rain, for example, might be enough to make you throw an umbrella in your briefcase before setting out for work, but what accuracy should we demand in a solar forecast before we divert vital transatlantic radio communications to different channels or change the launch plans of the intended orbit of a multimillion-dollar satellite?
Lest you think that solar activity is just the concern of technicians and technocrats, I hasten to point out that even yuppies may be interested. That's because, as is well known, yuppies cannot do without Chablis, and Soviet and Czech nuclear physicists, headed by A. A. Bur- 
chuladze of the Tbilisi State University in the U.S.S.R., announced in 1980 that 
the radioactive isotope carbon-14, which is produced when cosmic rays hit the earth's atmosphere, is present in wines of different vintage in amounts that depend on the phase of the sunspot cycle at the time the respective wine grapes were grown. Anyone who can detect "a slight hint of almond" in a fine wine (which, I suspect, is about comparable to the ability to see a Great Bear in the direction of the Big Dipper) must be able to taste an ex-
cess of carbon-14 as well, and I wouldn't be surprised if such an expert were calling the C-14 "almond."

The current record sunspot number is about 195, which occurred at the peak of sunspot cycle number 19, in about 1958. That's when a few of the first artificial satellites were in orbit, and that's when geophysicists discovered one of the most remarkable and unexpected effects of solar activity. They learned that when there are lots of sunspots, satellites in low-earth orbit (those with low points in their orbits of just a few hundred miles) start spiraling downward and reenter the lower atmosphere and thus burn up sooner than other-
wise expected. That's what made the huge, orbiting Skylab fall in July 1979. At such times, disturbed regions in the solar corona above the sunspots produce strong emissions of far ultraviolet radiation and X-rays. Far ultraviolet rays are those with even shorter wavelengths than ordinary ultraviolet rays, which, in turn, are shorter than the waves of visible light. This far ultraviolet radiation and the X-rays from coronal disturbances do not reach the earth's surface because they are absorbed by, and deposit their energy in, the upper atmosphere at altitudes of about 120 to 150 miles. The resultant heat makes the upper atmospheric gases rise like hot air over a radiator. Orbiting satellites at higher altitudes then meet more resis-
tance, known as atmospheric drag, to their flight, and more drag makes them come down sooner.

Ironically, increased drag at the next sunspot maximum will cause the principal satellite studying solar disturbances, the Solar Max, to reenter the earth's atmosphere earlier than scientists had hoped. Thus, the very phenomena that Solar Max was designed to investigate will eventually contribute to its demise. And
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Occultation in the Eastern Sky

by Thomas D. Nicholson

Perhaps November’s best sky show is on the morning of the last day, the 30th, when the waning gibbous moon, only one day before last quarter, occults Leo’s bright star Regulus.

The night before, after the moon and Regulus rise (about 10:30 p.m. or so), watchers will see Regulus moving up the eastern sky just behind the moon, and close watching will detect that the distance between them slowly narrows. Sometime between 4:30 and 6:00 a.m., depending on your location, Regulus will disappear behind the bright left edge of the moon, and then a half-hour to an hour or more later the star will suddenly pop into view from behind the dark right edge of the gibbous moon.

The exact times and duration of the events vary from place to place, but the table below identifies them for various locations. For places nearby, times will vary slightly, so it may pay to look a little earlier than the times given in order not to miss the disappearance or reappearance of the star.

Occultations of stars by the moon, even bright stars and planets, are not rare. They occur in regular cycles at periodic intervals (see “Celestial Events,” June 1988). This year, for example, a few dozen occultations of bright stars or planets oc-

When to See the Moon’s Occultation of Regulus

The times of Regulus’ disappearance behind the moon’s bright edge and its reappearance at the dark edge are indicated for several major cities. On November 30, the moon’s shadow approaches from the upper left and moves across the continent toward the lower right. Thus, times are progressively later to the east and south (after adjusting for time zone differences). Observers should begin looking before the predicted times.
Celestial Events

Cur, and hundreds more involve stars visible to the unaided eye. Among the bright stars, a monthly cycle with Spica is ending, once with Antares continues throughout the year, one with Regulus begins, and in addition, Mars is occulted once, Venus three times, and Mercury twice.

With all those events, you would think that we stood a fair chance of seeing some. Not so. Occultations, like eclipses, are geographically selective in the viewing opportunities they offer. And like eclipses, they are caused by shadows; the shadow of the star’s light, cast by the moon, falling on the earth. In this case it isn’t a visible shadow in the usual sense, but an area in which the star is blocked by the moon.

The slow, dramatic approach of the moon’s bright limb to Regulus before the star disappears and then the sudden, abrupt reappearance of the star from behind the moon’s dark limb will be exciting to watch in the morning sky of November 30. The excitement will be heightened by viewing with binoculars or a small telescope, which will accentuate the gradual motion of the moon relative to the star. Amateur and professional astronomers observe occultations (often of much dimmer stars than Regulus) to measure and refine our data on the moon’s position and motion, the profile along its edge, as well as the positions of stars along the moon’s path in the sky.

Occultations of Regulus occurred over North America twice before this year, but both times in daylight or twilight, when the bright sky made it impossible or difficult to observe. But if weather cooperates on the 30th, all it takes to see the event easily is the willpower to get up in the early morning.

Events in the following calendar occur in local time unless otherwise indicated.

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November 1: Hard-to-see Mercury, above and left of Virgo’s bright star Spica, rises in morning twilight. With an unobstructed eastern horizon, both can be seen before the rising sun obscures them. Binoculars may help.

November 2: Meteor watchers looking for the southern Taurid shower shouldn’t be bothered by the dim waning crescent moon, even though it is up by 1:00 a.m. The meteors, up to about a dozen or so per hour, are usually not very bright.

November 3: Leo’s bright star Regulus is close to the moon after rising early this morning. The moon occulted (covered) the star in dark skies over Europe last night, but by the time they rise here the moon is moving away from Regulus.

November 4: Apogee moon (farthest from the earth) is a crescent in Leo.

November 6: The slender late crescent moon is near brilliant Venus this morning, rising before 4:00 a.m. in the east.

November 7: The thinner crescent moon, rising about 5:00 a.m., is near Virgo’s bright star Spica this morning.

November 9: New moon is in Libra at 9:20 a.m., EST.

November 10: Another close lunar conjunction, with Scorpius’ Antares, is difficult to see. Star and moon (just past new) are too low in the southwest at evening twilight. Antares is covered by the moon in the southern Eastern Hemisphere.

November 12: Our first easy view of the evening crescent moon comes as it passes Saturn, the bright object above it.

November 13–15: Blame the tilt of the moon’s orbit (5° to the earth’s) for November’s low waxing crescent moon, more than 28° below the equator on the 13th.

November 16: First-quarter moon, just crossing the border between Capricornus and Aquarius, occurs at 4:35 p.m., EST. Capricornus’ bikini-shaped group of dim stars, to the right of the moon, slopes down toward Saturn in the west.

November 17: The waxing gibbous moon sets shortly after midnight, thereby not interfering with viewing the Leonid meteor shower. The swift Leonids, often dramatically bright, normally yield only about fifteen or so meteors, but have been prominent in past years. Look for Spica about dawn, when it will be near the much brighter Venus.

November 18–19: The moon passes above Mars during daytime on the 19th, shifting from the planet’s right to left from the 18th to the 19th. Mars, now almost two months past its September close approach, is still brilliant, easily seen all month as it moves from the southeast at dusk to the west, where it sets after midnight.

November 20: Perigee moon (nearest the earth) is in Pisces.

November 22: Jupiter, opposite the sun, rises at sunset and sets at sunrise, becoming an evening star.

November 23: The moon is full at 10:53 a.m., EST, and is in conjunction with Jupiter at noon. The two will be close together as they cross the sky tonight, Jupiter easily visible in the glow of moonlight below the moon, the Bull’s reddish star Aldebaran dimmer in the moonlight to Jupiter’s left. The moon shifts leftward relative to Jupiter and Aldebaran during the night.

November 25–27: The waning gibbous moon, rising after sunset, moves through Gemini on the 25th and 26th, into Cancer by the 27th, when it rises virtually in line with the Twin’s close-together bright stars, Pollux and Castor.

November 29–30: Again in Leo this month, the moon moves slowly toward Regulus on the night of the 29th as they rise out of the east after 10:30 p.m. Toward dawn on the 30th, the moon passes Regulus, occulting it for up to an hour or more from most of North America.

Editor’s Note: The Sky Map in the October issue shows the evening constellations and stars for this month and gives the dates and times for use.

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In the Pan-Caribbean Kitchen

Puerto Rican food, although varied and distinct, is part of a larger tradition

by Raymond Sokolov

In order to make the case that the cuisine of Puerto Rico is a venerable and complicated system of ideas and dishes, I have lately been stressing the uniqueness of the food of that extraordinary island. But the conditions that produced such brilliant hybrids as alcapurrias de jueyes (fritters with a plantain-taro dough and a native mangrove crab filling)—in which Spanish technique is applied to African, non-Caribbean New World, and indigenous ingredients—also made them available to the entire Spanish Caribbean. Indeed, the cuisine must have been more or less available to the entire Spanish empire, from Seville to Manila. And in the tinier but very cosmopolitan world of the Caribbean, the culinary turbulence of San Juan could, in the heyday of European colonization, be found in any of the island capitals.

The processes of influence and invention, of transplantation and cross-fertilization, that marked the Puerto Rican kitchen were also at work in Martinique and Jamaica, Curaçao and Trinidad. And in each of these places, dishes evolved that the modern traveler encounters as signposts of nationality: just as historically minded cooks in Puerto Rico will serve you asopao (from Spanish asopado, "souped"), a liquid rice stew of chicken or shellfish, so the Martinican epicure will flaunt patte-en-pot (paw in pot), a lamb ragout that includes the feet.

Gourmets (and I use the term advisedly) will argue about the validity of any and all of these claims of nationality. The Dominican chef at La Sarten on Amsterdam Avenue in New York City, not far from the American Museum of Natural History, serves asopao on a menu identifiable as Dominican by the presence of chicharrones de pollo (small, fried chicken pieces named for their resem-

Buljol, a salt cod and avocado dish served for breakfast in Trinidad
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blance to pork cracklings). Does this make asopao less Puerto Rican or chicharrones de pollo less Dominican? Not at all. Their juxtaposition on the same menu may simply represent a wish by the restaurant to attract a pan-Hispanic clientele. But this is not the first time that asopao has been served in a non-Puerto Rican context. Victor's, the avowedly Cuban restaurant a few blocks away, has also offered New Yorkers asopao in its time. The Caribbean is not so large, and its denizens travel and take their recipes with them. Especially in the formative days of these cuisines, when all the Spanish islands were truly Spanish, it would have been impossible for islanders to be completely insular. Obviously, they weren't, and what we perceive today as typical of one island or another is often a dish that, after four hundred years, has emerged as a local favorite, rather than an exclusive local invention with a pedigree that has been clearly established.

So when one speaks of Puerto Rican cookery, one makes a necessary but imperfect generalization about a group of dishes with a common history and a current life on one island where those dishes are more prominent than elsewhere. Some, perhaps, are almost never found anywhere else. But it is difficult to prove a negative, and safer to say that Puerto Rican dishes are those that most especially mark the gastronomic life of the island. Many of these same dishes are also found on those neighboring islands closest to Puerto Rico in history: the Dominican Republic and Cuba. But the emphasis, the style, the flavor, and the frequency vary enough so that one can speak sensibly about different, if related, cuisines.

I have been focusing on the food of Puerto Rico as a separate cuisine because Puerto Rico does arguably have the most fully developed, most distinct, and most diversely original cuisine in the Americas. But the island's origins as part of a culturally coherent world empire and its regional ties with other islands, even those with historic ties to England, France, and the Netherlands, link it with other microcuisines of the region and make it part of a pan-Caribbean kitchen.

To begin with, there are the indigenous ingredients and the fish and to some minor degree the lingering Carib-Arawak-Taino traditions for preparing them. But the more remarkable traits defining the pan-Caribbean cuisine are the dishes that merge continents and hemispheres. Perhaps no food better exemplifies this circumglobal aspect of Caribbean gastronomy than salt cod.

Long before Columbus, this tasty pre-
served fish of northern waters had spread to Iberia and Italy and made itself at home. Salt cod travels well, and it was an obvious candidate for ships' holds carrying provisions to the colonists of the New World, hungry for familiar tastes and, in the early days, just plain hungry. The transatlantic cod trade never stopped. And today at food stands on Puerto Rican beaches, you will be happy to find salt cod fritters known as bacalaitos (from standard Spanish bacalao, "codfish"). But you will also find salt cod fritters on other islands under other names.

As Elisabeth Lambert Ortiz observes in The Complete Book of Caribbean Cooking, bacalaitos are members of the same family as acarita in Trinidad, stamp and go in Jamaica, acrats de morue in the French islands, and marinadas in Haiti. Mrs. Ortiz also notes the differences among them. Some recipes have raising agents in their batter (yeast or baking soda), some don't. Seasonings vary from place to place as do extra ingredients. On Trinidad, fried yeast biscuits called floats are served with cod acarita. But the basic idea—shredding salt cod and frying it in batter—does seem to descend from a universal archetype. And that archetype seems to be West African, a fritter called acarita.

The fritter vocabulary of the Caribbean is immense, unprecedented in Europe, certainly in Spain where the idea is mostly limited to desserts. But in the French islands, one finds fritters based on taro, hearts of palm, chatoye, breadfruit, pumpkin, black-eyed peas, minnows, crayfish, and of course, salt cod. In Jamaica, fritters made from black-eyed peas or soybeans are called akira. On Curaçao, calas is the name for fritters made of black-eyed peas. Are these related to the New Orleanian rice fritters of the same name? I bet they are. And then there are Trinidadian phoulouri, split-pea fritters.

Similarly, most islands have their fried stuffed pastries—pasteles, pastelitos, pasteits, empanadas, empanaditas, empanadas. Another trans-Caribbean combination is avocado and salt cod in a salad or canapé spread.

And let's not forget coo-coo, also known as funche and fungi. This is a chameleon of a dish, a concept really—a cooked side dish based on a starch, usually cornmeal. People with a European background in cooking will be thinking that this is some sort of cousin of polenta, but I think we have a case of spontaneous culinary generation here, as maize became available throughout the world and cooks discovered how to use it. Polenta and its Romanian neighbor mamaliga are not, from this perspective, the archetypes, but simply

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they sailed to the Philippines, the Spanish throne's window on China. These so-called Manila galleons brought back many things to Mexico, including those baroque ivory crucifixes and madonnas executed by Chinese artists with Western teachers in the Philippines. And these galleons, returning from Mexico to Manila, brought, *inter alia*, foods and food ideas, from Spain itself and from Mexico.

This is how tamales entered the standard culinary life of Manila along with that typical dish of Madrid, tripe with chickpeas. Filipinos, according to our leading authority, Reynaldo Alejandro, also eat a rice chicken soup, *arroz caldo con pollo*, which looks to me like the grandchild of Valencian *arroz caldo* via Puerto Rican *asopao de pollo* made Asiatic with the superaddition in Manila of fresh ginger and the fermented fish sauce known locally as *patis*.

Raymond Sokolov is a writer whose special interests are the history and preparation of food.
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The Battle for the Viking Village
by John R. Alden

In 1961, when the city of Dublin decided to build a new civic office complex, the four acres of land between Christ Church cathedral and the River Liffey seemed like a good location. It was an unlucky choice. Under those four acres beside the Dubh Linn (Dark Pool) of the Liffey lay the heart of the original Viking settlement of Dublin, a small walled village more than eleven centuries old. Wood Quay tells the story of the long, bitter conflict over the fate of those remains.

The situation is in many ways familiar. There were archeologists working beside bulldozers, protests in the streets, angry squabbles in the civic councils, and a gaggle of suits and countersuits clogging the courts. The preservationists insisted the project could easily be moved, the builders answered that any delay would cost millions. But while the plot is familiar, at the site known as Wood Quay the roles and alliances were different. It was the City of Dublin that was destroying the archeological remains. It was the man in charge of the dig, the director of the National Museum of Ireland, arguing that the archeologists had done enough; it was members of the City Council insisting that the excavators needed more time. Wood Quay set the municipal bureaucracy against the City Council, the National Museum against the University College. It was nothing less than civil war, all fought over some scruffy remains beneath the center of downtown Dublin.

The story begins with the Vikings, who first came to Ireland to pillage and destroy. But the raiders were also traders, and in A.D. 841 they built a permanent village on the south bank of the River Liffey. "Streets quickly followed streets, business neighborhoods arose, and foreign trade brought into the new town products from other points on the far-flung Viking network." A stone-faced wall some fifteen

Archeological excavations at the Wood Quay site, November 1978
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feet high and five feet thick was built around the town, and a wooden quay put in along the water’s edge to give ships a secure place to anchor.

Over the next few centuries, as the river was gradually filled in, more quays were built and the new land behind them was quickly covered by the expanding city. Houses were abandoned and rebuilt, fill was dumped, and by the present century the remains of Dublin’s Viking (a.d. 841 to 1170) and Norman (from the late-twelth to the fifteenth century) occupations were buried deep beneath the surface of the modern city. The only visible sign of the original settlement lay in the convoluted street pattern of central Dublin, which, the Wood Quay excavations demonstrated, had remained more or less unchanged for more than a millennium.

Dubliners, at least those who cared about such things, knew the medieval remains were there. But nobody was interested enough to do anything about it. The Middle Ages were the intellectual territory of historians, and until a few decades ago historians worked almost exclusively with documents. Archeologists were the people who did excavations, and in Ireland most academic archeologists were interested in prehistory. “The Middle Ages,” said one Irish historian, is “just stuff out of the newspapers for them.”

In Ireland, medieval archeology was left, more or less by default, to two public institutions—the Parks and Monuments Branch of the Office of Public Works and the National Museum of Ireland. Their names alone warn that neither would be ideally suited for excavating a site like Wood Quay. Whatever else they might be, the remains uncovered here were neither parklike nor monumental. And museums, by their very nature storehouses, have all too frequently proved more interested in objects than in the social and economic relationships they represent.

Today, when academic lines are not so rigidly drawn, university-based archeologists and historians would fight like Vikings for the chance to excavate a site like Wood Quay. But in the 1960s, when work in downtown Dublin was getting under way, “historic” archeology was something suspect. It fell between the disciplinary cracks, clearly not prehistory but without writing, not history either. (This was also true in the United States, even though most American archeologists were trained as anthropologists rather than as historians. Somehow it didn’t seem really anthropological to dig up your own backyard.) So the task of excavating Dublin’s medieval occupations was given to the object- and monument-oriented National Museum, which dug into the ancient re-
 mains at High Street (1962–72), Wine-tavern Street (1969–73), Christ Church Place (1972–76), and finally, from 1974 to 1981, at Wood Quay.

Because all of these sites were buried in wet, oxygen-free mud, the remains of the Viking and Norman towns were remarkably well preserved. That fact, writes Heffernan, “means wood undecayed, cloth still supple, contents of stomachs of buried bodies intact, ashes undisturbed in heartths, coins in piggy banks, shoes just resoled, domestic furnishings, jewelry, toys, tools, artifacts, and houses and house plots mappable.” There were leather-working, wood working, and bone-carving workshops. Remains of thirteenth-century vessels built of Irish timber demonstrated a local shipbuilding industry, and the construction techniques evident in the wooden seawall, which might have given the site its name, revealed a great deal about medieval Irish carpentry. Wood Quay and the associated downtown excavations didn’t just offer a glimpse of medieval Irish life, they presented the rich, vital record of an entire town.

In terms of getting information out of the ground, the museum seems to have done a fine job. They recovered more than a million cloth, leather, bone, stone, wood, ceramic, and metal objects, washed and numbered each one, and stored them neatly away in great tiers of cases and drawers. Occupation levels were separated and mapped, materials are being studied by suitable specialists, and the process of publishing the results is under way. So why was there any controversy? Why did members of the City Council stage a sit-in at the site? Why did Hot Press, a sort of Irish Rolling Stone, call the bureaucrats responsible for the excavation “nincompoops and cretins,” and what led the director of the National Museum to call his archeological colleagues from Dublin’s University College “rabble”? How did what should have been a straightforward excavation turn into such a bitter public battle?

Thomas Heffernan, who is a professor of English at Adelphi University in New York, describes the primrose path from a new civic office building to “a bloody national disgrace” in exhaustive (and often confusing) detail. He introduces dozens of unfamiliar people, sits in on protests, reviews council meetings and court suits, and guides us through the tangles of an unfamiliar political system. But perhaps because he is not an archeologist himself, the author isn’t clear enough about the underlying cause of the Wood Quay conflict. This otherwise intriguing book was disappointing because it reported all the
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NATURAL HISTORY 1977

Marchers move through Dublin toward the Wood Quay site, March 31, 1979

WOOD QUAY

Wood Quay wasn’t simply a fight about a site—it was a fight about what archaeology should be. Dublin’s city bureaucracy, two successive directors of the National Museum, and about half of the City Council thought of archeology as monuments and artifacts, as Stonehenge and stone axes. The archeologists and historians of Dublin’s University College, the other half of the City Council, and the people actually excavating Wood Quay saw archeology as a window on the life of the past.

The minutes of a 1973 meeting on the future of Wood Quay make the first position clear. In them, Dr. A. T. Lucas, who at the time was head of the National Museum, is recorded as saying that “the Museum is principally interested in the recovery and preservation of artifacts,” with the caveat that “it would be desirable to preserve the Old City wall.” But designating the site that a similarly minded archeologist called “this hole in Dublin” a national monument? Unthinkable. It was nothing but a bit of wall and some scraps of wattle and daub houses.

The director of excavation thought differently. “What you have here is a total town—streets, houses, the layout, the original city, townscapes, town planning. That’s what’s important. Environment, not…another two-penny game piece. There’s millions of those.” To the second set of observers, the scraps of wattle and daub houses beneath Dublin represented the rarest treasure of all—an undisturbed record of medieval society in all its rich
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—B. D. S.

Photograph by Hannu Hautala
At the American Museum

Dinosaurs, Mammoths, and Cavemen

Charles Robert Knight pioneered the art of portraying prehistoric life. His murals, paintings, drawings, and sculptures of extinct animals and early humans were the first realistic depictions of the primeval world. For more than eighty years, his work has been the model for scientifically accurate renderings of dinosaurs and their contemporaries.

**Dinosaurs, Mammoths, and Cavemen: The Art of Charles R. Knight,** an exhibition organized by the Los Angeles County Museum of Natural History, presents more than 75 of Knight's works in the Naturemax Gallery of the American Museum of Natural History through January 31, 1989. Twenty-one of Knight's paintings and drawings commissioned by the American Museum have been restored by guest curator Sylvia Czerkas, and a group of models he made for the Museum have been recast for the exhibit.

Born in Brooklyn in 1874, Knight showed a scientific interest in animals from the age of five years, when his father first took him to the American Museum. As a young man, he attended art school at the Metropolitan Museum and got his first job drawing animals for stained-glass windows. While working as a magazine illustrator, he spent many hours in the American Museum's taxidermy department and at the Central Park Zoo, sketching animals and studying their anatomy. Knight then began to work with paleontologist Henry Fairfield Osborn to create lifelike restorations of prehistoric animals for Museum exhibits. They mounted fossil skeletons in action poses, a radical technique at that time, but one that was soon widely imitated. With the legendary paleontologist Edward Drinker Cope, Knight produced detailed illustrations of dinosaurs, often from mere fragments of bone. "I felt," he wrote, "that I had stepped back into an ancient world—filled with all sorts of bizarre and curious things, and in my imagination I could picture quite distinctly just what these mighty beasts looked like as they walked or swam in search of food." The attitudes and appearances of Knight's creatures formed the modern image of dinosaurs.

Knight brought prehistory to life, envisioning the postures of extinct animals by studying their living descendants. His careful observations of animal behavior infused his art with immediacy and emotion. "Rarely do we see animal reproductions that reveal a truly profound insight into the character of the creature represented," he wrote fifty years ago in *Natural History*. "Never forget the mind behind the muscular action."

**Naturemax**

*Behold Hawaii,* a new IMAX film by Greg MacGillivray in the Naturemax Theater, lets the viewer soar over island cliffs, peer into volcanic craters, and surf inside the crest of a giant wave. The film is shot on frames ten times the size of standard 35-mm frames and projected onto a four-story screen, New York City's largest. The first superscreen film to employ fictional characters, *Behold Hawaii* is the story of a young hula dancer who meets his ancestors in a dream. Also playing is *Dance of Life,* an overview of Indonesian art and culture. For show times and ticket prices call (212) 769-5650.

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*Charles Knight's 1909 painting of an American mastodon was based on a skeleton found in upstate New York.*
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June 19 – July 1, 1989

Robert F. Denno (page 40) says that since that fateful day in 1973 when he first noticed masses of planthoppers migrating in a New Jersey marsh, these small insects have dominated his research life. He has pursued willow beetles in Sweden and butterflies in Venezuela, but it is the salt-marsh planthoppers—relatives of cicadas and treehoppers—to which he returns. Denno is currently studying planthopper reproductive biology, interspecies competition, and community structure. In the future, he hopes to investigate how the hoppers affect the chemistry of their host plants and how water stress and heat stress in the plants influence the hoppers. A professor of insect ecology at the University of Maryland, Denno has also taught pest management in Costa Rica, Venezuela, and Sweden. For more on migration, he suggests Migration: Mechanisms and Adaptive Significance, edited by Mary A. Rankin and published as volume 27 of the Marine Science Institute’s Contributions in Marine Science (Port Aransas: University of Texas at Austin, 1985). A nice introduction to the planthoppers’ environment is Life and Death of a Salt Marsh, by John and Mildred Teal (New York: Ballantine Books, Inc., 1974).
Aldona Jonaitis (page 50), vice provost for undergraduate studies at the State University of New York at Stony Brook, has been on the school’s art faculty since 1974. During the many hours spent at the American Museum researching her first book, Art of the Northern Tlingit (Seattle: University of Washington Press, 1986), she began to wonder how all those wonderful treasures got to the institution on Central Park West. The question resulted in the book from which this month’s article is adapted. Jonaitis’s current research—on Kwakiutl cuisine—joins her scholarly interests with what she describes as “an obsessive involvement with cooking.” For additional reading on the Jesup Expedition, she recommends “Scholars amid Squalor,” by Stanley A. Freed, Ruth S. Freed, and Laila Williamson (Natural History, March 1988). Ira Jacknis’s article, “Franz Boas and Photography,” in the journal Studies in Visual Communication (vol. 10, 1984), touches on the Boas–Hunt relationship, and Douglas Cole’s Captured Heritage: The Scramble for Northwest Coast Artifacts (Seattle: University of Washington Press, 1985) is an excellent full-length discussion of museum acquisition of Northwest Coast art.

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Fred Bruemmer (page 58) is a frequent contributor of both photographs and stories to Natural History. Although his specialty is the Arctic (he last wrote on permafrost in the April 1987 issue), a trip to photograph fur seals off the southern coast of Africa prompted him to learn about the history of the now flourishing animals. For further reading on fur seals, he recommends Seals of the World, by Judith E. King (Ithaca: Cornell University Press, 1983). For his next project, Bruemmer has returned to the Arctic to photograph narwhals. His latest book is Seasons of the Seal (Ashland: NorthWord, 1988).

Michael Smith (page 66) admits that when it comes to taking in the details of an animal’s structure, artists, not scientists, may be the keenest observers. His own attempts at illustration have taught him a great deal about the fishes that he studies and given him an appreciation of the art of scientific illustration. Smith is Kalbfleisch assistant curator of fishes at the American Museum. He has studied desert fishes of the American Southwest and Mexico and is now surveying the Greater Antilles to determine the distribution of Caribbean fishes. For more on the art of scientific illustration, Smith recommends Scientific Illustration: A Guide for the Beginning Artist, by Zbigiew T. Jastezewski (New Jersey: Prentice Hall, 1985), and Frances Zweifels’s A Handbook of Biological Illustration (Chicago: University of Chicago Press, 1961).

Hannu Hautala (page 98) has been a wildlife photographer since 1970 and has had exhibitions of his work in Sweden, the Soviet Union, Japan, and his native Finland. He has published eight books of photographs and hopes to have his first collection published soon in the United States. His specialty is nature in the North and he is at work on a book about the light northern nights. For this month’s “Natural Moment” Hautala spent two weeks in a mobile blind observing the mating rituals of ruffs. Using a 2.8 stop on Kodachrome 64 film, he took the picture with a motor-driven Canon A-1 with a 300-mm lens. A long exposure time was necessary to capture the dynamics of the action.
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The Soul of Lao Yu

In an urban Chinese household, anguish over a mother’s death is intensified by conflict over the fate of her body

by William R. Jankowiak

Lao Yu died as she had wanted—in her home. Her death came as no surprise to her family, who had known of her illness for some time. During her eightieth year she had grown increasingly restless and ornery, complaining that her coffin had not yet been built and that her family didn’t respect her enough to have a proper Chinese burial but was going to save money by cremating her body. She believed cremation (prescribed by state law) would destroy her soul and any chance of being carried on the back of a crane to Western Paradise, the “Land of Total Bliss” in China’s Buddhist-derived popular religion. Unknown to Lao, or “old,” Yu, her anxiety over her fate had also set off among her family (a husband, three married sons, one married daughter, and four unmarried grandchildren) an intense debate over the meaning of life, death, and family loyalty that would not be resolved for years to come, if ever.

Lao Yu’s discomfort and her family’s uncertainty about how to respond to her death are representative of similar conflicts in other urban Chinese households. For more than 2,000 years the vast majority of Chinese have shuddered over the very thought of cremation. Because the body is believed to be sacred, any violation of the corpse will result in the destruction of the soul, thereby preventing the person from being reborn. The burning of a corpse is consequently viewed as a brutal and severe form of punishment. While doing fieldwork in the northern Chinese countryside, I once witnessed such a cremation. A pregnant woman had committed suicide, and her husband decided to punish her and prevent the return of her ghost by burning her corpse. Because he was also fearful that her child would return as an angry ghost, he waited until his wife’s corpse was ablaze, then ripped the fetus from the corpse and, in a separate area, set it likewise on fire.

In traditional Chinese cosmology, a clear relationship exists between a corpse and the life of its soul. To destroy one is to destroy the other. The state does not believe in the existence of a supernatural domain and has insisted that death be treated pragmatically. From a practical
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viewpoint, the country just does not have enough lumber and land to bury its expanding urban population. Urban Chinese (or at least Communist Party members) seem to share this view of death. Rural peasants have been able to circumvent this policy, but urbanites generally have not. Consequently, in most large Chinese cities the elaborate funeral is rare.

In China’s smaller cities, however, burial remains a real possibility. Deciding which form of funeral to undertake often cuts to the core of a person’s beliefs about the meaning of life and the role of the supernatural. In Hohhot, the capital of the Inner Mongolian Autonomous Region (IMAR), with a population of 492,000 people (80 percent of whom are Han and 20 percent ethnic minorities), many who live in the city’s old district have retained the right to be buried in their native villages in the city’s suburbs. For those who migrated from other regions, there are uncultivated patches of land to the north of the city that are used as grave sites. If a Hohhotian family can make the necessary arrangements (that is, obtain the lumber needed to construct the coffin and a truck and/or bus to transport relatives and friends to the burial site), they can easily bury their dead. More problematic, however, is the conflict that arises when traditional cosmological notions surrounding the deceased are reevaluated as this socialist country moves down the path of secular humanism.

The senior generation of Hohhotians (those fifty years of age and older) overwhelmingly prefer burial to cremation. For them, death plunges the family into deep communion with its ancestors by opening the door between the living and the dead. By and large, the younger generation, especially those who migrated from regions outside the IMAR, no longer believe this to be true. For them the gods do not exist nor is a traditional funeral important. Given this state of affairs, many Hohhotian families remain uncertain and divided over how best to meet their family obligations.

Several weeks before Lao Yu died, her family began to debate, in earnest, which form of funeral they should perform. The oldest son, a state cadre, worried that participating in a traditional rite would have a negative effect on his governmental career. The daughter, a college graduate, believed the state was correct in criticizing traditional burials as a waste of money, unclean, and superstitious. She favored cremation. The middle and youngest sons, a driver and a doctor, along with their father, a retired worker, strongly favored holding a traditional funeral. Both the oldest son and his sister insisted they didn’t believe in spirits, whereas their father and younger brother did. Lao Yu’s grandchildren weren’t sure. After much debate, everyone agreed that they should honor their mother’s request and bury her as she desired—in a coffin in the countryside. But first they needed advice about a number of things: Where to obtain a grave site; who would dig the grave; should they hire a geomancer to insure family luck or was that a waste of money; which work unit would provide a truck and/or bus to transport the body to the grave site; how big a postfuneral feast should they hold; and how many paper money-trees, paper servants, cars, and/or bicycles should they buy. To help them make these decisions, the family turned to friends, neighbors, and an eighty-three-year-old Daoist priest.

The anguish that Lao Yu’s death caused the family was intensified by their own uncertainty over how best to proceed. Their predicament remained a constant source of irritation and the major reason for repeated family disagreements. Almost immediately after it was decided to hold a “grand funeral”—“the biggest funeral since the Cultural Revolution,” said the oldest son—the first of what were to be many quarrels broke out. On the surface the issue was trivial enough: should the family buy a paper car or a paper bicycle? Some family members argued that Lao Yu never rode a bike so they shouldn’t buy her one, but that if they were going to buy her a vehicle, they should buy a car so she could travel in style in the next life. Other family members thought the idea of spending so much money on paper items was silly and that it would be better to buy more expensive cuts of meat for the postfuneral feast. When the youngest brother heard this, he furiously argued that “our mother will be able to do many things that she hadn’t been able to do before, so that we should send her the most modern thing—a car.” The oldest son noted that while “it was true that there might not be another world, our mother believed that there was, so out of respect for her we should also believe.” His college-educated sister argued that this was a stupid line of reasoning and that “they didn’t have enough money to hold a big feast and buy a lot of things.” Their aunt (Lao Yu’s sister), who had been quietly listening, wondered what the neighbors would say if the family held a funeral but did not buy any servants or a vehicle to send to the next world. She added that if “we don’t have a golden boy and a jade girl, the neighbors will accuse us of being cheap. We must think of our reputation.” The discussion ended when Lao Yu’s husband, eighty-six and enfeebled, who had been listening for a long time, revealed his preference forcefully: “My wife deserves a proper funeral. We should have everything.” So it was agreed that the Yu family, with the financial assistance of relatives, friends, and some neighbors, would have a very traditional funeral in the grand style. But first they had a pressing problem: selecting who was going to prepare Lao Yu for burial.

Before the soul can enter into Western Paradise, the corpse must be ritually cleansed in order to prevent pollution. Four specially dressed family members dip four cotton-swabbed chopsticks into a bowl of white alcohol and wash the eye-

The more white the mourners wear, the closer the relationship to the deceased. Here, the coffin is lowered into the earth by men who are probably cousins or friends of the family.
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The Yu family appeared reasonably comfortable with their decision to hold a traditional funeral, that is, until they had to select the date.

Tradition demanded that the funeral be held on the most auspicious day possible, as determined by three factors: the geomancer (if one had been hired), family wealth, and personal convenience. The family ideal is that the family should wait forty-nine days, a practice derived from Buddhism. During the freezing northern winter months, sanitation does not present a problem. During the summer, however, it does. Sanitation concerns force the family to shorten the maximum waiting period to seven days during the summer. I have been told some rural families may delay burial for forty-nine days, but as one youth remembers, "not even four or five bottles of Baijiu [Chinese alcohol] poured daily over the coffin could lessen the stench." Despite the odor, no villager protests the long wait. In urban Hohhot, however, the longest a family will wait during the winter months is seven days, and in the summer months, three days.

Odd-numbered days have always been preferred for funerals (odd symbolizing human attributes; even, nonhuman ones). The difficulties of arranging the support facilities to hold a traditional funeral sometimes forces many families to reluctantly break with this tradition. The Yu family was no exception. The family wanted to hold the funeral on March 11, the seventh day after Lao Yu died, but the logistics of obtaining two vehicles, compounded by the difficulty that some of their friends and neighbors had in getting the day off, forced them to consider changing the date to March 10, a Sunday. The youngest brother insisted they should hold the rites on Monday, even if it meant that only half the guests would attend. The eldest brother, now obsessed with the idea of holding a grand funeral, felt it would be all right to ignore tradition and hold the funeral on an even-numbered day. His younger brother exploded at this suggestion, and accused his eldest sibling of "not loving mother, nor caring about your own family's good fortune." That outburst brought the entire family, already emotionally exhausted, into another intense discussion over the meaning of numerology, tradition, and the reality of urban living. Emotionally spent, they settled the issue only when their father, who preferred to let his sons organize the entire funerary rite, announced "it would be all right to hold the rite on an even-numbered day." With that decided, the next issue for the Yu family was whether to start the funerary proceedings in the morning or in the evening.

Traditionally, funerals are held in the morning so that the scorching noontday sun cannot burn up and destroy the soul lingering near the corpse. During the day, the soul takes refuge from the elements by remaining inside a specially constructed canopy built to protect both the coffin and the deceased's soul. Once the funeral procession begins, the canopy is disassembled, exposing the coffin and the hovering soul to the elements. In order to avoid the unsympathetic comments of those who believe that burial is a remnant of China's "feudal past," a number of Hohhotians, who had moved from the old city to the new city district, have adapted to the change in social climate by holding the funeral in late evening. This wrinkle, however, defeats a secondary and very important function of the funeral: the public display of family wealth by drama and pageantry. Chinese funerals are not meant to be private affairs, but public demonstrations of devotion, wealth, and family solidarity. Thus, when someone suggested that the Yu family might want to hold an evening funeral, Lao Yu's daughter quickly vetoed that idea by noting that "most people living in the old city are familiar and sympathetic with the traditional burial custom." For once, the entire family was in agreement.

The next task to be performed was a little more difficult for the Yu family: Who was going to stay up at night and keep Lao Yu company? The oldest son volunteered, then became violently ill. Afterward, he privately told me that although he didn't believe in ghosts, he was too scared to sit up all night with his dead mother. Because other family members, particularly the youngest brother, showed no fear or leersiness around the corpse, it was decided that the youngest brother would sit up the first night, with other relatives taking turns on alternate nights. That settled, the middle brother began to place food outside the door to appease any wandering ghosts. His father stopped him, by calling out that it was too dangerous to give food to wandering ghosts; that "if you give one ghost food, other ghosts will also come around." When his daughter heard her father's comment, she became embarrassed, and whispered to me, "My father believes in the old ways."

At this point, the Yu family seemed to become more relaxed, and they rapidly and smoothly resolved a number of minor organizational details. It seemed that the family was finally going to publicly demonstrate their unity and hold a grand funeral. Then the day of the funeral arrived.

By seven o'clock Sunday morning, the courtyard was busy with a multitude of activities. Neighbors, friends, and relatives were bringing food and the cloth that, when presented to a bereaved family, is used to make mourning clothes. Strangers, realizing that a public drama was in progress, stopped their morning sojourn and assembled along the side of the street. Most of them had seen a traditional funeral before; those born in the new city district, however, probably had not. This division between districts and generations and geographical regions was forcefully illustrated when two college students, who knew me, happened to come upon the funeral by chance. Amazed and confused, they repeatedly asked me to explain the meaning of the ritual.

As is customary in China, the funeral began at about nine o'clock, with the junior members of the Yu family and their offspring kneeling in generational sequence before the coffin. After a minute or so of kneeling, all the males and their children retired to the Yu house, whereupon the women loudly began to wail, expressing grief at the loss of their mother. Tradition demands that a daughter-in-law cry at the funeral of her mother-in-law even if she didn't like her. Because the villagers know the true quality of that relationship, they are aware of whether a daughter-in-law's grief is genuine or perfunctory. On this day, however, no one's sincerity was questioned. All three of Lao Yu's daughers-in-law, as well as her daughter, cried with such vigor that they moved their husbands and even some onlookers to tears. It seemed that everyone loved Lao Yu. Forty-five minutes later the wailing ceased, a signal to the males and their offspring to return to the front of the coffin. Lao Yu's daughter and three sons then gathered around the coffin, while a male friend of the family drove wooden pegs into it. Nailing the coffin closed is another instance of the continuing dialogue with the dead. It is a collective statement of sorrow and continuing concern for the deceased's welfare. Because the properties of iron (black and metal) are believed to be potentially threatening to the corpse, only wooden nails are used. If iron were to pierce either the deceased's soul or the corpse, the soul would be in danger of never being reborn. Accordingly, wooden mallets are also required.

As the nails are struck, the nail driver cries out, "Avoid my nails," which means, "I'm sorry; I hope this doesn't hurt you." With each blow of the mallet, Lao Yu's children burst into tears while holding on to a corner of the coffin. The oldest son,
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who forty-eight hours earlier had worried about his reputation among work-unit colleagues, was so overwhelmed by grief that he repeatedly banged his head into the side of the coffin, causing his nose to bleed. Later, everyone who had witnessed this reported being moved.

Immediately following the sealing of the coffin, it is placed on a flatted truck, and the mourners turn their attention to a medium-sized clay flowerpot, which has been used throughout the week as a ritualistic vessel for burning the mourning money. The coffin sits on a pile of buckwheat shells, which were the pillow stuffing of the deceased. The eldest son (sometimes all the sons of the deceased) holds a white mourning stave and, facing the coffin, kneels directly behind the chief male mourners. The other mourners also kneel, positioning themselves by generation. All other married and blood kin (in descending generational order), friends, and invited neighbors station themselves between a sizable crowd of onlookers and the chief mourners. The funeral, which has been publicly open, suddenly becomes closed. This phase of the mourning rite is only for the invited guests (among whom I was fortunate to be included). It symbolizes the end of the soul’s earthly existence and the beginning of a new identity. The soul is seen as leaving forever the domestic sphere of daily concerns. According to traditional beliefs, it will henceforth be periodically recognized and honored as an esteemed guest, but never again will the soul be asked or expected to participate in everyday life. In fact, if the soul continues to manifest itself in mundane affairs, kin will become alarmed, apprehensive that the soul is unhappy and displeased.

The breaking of the ritualistic mourning vessel has its own meaning. It represents either joint family solidarity or sibling rivalry. In the past, whoever smashed the mourning vessel claimed the right to inherit the deceased’s property. Quarrels often erupted among brothers and, potentially, among nephews, over the right to break the mourning vessel. Today, within the urban milieu, brothers and sometimes grandsons often break the vessel together, thus symbolizing filial loyalty and brotherly harmony.

Following the breaking of the vessel, close female agnates and daughters-in-law burst into one long, continuous wail, while the male mourners quietly fight to control themselves. It is a profound and sacred moment. Within two to four minutes, the wailing ends. Young children who inappropriately continue crying are slapped and told to stop by an elderly neighbor. Here the funeral has entered into a secular period of rest. Friends and kin speedily and unceremoniously dismantle the canopy, dumping foodstuffs into a bucket and carrying the funerary offerings to the waiting truck. In silence, both men and women board the bus and head for the grave site. Unlike practices in Taiwan and the southern coastal regions of Guangzhou and Fujian, where women are considered to be too polluting to accompany the funeral cortège to the cemetery, Hohotian women (as in other northern localities) are expected to continue participating in a variety of grave site rituals.

At the grave, which had been dug the previous day, the Daoist priest, who had been silently observing the rite, stepped forward and instructed the mourners to circle the grave that held Lao Yu’s coffin three times, while using their left hands to push dirt into the grave. After circling, the mourners walked away. Then the Daoist priest became upset and angrily yelled that they “were still in hell” and warned that if they wanted to get out, they had to retrace their steps in a counterclockwise direction. At this gross violation of the ritual, the youngest brother became furious at his older brother’s lack of knowledge and called out loud enough for everyone to hear, “Older brother should know better, but he is stupid.”

Retracing their steps out of hell, the male mourners knelt in front of the grave while their brother-in-law quickly burned the funerary offerings. As the fire subsided, the eldest grandson pushed a living tree (a symbol of the family’s future prosperity) into the grave. Emotionally exhausted, the mourners boarded the bus, fearful of wandering ghosts, and deliberately returned to the Yu home via a different route than they had come. Upon entering the Yu courtyard, each mourner picked up a large chopping knife and rubbed it over a bowl of grain alcohol while eating a small piece of bread (a symbol of good luck). The alcohol and knife are thought to protect the mourners from hungry ghosts that might follow the mourners home.

Inside the Yu home, a banquet had been prepared that closely resembled a traditional wedding feast, celebrating happiness, continuity, and family unity. Since everyone maintained a different conception of the power of the supernaturals, the family could not reconcile their fundamental disagreements over how best to respond to the demands that death made on themselves and their family. For the eldest son, caught between the socialist interpretation of reality and the traditional ethos, his mother’s death provoked an irreconcilable conflict between duties
owed to two different world views. His younger brothers, who believe in the traditional customs, were less troubled by their mother’s death and their participation in the traditional rite. Firmly believing in the continued power of the supernatural, they diligently performed their duties and found the ritual, on the whole, emotionally satisfying. For them, the supernatural domain remained filled with some gods, numerous ghosts, and reasonably contented ancestors. Their sister, untroubled by the nonexistence of a supernatural domain, willingly participated in the traditional funerary rite and, until her elder brother lost control of himself, appeared content with that participation.

After an hour or so of eating and toasting, the immediate members of the Yu family were totally inebriated and attempts at maintaining a show of family unity disappeared rapidly with each additional toast. Lao Yu’s oldest son, while continuing to worry that his work unit would criticize him for participating in a feudal ritual, simultaneously worried that his mother was not pleased with his performance at the grave site. Moving from one table to another, thanking everyone for helping the family, he slurred (in front of his sister), “Do you think mother was satisfied?” His sister immediately shot back, “Why shouldn’t she be? Everyone is satisfied. Sit down. Stop worrying.” To this he replied, “I’m uneasy.” “Why?” shouted his sister, with tears running down her face, “Our mother is dead, gone, and will never return. Dead is dead, there is nothing more.” Angryly he cried out, “Shut up. You don’t believe. You are not a good daughter.” To which she responded, “Who isn’t a good daughter? I love mother. You are a gambler and a drunk.” Hearing this exchange, the youngest brother attacked his sister for thinking that having an education meant rejection of the old customs, adding that “mother was disappointed with you.” Cursing him, she called out, “What kind of thing are you?” This exchange stunned everyone. Suddenly the room was filled with people urging the agitated siblings to “sit down,” “eat,” “drink,” and “stop worrying.” A neighbor sitting next to me leaned over and whispered, “Such things should not happen; this is a bad sign.” Lao Yu’s husband, the symbolic patriarch of the family, by now exhausted and completely drunk, could only murmur, “What kind of family is this?”

William R. Jankowiak, an assistant professor of anthropology at Tulane University, is currently at work on a book about life in Hohhot, Inner Mongolia.
Ten Thousand Acts of Kindness

Who occupies the driver’s seat of human history?

by Stephen Jay Gould

The visitor’s center at Petrified Forest National Park, in Arizona, houses an exhibit both heartwarming and depressing. Signs throughout the park beg, exhort, order, and plead with visitors not to collect and keep any fossil wood, lest the park be denuded on less than a geological time scale. The exhibit contains pieces of wood stolen from the park, but returned in guilt—the heartwarming side.

The depressing side resides in the notes written to explain decisions to send the contraband back to its natural place. No note from an adult cites any moral principle or even a purely personal sense of guilt. All tell tales of bad luck, usually trivial rather than catastrophic, that occurred soon after the theft—Uncle Joe’s broken hip or three hundred bucks worth of fender bender. The wood, as an evil talisman, must be returned. Apparently, these penitents understand neither principles of conservation nor laws of probability. A single exception—restoring one’s faith in primal feeling—lies in the only letter from a child: Dear Mr. Ranger, I took this and felt bad later. I’m sending it back. I’m sorry.

I have often wondered why so many people feel compelled to take such a souvenir in the face of so many good reasons for abstaining. I know that the motives are varied and complex, but I believe that for many people, a primary impetus arises from a common misunderstanding about fossils.

Many people think that fossils, almost by definition, are rare and precious. (Some are, of course—the six specimens of Archaeopteryx and our limited evidence of human ancestry, for example.) The urge to own something both uncommon and unusual must inspire many of the thefts. But most ordinary fossils, including petrified wood, are not single jewels on vast beaches of common sand, but intrinsic and abundant parts of their geological strata. Why purloin a piece from a national park, thereby committing both an illegal and an immoral act, when petrified wood can be found in abundance at so many places right outside the park boundaries? The fossils are beautiful, and they are tempting. But they are also plentiful.

Fossils are, for the most part, not like single archeological sites—limited to one spot and easily exhausted without hope of replenishment. Destroy Troy by careless collecting, and that’s that forever. (On this point, two tangential and contentious comments deserve essays in themselves, but shall have to pass by in epitome. First, most fossil localities should not be regulated like unique archeological sites. Fossils in the ground, wrapped in red tape, are worthless, and fossils exposed in an outcrop will quickly be weathered and destroyed if not collected. I abhor both careless collecting and commercial exploitation of fossils with scientific value, but misplaced regulation, based on a false taxonomy equating paleontology with archeology, can be just as bad. Second, paleontological expeditions are not called digs, because we so rarely go to a single spot and excavate. Since specimens are usually intrinsic to strata and spread throughout wide areas of outcrop, digging in one place would be a very foolish way to collect most fossils. But the word dig has permeated pop culture and is now invariably used by people with superficial understanding who try to appear “in the know.” If you wish to prove the opposite of your intention to impress, then ask a paleontologist, as I have been asked perhaps a thousand times, “Have you been on any interesting digs lately?” Sorry for those petty explosions, but grant me the catharsis of getting these two things off my chest.)

Many fossils, then, are abundant components of their strata, exposed over miles of outcrop: just consider the clam shells exposed by the millions on polished marble surfaces in the bathrooms of New York’s finest art deco skyscrapers, or the thousands of Turritella shells weathering out of the limestone in older parts of Quasimodo’s bailiwick at Notre-Dame de Paris.

The Big Badlands of South Dakota re-play the tale of the Petrified Forest. Fossil vertebrates can be outstandingly abundant, and these beds have been collected by professionals for more than a century. In much of the Brule Formation, source of the “worst” terrain, fossils are so common that every tiny pinnacle and elevation has a bone on top. (The fossils are harder than the enclosing sediments. Bones and teeth therefore weather out to form tops of tiny
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promontories, capping and protecting a column of sediment below, while surrounding rock crumbles away on all sides.) Yet visitors think they are seeing precious and tempting rarities on the official trails—and the stealing begins again. On the major nature trail, park officials covered the best specimens with plastic boxes. But people broke the boxes and took the bones underneath. So naturalists replaced the real fossils with casts and then put the plastic boxes back for good measure.

This extraordinary abundance of some fossils illustrates something important about the history of life. Evolution is a theory about change through time—"descent with modification," in Darwin's words. Yet, when fossils are most abundant during substantial stretches of time, well-represented species are usually stable throughout their temporal range, or alter so little and in such superficial ways (usually in size alone), that an extrapolation of observed change into longer periods of geological time could not possibly yield the extensive modifications that mark general pathways of evolution in larger groups. Most of the time, when the evidence is best, nothing much happens to most species.

Niles Eldredge and I have tried to resolve this paradox with our theory of punctuated equilibrium. We hold that most evolution is concentrated in events of speciation, the separation and splitting off of an isolated population from a persisting ancestral stock. These events of splitting are glacially slow when measured on the scale of a human life—usually thousands of years. But slow in our terms can be instantaneous in geological perspective. A thousand years is one-tenth of one percent of a million years, and a million years is a good deal less than average for the duration of most fossil species. Thus, if species tend to arise in a few thousand years and then persist unchanged for more than a million years, we will rarely find evidence for their momentary origin, and our fossil record will only pick up the long periods of prosperity and stability. Since fossil deposits of overwhelming abundance record such periods of success for widespread species living in stasis, we can resolve the apparent paradox that when fossils are most common, evolution is most rarely observed.

The abundant fossils of the classic Big Badlands strata provide an excellent illustration of this paradox. My colleague Donald Prothero has been studying all well-preserved mammalian species in these deposits. He finds that none change gradually during their residence in Big Badlands strata. New species enter with geological abruptness, either because they have evolved in situ as the theory of punctuated equilibrium predicts or because they have simply migrated into the area.

One of my graduate students, Tim Heaton, has just completed a thesis on the most common genus of rodents (themselves the most diverse group of mammals) from Oligocene sediments throughout western North America, prominently including the Big Badlands. Paleontologists divide the Oligocene into three "land mammal ages" called Chadronian, Orellan, and Whitneyan. Heaton's genus, Ischyromys, is relatively rare in the Chadronian, but fantastically abundant in the Orellan, where thousands of jaws have been collected (and nearly all—in an extended fit of admirable activity—photographed, measured, and statistically analyzed by Heaton).

The Orellan Ischyromys has a traditional interpretation consistent with conventional views of evolutionary gradualism. The Orellan sequence has been read as a tale of steady increase in size within a single species. But Heaton's statistical work on several thousand specimens has disproved this old idea in favor of an opposite interpretation. Heaton finds two separate species, one small and one large, in the lower Orellan; the small species then becomes extinct and only the large form persists into the upper Orellan. Neither species shows much, if any, change throughout its range (the large form may undergo a slight size increase in the upper beds). The old impression of gradual increase results from mixing the two species together and falsely treating the complex as a single form. As the small species decreases in abundance and finally dies off, average size of the whole complex increases because more and more (and finally all) specimens represent the stable large form—not because any gradual evolution is occurring.

On the other hand, in the older Chadronian beds, where Ischyromys is relatively rare, Heaton has discovered a previously unrecognized richness of taxonomic diversity: several species of Ischyromys and a related genus, Titanotherium. Although none of these species shows any change after its origin (most are too rare to provide much evidence for anything beyond their existence), this diversity illustrates marked evolutionary activity for Ischyromys in the Chadronian, while Heaton has shown that nothing happens (beyond the extinction of the small species) in the overlying Orellan, where Ischyromys is so abundant. The small, isolated, and rapidly speciating populations that produced so much evolution among Chadronian Ischyromys did not often leave their calling cards in the fossil record.

Again, we note the paradox: nothing much happens for most of the time when evidence abounds; everything happens in largely unrecorded geological moments. We could attribute this pattern to either a devious or humorous God, out to confuse us or merely to chuckle at our frustration. But I choose to look upon this phenomenon in a positive light, for it is trying to tell us something important. There is a lesson, not merely frustration, in the message that change is concentrated in infrequent bursts and that stability is the usual nature of species and systems at any moment.

Being human, I love to foot my own horn in support of punctuated equilibrium. But I am writing this essay for another reason. What's past (in this essay), as the Bard says, is prologue—a prologue to make a point by analogy about the real subject of this essay: the vexatious issue of human nature.

Let us return to the irony of Ischyromys in the Chadronian and Orellan, and of punctuated equilibrium in general. Evolution has constructed the tree of life; yet, at least almost any moment for any species, change is not occurring and stasis prevails. If we then ask, What is the normal nature of a species? the only possible reply is, stability. Yet exquisitely rare change has built the tree of life and made history on a broad scale. We now come to the nub of my argument: the defining property of a species, its normal state, its appearance at almost any time, is contrary to the process that makes history (and new species). If we tried to infer the nature of species from the process that constructs the history of life, we would get everything precisely backward—for events of great rarity (but with extensive consequences) make history.

I believe that this same tension and contrast exist between human nature and the events that construct our history. We have committed an enormous error in assuming that the behavioral traits involved in history-making events must define the ordinary properties of human nature. Must we not link the causes of our history, or so the false argument goes, to the nature of our being?

But if my analogy holds, precisely the opposite might be true. If rare behaviors make history, then our usual nature must be defined by our ordinary actions in an everyday world that engulfs us nearly all the time, but does not set the fate of nations. The causes of history may be opposed to the ordinary forces that prevail at
When Maggie does the test driving...magazine readers flock to the showroom.

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almost every moment—just as the processes that construct the tree of life are invisible and inactive nearly all the time within stable species.

History is made by warfare, greed, lust for power, hatred, and xenophobia (with some other, more admirable motives thrown in here and there). We therefore often assume that these obviously human traits define our essential nature. How often have we been told that “man” is, by nature, aggressive and selfishly acquisitive?

Such claims make no sense to me—in a purely empirical way, not as a statement about hope or preferred morality. What do we see on any ordinary day on the streets or in the homes of any American city—even in the subways of New York City? Thousands of tiny and insignificant acts of kindness and consideration. We step aside to let someone pass, smile at a child, chat aimlessly with an acquaintance or even with a stranger. At most moments, on most days, in most places, what do you ever see of the dark side—perhaps a parent slapping a child or a teen-ager on a skateboard cutting off an old lady? Look. I’m no ivory-tower Pollyanna, and I did grow up on the streets of New York. I understand the unpleasantness and danger of crowded cities. I’m only trying to make a statistical point.

Nothing is more unfamiliar or uncongenial to the human mind than thinking correctly about probabilities. Many of us have the impression that daily life is an unending series of unpleasantnesses—that 50 percent or more of human encounters are stressful or aggressive. But think about it seriously for a moment. Such levels of nastiness cannot possibly be sustained. Society would devolve to anarchy in an instant if half our encounters to another human being were met with a punch in the nose.

No, nearly every encounter with another person is at least neutral and usually pleasant enough. Homo sapiens is a remarkably genial species. Ethologists consider other animals relatively peaceful if they see but one or two aggressive encounters while observing an organism for, say, tens of hours. But think of how many millions of hours we can log for most people on most days without noting anything more threatening than a raised third finger once a week or so.

Why, then, do most of us have the impression that people are so aggressive, and intrinsically so? The answer, I think, lies in the asymmetry of effects—the truly tragic side of human existence. Unfortunately, one incident of violence can undo ten thousand acts of kindness, and we easily forget the predominance of kindness over aggression by confusing effect with frequency. One racially motivated beating can wipe out years of patient education for respect and tolerance in a school or community. One murder can convert a friendly town, replete with trust, into a nexus of fear with people behind barred doors, suspicious of everyone and afraid to go out at night. Kindness is so fragile, so easy to efface; violence is so powerful.

This crushing and tragic asymmetry of kindness and violence is infinitely magnified when we consider the causes of history in the large. One book burning in the library of Alexandria can wipe out the accumulated wisdom of antiquity. One supposed insult, one crazed act of assassination, can undo decades of patient diplomacy, cultural exchanges, peace corps, pen pals—small acts of kindness involving millions of citizens—and bring two nations to a war that no one wants, but that kills millions and irrevocably changes the paths of history.

Yes, I fully admit that the dark side of human possibility makes most of our history. But this tragic fact does not imply that the behavioral traits of the dark side define the essence of human nature. On the contrary, I would argue, by analogy to the ordinary versus the history making in evolution, that the realities of human interactions at almost any moment of our daily lives run contrary, and must in any stable society, to the rare and disruptive events that construct history. If you want to understand human nature, defined as our usual propensities in ordinary situations, then find out what traits make history and identify human nature with the opposite sources of stability—the predictable behaviors of nonaggression that prevail for 99.9 percent of our lives. The real tragedy of human existence is not that we are nasty by nature, but that a cruel structural asymmetry grants to rare events of meanness such power to shape our history.

An obvious argument against my thesis holds that I have confused a social possibility of basically democratic societies with a more general human propensity. This alternative view might grant my claims that stability must rule at nearly all moments and that much rarer events make history. But perhaps this stability arises by predominant behaviors of geniality only in relatively free and democratic societies. Perhaps the stability of most cultures has been achieved by the same “dark” forces that make history when they break out of balance—fear, aggression, terror, and domination of rich over poor, men over women, adults over children, and armed over defenseless. I allow
that these forces have often kept balances, but still strongly assert that we fail to count the ten thousand ordinary acts of nonaggression—done if only because people know their places and do not usually challenge the sources of order—that overwhelm each overt show of strength even in societies structured by domination. To base daily stability on anything other than our natural geniality requires a perverted social structure explicitly dedicated to breaking the human soul—the Auschwitz model, if you will. I am not, by the way, asserting that humans are either genial or aggressive by inborn biological necessity. Obviously, both kindness and violence lie within the bounds of our nature because we perpetuate both, in spades. I only advance a structural claim that social stability rules nearly all the time and must be based on an overwhelmingly predominant (but tragically ignored) frequency of genial acts, and that geniality is therefore our usual and preferred response nearly all the time.

Please don't read this essay as a bloated effort in the soft tradition of, dare I say it, liberal academic apologies for human harshness, or wishy-washy, far-fetched attempts to make humans look good in a world of woe. This is not an essay about optimism; it is an essay about tragedy. If I felt that humans were nasty by nature, I would just say, the hell with it. We get what we deserve, or what evolution left us as a legacy. But the center of human nature is rooted in the ten thousand ordinary acts of kindness that define our days. Nothing can be more tragic than that this Everest of geniality stands upside down on its pointed summit and can be toppled so easily by rare events contrary to our everyday nature—and that these rare events make our history. In some deep sense, we do not get what we deserve.

The solution to our woes lies not in overcoming our “nature” but in fracturing the “great asymmetry,” and allowing our ordinary propensities to direct our lives. But how can we put the commonplace into the driver’s seat of history?

Epilogue: This essay marks the completion of fifteen years of columns for *Natural History*. My thanks to editors and, above all, readers for providing such a “bully pulpit.” Nothing can go on forever or even for very long, but God, the American Museum, health, and state of the world willing, I’d like to go for the silver and try for another ten years. No more.

Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.
Ponderosa pines dot Red Canyon, below, whose weathered limestone is part of the Colorado Plateau's Wasatch Formation. Botanists have identified ten species of plants that grow exclusively on this type of soil. Among them is Widtsoe buckwheat, opposite page.

Tom Dantelsen
Red Canyon, Utah

by Robert H. Mohlenbrock

Most tourists driving between Utah's Zion and Bryce Canyon national parks pass through the heart of Red Canyon in the Dixie National Forest. No one can miss the brilliant rocks that make up Red Canyon, but most people, hellbent on getting to either Zion or Bryce, will pause along the road near a short tunnel only long enough to snap a photo from the car window.

Red Canyon lies at the upper end of the Paunsaugunt Plateau, one of the most colorful areas in the United States. The vivid pink-and-scarlet rocks of Red Canyon, the same type seen at Bryce Canyon, are primarily limestone, a part of the Wasatch Formation deposited in a freshwater lake during the early Tertiary period some sixty million years ago. The Wasatch is the uppermost—and therefore youngest—rock layer found in the Colorado Plateau region, a geologic uplift that extends more than 100,000 square miles. Unweathered Wasatch limestone may be pale pink, red, gray, or even white, but according to geologist Herbert Gregory, weathering produces a strong pink color, which is due to the oxidation of iron and manganese.

The top of the plateau is dominated by coniferous forests and sagebrush and rimmed by spectacular cliffs, called breaks by the local residents. The red Sunset Cliffs form the western border of the canyon, while on the southeastern edge are the contrasting, precipitous White Cliffs.

Much of the dry, exposed red limestone has a sparse cover of vegetation, with a scattering of shrubby plants. Fragments of coniferous forests have developed only in a few, more protected sites. Despite this apparent paucity of vegetation, numerous plants lie scattered across the gravelly limestone. Almost a dozen of them are endemic, known only from Red Canyon and vicinity and found nowhere else in the world. Endemism has always fascinated naturalists. (Some areas, like Hawaii, have more than their share of endemic organisms; others, like my home state of Illinois, have no species of flowering plant to call their own.)

While botanists are unable to explain precisely why Red Canyon has an unusually high number of endemic plants, it seems safe to say that the answer has to do with the red limestone, since it is only on this particular geological formation that they are found. These plants have formed some sort of link with the rock that permits them to survive and reproduce where many other herbs cannot. These endemics are so well adapted to the locality that they cannot survive in areas where no red limestone is found.

The ten endemic wildflowers found in Red Canyon are all dwarfs, three to ten inches tall, perhaps a response to the arid conditions that prevail there during the growing season. For four of these endemics, Red Canyon is the type locality, that is, the first place in the world where each was discovered. These are: yellowish cryptanth, a dwarf perennial belonging to the borage family; breaks bladderpod, a miniature yellow-flowered mustard; Jones' locoweed, a three-inch-tall, pink-flowered member of the pea family; and Red Canyon beardtongue, a showy species that stands only six inches tall but bears blue flowers nearly two inches long.

The other six endemics are equally rare, being confined to the colorful limestone of
Red Canyon

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the Wasatch Formation. They are: spring parsley, breaks whitlowgrass, Widtsoe buckwheat, daggerleaf phlox, plateau catchfly, and least Townsendia, a threeinch-tall plant with daisylike flowering heads two to three inches in diameter.

Although Red Canyon is largely devoid of trees, small coniferous forests of ponderosa pine and Douglas fir exist in areas where more moisture is available. In many regions of the West these species often reach more than a hundred feet, but because Red Canyon is so dry they rarely attain a height of sixty feet. Joel Tuhy, public lands coordinator for The Nature Conservancy in Utah, has studied the region extensively and noted that on the cooler, steeper, north-facing slopes, Douglas fir is dominant, while on the top of the plateau, ponderosa pine predominates. In both areas, greenleaf manzanita is the prevailing shrub.

Tuhy has discovered a very small but distinct plant community that has developed where groundwater is forced up near the surface by a shallow zone of white sandstone. Plants that require more moisture than is usually available in other parts of Red Canyon have found a home here. Among them are the shrubby cinquefoil (a species also found in the northeastern United States) and the death camas, an elegant wildflower belonging to the lily family.

Although most of Red Canyon is carved out of vivid red limestone, Black Mountain on the western edge provides a stark contrast with its steep slopes of dark volcanic basalt. The northern and eastern slopes support a forest of ponderosa pine and Douglas fir, but piñon pine and Rocky Mountain juniper are also important species. These trees tend to grow taller and more densely than those on the nearby limestone formation, probably because more moisture is available and because organic nutrients do not leach away from basalt as readily as from limestone. Beneath the overstory of trees is a shrub layer consisting primarily of curl-leaf manzanita and Martin’s ceanothus.

The southeastern slope of Black Mountain resembles the open woods of piñon pine and Utah juniper that are found in much of the intermountain region. Beneath them is a rocky soil, suitable for only a very few herbaceous species. On the upper sides of the mountain, there are a few nearly barren slopes of basaltic boulders. Specimens of wax current and red raspberry can be found here, but only in crevices between the boulders, where soil has accumulated over the years.

Recently, 460 acres of Red Canyon, lying to the north of Utah State Highway 12, have been designated a Research Natural Area by the U.S. Forest Service, a status that should help preserve the canyon’s special features.

"This Land" highlights the biological phenomena of the 154 U.S. national forests. Robert H. Mohlenbrock is Distinguished Professor of Botany at Southern Illinois University at Carbondale.
Strange Traveling Companions

A hunter and his dog are heir to a long tradition of interspecies foraging

by Jared Diamond

It was another typical morning of bird-watching in the New Guinea jungle. My shirt was already soaked with sweat, but I preferred that discomfort to the alternative of going shirtless among the mosquitoes. I scraped a leech off my ankle and tried not to scratch the fiendishly itchy chigger bites on my thighs. With my right hand I waved a stick in front of my face to brush away spider webs, while occasionally running my left hand through my hair to remove spiders that the stick had missed. I wouldn't have minded all that chronic low-level discomfort if the birding had been good, but so far I had only seen a few rubbish species and seen nothing. The jungle seemed nearly lifeless. Once again, I began to wonder if I was losing my acuity as a birder, and if it was time to spend a few years to leave New Guinea to other ornithologists.

A faint "ts-ts" in the distance caught my attention. I stopped to listen. Yes, definitely ts-ts; also a metallic trill. A shape darted in the treetops. Still more calls much closer now, motion straight ahead in the undergrowth. Twitter of a black berry-pecker at fifteen feet, yellow-bellied fly-eater pair just above, brown whistler calling, three pygmy honey eaters. Birds too numerous now to pause to take notes. Most of the birds are at ten to thirty feet, boat-billed flycatcher leading. Was that a shining cuckoo calling? Damn! I missed it. Fantail's descending whistle, female golden monarch hover-gleaning. Where is that bloody cuckoo? Fly-eaters joined by two juveniles, the monarch foraging above the other birds now. Yes, it is the cuckoo, first record here!—remember it for when I pause to write notes later.

The jungle around me was alive with birds. For twenty minutes I followed their slow progress until they gradually pulled away, leaving the jungle as empty and silent as it had been before. No, I wasn't losing my acuity as a birder. Instead, most species of small insectivorous songbirds here foraged together in an itinerant group, so that one was either swamped by birds or saw none at all.

Such mixed-species flocks, as they are called, can be the bane or delight of jungle birding. While mixed flocks are not unknown among American and European songbirds (especially in the fall and winter), they reach their highest organization in tropical rain forests, where they may comprise dozens of species and more than a hundred individuals. Certain species act as flock leaders; others as followers. Banding studies have shown that tropical rain forest flocks are centered on a stable core of individuals: birds of different species that go about together from shortly after dawn until late in the afternoon, day after day, for years and probably for their entire adult lives.

But mixed-species flocking isn't confined to birds. Whether one calls the units flocks, herds, or schools, they are a widespread phenomenon in animal behavior. In fact, the most spectacular examples don't involve birds at all but are the mixed herds of large grazing mammals that roam the African plains. Those herds are rivaled in the sea by mixed schools of coral-reef fishes or by whales and porpoises. And the members of one flock need not be confined to a single vertebrate class. In numerous cases, birds follow mammals or, less often, the reverse.

Students of animal behavior have long been testing explanations for why animals sometimes forage individually, sometimes in large, conspecific groups (that is, ones whose members all belong to the same species). More recently, mixed-species flocks have also been attracting attention. Why do only certain species mix, often just at certain times and places? Do all flock members reap the same type of benefit or do different benefits accrue to different member species? For that matter, do all member species benefit or are there some members for whom flocking is neither beneficial nor harmful—and is it even disadvantageous to others? Earlier theorizing tended to search for "the single reason" that explained flocking in all cases. It now seems clear that the benefits of flocking are diverse. I'll explain what seem to me to be the five most frequent types of benefits.

The first type of benefit is exemplified by an eerie incident that occurred when I found myself the unwitting leader of a two-species "flock" in New Guinea's Foja Mountains. A helicopter had dropped me in this isolated range uninhabited by people. As I walked through the jungle, intent on birds and enjoying having a pristine wilderness entirely to myself, I became vaguely aware of a black shape somewhere behind me. I stopped, looked around, saw nothing, and walked on, slightly unnerved. Again I had a sense of a figure following me, quickly turned, and glimpsed a black creature vanishing behind a tree. I felt my heart pounding as I reflected that I had no radio to call for help and the helicopter wasn't due back for a week. I began talking to myself in
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order to calm down: "Take it easy, Jared, there are no people here. Why would any- one follow you? New Guinea doesn't have any known dangerous animals." Again a black shape flashed, and this time I spun around quickly enough to see it. It was a black, insect-eating bird called a drongo, following me in order to capture insects disturbed by my footsteps.

Drognos in Asia and Africa are notorious for following large mammals, such as elephants and giraffes, and feeding on the insects that fly up in their wake. In effect, the drognos use other animals as beaters, much as tiger-hunting maharajahs used human beaters. Monkeys foraging in the forest canopy produce a veritable rain of flushed insects and fruit, which attracts a cloud of followers, including not only drognos sallying after the insects but also antelopes and lizards eating fruit that falls to the ground and squirrels and hawks and hornbills chasing small prey disturbed in the canopy. Because New Guinea lacks large mammals, New Guinea drognos usually follow flocks of birds that rummage through the vegetation, as do mon- keys. But in both New Guinea and Africa, drognos that can't find their usual beaters will settle for following people.

To North American bird watchers, the most familiar examples of flocking animals that use other species as beaters are cattle egrets and cowbirds, which can often be seen following cattle to eat the flushed insects. Originally, the cattle egret followed wild ungulates in Africa, and the cowbird followed bison on the Great Plains. With the arrival of American pion- eers, these two bird species spread across the United States and came to employ cattle as beaters. American birders who have visited tropical Central and South America will also be familiar with the many antbirds and other bird species called professional army-ant followers because they regularly feed on insects flushed by army-ant swarms. Just as desperate drognos follow people, and egrets and cowbirds follow livestock, so other birds have learned to use human technology as beaters. All of us have seen flocks of gulls hovering around tractors, but we may not have realized the benefit that tractors bring to gulls: disturbed or plowed-up earthworms, grasshoppers, lizards, mice, and other small animals on which the gulls can feed. Falcons follow trains to seize flushed birds, while seabirds follow ships for garbage and disturbed fish. Those seabirds in turn became leaders when World War I U-boat captains learned to find their targets by steering after the seabirds, which often proved to be flying toward distant ships.
In the examples I’ve given so far, a follower species reaps benefits while a leader species neither gains nor loses; the follower merely acquires food items that the leader wouldn’t eat anyway. From that division of roles, it’s but a small step to the follower becoming a pirate and seizing food items that the leader would indeed have eaten. When following flocks of small insect-eating birds, drongos often assume the role of pirate, rather than just innocently using the small birds as beaters. But the most famous avian pirates are bald eagles and frigatebirds, which follow ospreys and terns, respectively, to seize fish that these birds capture.

There’s another type of situation where flocking produces a loser as well as a winner. Snorkelers in tropical waters throughout the world are familiar with the solitary little fish called damselfish, which stake out a territory barely a few feet across on a coral reef. It’s a comical sight for a snorkeler to be faced with a five-inch-long damselfish, bravely displaying and trying to look fearsome. A damselfish can drive off single individuals of much larger fish species, like parrotfish. But parrotfish traveling in schools swamp the poor damselfish’s defenses and strip its territory bare of food in a few minutes. Similarly, flocks of Australian honey eaters can overwhelm a single territorial bird and quickly drink all the nectar in its territory, although the territory owner could have driven off each marauder individually. Thus, the flock functions in these cases as a gang of muggers.

Why does a leader species tolerate follower species if they do the leader no good or even do harm? The answer can be as simple as that the leader is unable to shake the followers and thus has no choice. Nevertheless, the leader often does get a benefit: protection against predators provided by a follower species that acts as sentinel. In New Guinea, I noticed that drongos usually follow groups of noisy birds called babblers, whose calls back and forth to one another may attract goshawks. The babblers behave as if they are very concerned about hawks: they are furtive and dive into dense vine tangles whenever they get the chance. But the nearsighted babblers themselves are ill-equipped to detect hawks because they feed by gleaning small insects off the vegetation and keep their eyes glued on leaves a few inches in front of them. Instead, the farsighted drongo, which is constantly scanning for large flying insects dozens of feet away, is much more likely to spot a hawk. The drongo functions as a sentinel and gives loud alarm calls that benefit the babblers.

There’s a similar division of labor going on in the spectacular photos one often sees of mixed herds of zebra, giraffe, wildebeest, and ostrich grazing together on African plains. The zebra is nearsighted but has acute hearing, while the other three species are farsighted. Together, these species can detect predators more successfully than any one of them could by itself.

Sentinels aren’t the sole reason why flocking reduces the risk of predation. The larger the flock, the lower the risk for any particular individual that it will be the one that a predator attacks. Hence, in flocks of birds as well as in schools of fish, the individuals on the periphery, where the risk of attack is greatest, continually and selfishly try to push their way toward the center. In addition, the larger the flock, the harder it is for a predator to focus on any single individual and to make a kill at all. Human predators such as quail hunters have the same problem: paradoxically, it is easier to kill a single quail that flushes than to make a kill from a covey of twelve, because tracking any bird among twelve shapes crisscrossing in different directions is so confusing.

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Flocking is to increase feeding efficiency. At first, one might have guessed the opposite: that many individuals together would interfere and compete with one another. In fact, flocking increases when food becomes scarcer and feeding efficiency is most at a premium (for example, toward the end of the winter for birds in the United States and Europe, toward the end of the dry season for tropical birds). Part of the explanation is that more eyes have a better chance of finding a good patch of food than does a single pair of eyes. The other reason is to coordinate the search for food. If many species are independently looking for similar food items and each species doesn't know where other species have recently foraged, one species may waste time foraging in an area that another species has recently swept clean.

As an analogy, consider five janitors who clean up a large hall after a convention, each of whom gets paid per pound of trash collected. Imagine that one janitor uses a broom, another a vacuum cleaner, another a pitchfork, another a rake, and another a bare hands. Like the different species of insectivorous birds in a flock, each janitor is better adapted than the others to capture certain prey (here, trash) items, but there are some items that any of these several janitors would be equipped to collect. A good strategy is for the five janitors to forage together through the hall, thereby constantly assuring themselves of trash-rich areas and avoiding areas with slim pickings (from having already been partly cleaned by other janitors).

When I began my career in ornithology in the early 1960s, there was some tendency among animal behaviorists to argue about what was the one dominant reason behind flocking (or herding or schooling). As we've seen, we now know that there isn't a universal answer. Flocking may be beneficial by providing beaters, chances for piracy, strength in numbers, protection against predators, or increased foraging efficiency. Different species may gain different benefits under different circumstances. But flocking also involves costs. Thus, any given species joins a flock when the sum of the benefits outweighs the sum of the costs.

Here again, a human analogy may be helpful. Ask yourself what impels a man and a woman to join in marriage? There isn't a universal answer. Instead, the hoped-for benefits of marriage include love, sex, companionship, and securing a coparent for having children. Marriage is also feared as involving costs, such as narrowed sexual opportunities, increased financial burdens, risk of abandonment, and someone else telling you...
what to do. We marry when the benefits seem to outweigh the costs, and different people weigh the various pros and cons differently.

As a final thought, I'll suggest that mixed-species flocks aren't just a quaint thing animals do, but that our own participation in a mixed-species flock in the late Pleistocene was a significant step toward the rise of civilization. I'm thinking of the process by which we domesticated dogs—a process that really involved dogs domesticating us as well. While the earliest identified bones of a domestic dog stem from about 12,000 years ago, bones of dogs at the first stages of domestication would have been indistinguishable from those of wolves, hence the process must have begun well before 12,000 years ago. Initially, wolves and humans would have been drawn to each other by at least three of the five advantages I've mentioned for other mixed-species flocks. Humans would have found wolves useful as sentinels against other predators; wolves would have pirated food at human campsites; and each species would have used the other as a beater, with humans killing prey that wolves had brought to bay, and wolves killing wounded prey that had fled from human hunters.

Eventually, humans and wolves together became a hunting team far more effective than either species alone—as anyone who has hunted with dogs will appreciate. Dogs can sniff out hidden prey that we could never see, overtake fleeing prey that we could never catch, and bring prey to bay so that the hunter has time to catch up and make the kill. Just as one example, when I was in New Guinea's Karimui Basin in 1963, one dog with particular skill at cornering pigs was in the process of enabling Karimui hunters to decimate the basin's wild pig population.

So what was the significance of the greatly increased hunting success that dogs gave us? It meant the ability to feed more babies, hence increased human population, which contributed in turn to the pressure behind the development of agriculture, which was a prerequisite for the rise of urban civilization. The next time you take your dog for a walk, pause a moment to reflect with pride on the tradition to which you are heir. You and your dog constitute the most remarkable mixed-species flock in evolutionary history. Without it, our species might not have progressed to the point of building the Parthenon.

Jared Diamond teaches physiology at UCLA Medical School and studies birds in New Guinea.

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Anatomy of an Epidemic
by Pascal James Imperato

*AIDS: The Burdens of History* is a collection of a dozen essays that carefully examine present social and cultural issues as they relate to AIDS (acquired immunodeficiency syndrome). They illuminate these issues by dealing with some aspects of the "burdens of history"—the inescapable significance of past events for present ones. These essays remind us that there are historical parallels for many of the issues now being debated, while at the same time noting the differences between then and now.

The editors, Elizabeth Fee and Daniel Fox, scholars known for their contributions to medical history, have assembled an impressive group of historians, public policy experts, and social scientists and in so doing have produced a provocative volume that is a pleasure to read. They take pains to note that the AIDS epidemic can tempt historians into facile analogies with past events and draw them into viewing the past from the perspective of our own time. Each of the contributors has struggled with these pitfalls in historical methodology and has been successful in avoiding them.

In the first essay, "Disease and Social Order in America: Perceptions and Expectations," Charles E. Rosenberg, of the University of Pennsylvania, concludes that biological mechanisms define and constrain social responses to disease. For example, if AIDS were spread as easily as the common cold, then society's response would be much more drastic. He also notes that the social response to AIDS is a vivid reminder that American society is fragmented, which in part explains the divergent views on key AIDS issues.

In one of the most provocative chapters, "Epidemics and History: Ecological Perspectives and Social Responses," Guenter B. Risse, of the University of California, San Francisco, carefully examines the historical responses of political and health organizations to epidemics. He describes in gripping detail three epidemics—bubonic plague in Rome in 1656, the New York City cholera epidemic of 1832, and the 1916 poliomyelitis epidemic in New York City. In all three epidemics, marginal groups, either ethnic minorities or the poor, were held responsible. In the 1656 bubonic plague epidemic in Rome, Neapolitan traders were at first blamed, then the poor, and finally the Jews. Almost two hundred years later, New Yorkers singled out Irish immigrants and the poor as the cause of the cholera epidemic of 1832. Not quite a century was to go before Italian immigrants in Brooklyn were viewed as the cause of the polio epidemic of 1916. In all three epidemics, civil liberties were infringed on in the name of public welfare.

The 1916 polio epidemic witnessed the forced separation of parents and children, the publishing of the names and addresses of the sick in newspapers, the placarding of houses, and the quarantining of family members of victims in their homes for two weeks. Polio victims, most of them children, were taken to isolation hospitals and their parents allowed to see them only once a month. Since the epidemic started in an area of Brooklyn with a high population of Italian immigrants, they were held responsible for it and stigmatized by both health officials and the press. New York City's commissioner of health, Dr. Haven Emerson, was unable to confirm the widely held impression that recent Italian immigrants had imported the disease, and U.S. consular officials in Italy reported an absence of the disease there. These facts had little effect on those who needed a scapegoat. By July, publicity about the epidemic was at a peak and families with children found that towns on Long Island, where many city residents vacationed, refused them entry. Long Island hotel owners were fined for renting rooms to families with children, and in some towns entering children were held in quarantine. The New York City Department of Health and the U.S. Public Health Service then devised a traveler's identification card, certifying that a child did not come from an infected household and was free of symptoms.

My grandparents, who had emigrated from Italy to Brooklyn twenty-three years before, obtained these health certificates for eight of their nine children. The oldest, who was attending Cooper Union, remained behind to watch the house with my great-grandfather. My grandparents sought refuge on the farm of friends in New Hyde Park, just across the city's border on Long Island. This was a fortuitous choice because they were able to avoid passage through local towns that might have barred their way.

A Home Defense League of 21,000 people was formed by the Police Department to search out filth and violations of the sanitary code. Movie theaters were closed to children below sixteen years of age; grocery stores, street vendors, and fruit markets were closely watched; and streets were regularly washed down with water. By September the disease's incidence was on the wane and my family returned to Brooklyn for the start of school. In retrospect, the Draconian measures instituted by the Health Department had little affect on the course of the epidemic. However, they did, as Risse explains, generate public distress and panic.

In a related chapter, "Quarantine and the Problem of AIDS," David F. Musto, of the Yale School of Medicine, carefully examines quarantine in relation to cholera, leprosy, tuberculosis, yellow fever, and drug addiction. He convincingly...
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shows that quarantining has never really worked. In general it has been expensive, cruel, ineffective, and a device for expressing public fears of foreigners or socially disapproved groups. This message of history should be made clear to all those who advocate the quarantining of AIDS victims or of those who are infected with the human immunodeficiency virus (HIV).

The refusal of some physicians to treat AIDS patients has received deserved attention in the American press. Daniel Fox, of the State University of New York at Stony Brook, in “The Politics of Physicians’ Responsibility in Epidemics: A Note on History,” provides historical perspective to this issue. While many physicians throughout history exposed themselves to personal risk during epidemics, others either refused to treat victims or fled. The historical record prior to the nineteenth century is full of examples of large-scale physician cowardice at the time of fatal epidemics. Galen fled from Rome in A.D. 166 when plague struck. He and the other notable physicians of ancient Greece and Rome neither set an example nor left specific advice about the care of epidemic victims. In fact, there was a strong tradition in Greek and Roman medicine not to accept incurable patients. Thus, the medieval physicians who were to confront the Black Death did not inherit a tradition of personal risk taking.

Numerous historians of the era chronicled both the cowardice and aversion of physicians at the time of the bubonic plague. During the epidemics in Europe, governments dealt with the problem of physician refusal to treat the sick by forcing physicians to do so or preventing them from fleecing or providing them with incentives to treat patients. A number of Italian cities created incentives in the form of good salaries, living expenses, and the promise of full citizenship. Those who accepted these offers became known as “plague doctors.” As Fox cogently notes, although they incurred risks, these doctors also had access to significant financial and social opportunities previously denied them.

Fox interprets the history of physician conduct during early epidemics in the United States as one that also reflected negotiations with civil authority: some physicians opting to assume the risks (and rewards) of caring for the sick, while others declined to render their services. Although this did occur, the behavior of physicians was usually highly individual, often determined by personal conscience or religious beliefs.

A code of ethics governing the behavior of physicians during epidemics did not exist until 1846 when it was promulgated by the American Medical Association. This code stipulated that physicians had an obligation to treat the victims of epidemic diseases even if their own lives were put in jeopardy. However, in 1957, this portion of the AMA’s code was deleted in view of the disappearance of serious epidemic disease. Remaining in the code was a 1912 provision that physicians had a choice in the matter of whom they treated except in emergency situations. At the outset of the AIDS epidemic, no other medical codes then in existence in the United States dealt with the issue of physicians’ assuming personal risk while treating patients. This accounts for the recent flurry of statements and guidelines on the subject by a large number of medical organizations.

Fox puts forth the assessment that the latter half of the nineteenth century and the first half of the twentieth century witnessed little in the way of physician cowardice during epidemics. It is true that much medical heroism characterized the profession during these years, especially during the cholera epidemics of the 1800s and the influenza epidemic of 1918. However, comparisons with previous eras are not entirely valid because this period also witnessed the rapid and formal evolution of public health services in the United States, which limited the degree of con-
confined to a tuberculosis sanitarium where care was provided under tax-supported auspices and by physicians who willingly chose to care for such patients. These physicians and those who worked in public health departments in essence became the modern era's plague doctors, voluntarily assuming risks for a range of personal and professional reasons. Thus, few physicians were put to the test. A number of physicians who practiced several decades ago have recently suggested that former tuberculosis sanitariums and infectious disease hospitals be reopened for the care of AIDS patients. Such an action would insulate most currently practicing American physicians from personal risk, similar to the insulation once enjoyed by some of their predecessors.

Fox makes a cogent analogy when he compares the plague doctors of old with the new cadre of doctors who treat AIDS patients. Financial rewards, housing, living expenses, and citizenship were the rewards in the Middle Ages. Fox notes that today's rewards are research funds or academic status. There is continuity, he says, between the physician in Chaucer's Canterbury Tales who derived pleasure from "the gold kept from pestilence" and the academic physician who told him, "AIDS has been good to me."

Other essays in the book deal with the enforcement of health measures, venereal disease in the twentieth century, AIDS in popular images and language, AIDS and the gay movement, and AIDS and the American health polity. This last chapter by Fox is a brilliant discussion of the structural and functional changes that occurred in the American health care system during the 1970s and 1980s. These changes included erosion of a once highly centralized federal authority, fragmentation, localization, and the creation of a health polity that was incapable of addressing the AIDS epidemic.

AIDS: The Burdens of History is a beautifully crafted book that is comprehensive, insightful, and unique in its approach. It will help all of us to understand the wisdom of George Santayana's words that "those who cannot remember the past are condemned to repeat it."

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Kau’s face is shrouded in smoke. He coughs, spits, exclaims how wonderfully strong the tobacco is, and passes the clay pipe with its long banana-leaf midrib stem to a companion eagerly waiting his turn.

The Efe are Pygmies, and tobacco is such an integral part of their life that the Lese villagers, who are forest farmers, often teasingly call it the food of the Pygmies. Many Efe are so addicted that they will work for three or four hours in a villager’s field for a thumb’s length of leaf tobacco. The implications of this behavior are not lost on the villagers, and tobacco is used extensively both as incentive and payment to the Efe who labor in their gardens. The exchange of tobacco for shamba (garden) labor is just one component of the complex, changing, and little understood relationship between Lese horticulturists and Efe bow hunters, here in the Ituri Forest of northeastern Zaire.

Much of the clearing, planting, weeding, and harvesting of Lese fields is done with the aid of Efe men and, more regularly, women. For this, Kau’s wife, Ulokbi, receives agricultural products, such as cassava, plantains, maize, and peanuts, which supply approximately 60 percent of her family’s annual calories. Not only do the Efe exchange field labor for cultivated foods and tobacco; they also hunt, fish, and gather honey, building materials, and medicines from the forest to trade for old aluminum cooking pots, scraps of “Goodwill” clothing, and metal to make arrow-
heads and knives. Yet the exchange is more than the mere, instantaneous trading of commodities. It affects where and how the Efe live, and to a lesser extent, it also shapes the daily lives of the Lese.

Following the trail into Kau’s camp, I noted that, as usual, his band was located in a particularly beautiful part of the forest. Although many Efe camps are situated at the edge of villagers’ gardens in the full glare of the equatorial sun, Kau always seems to choose gently sloping hillsides in the shade of mature forest and within easy access of sweet water. Heading across the camp toward Kau’s cooking fire, I passed three leaf huts and scattered a knot of hens scratching in search of tasty forest morsels. The chickens do not actually belong to Kau; they are another part of his relationship with Ngofe, his villager. Lese lend their chickens because they grow faster in the forest with its abundance of insects, and their wealth in hens is then safely hidden from the local tax collector. Kau and Ngofe have been exchange partners since both of them were young men, much as their respective fathers were and their sons will be. Most exchanges occur between these partners, but just before the year’s first harvest in June, when food is scarce because the previous year’s fields are nearly exhausted, Kau will be much more opportunistic, trading with whoever has something to eat.

Tate, an aged Lese, tells me that in his youth, when he lived in a village in the forest interior, the Efe provided his father with wild game, honey, and bark cloth, asking only for a little food from his shamba in return. With colonization and villager resettlement along the three
roads that traverse the Ituri, the Lese began employing Efe to help cultivate the new cash crops of peanuts, rice, cotton, and coffee. Now he complains that “the Efe will not work in my shamba unless I have an ample supply of tobacco and hemp, and on the few occasions that they return from the forest with meat, they hawk it to any villager who can provide the best deal.” Tate’s grumbling about the supposed laziness and newfound avarice of the Efe is mirrored by their bemoaning that all Lese are miserly, repeatedly cheating them out of their just rewards. Much as in any cooperative system, the Lese and Efe appear to be constantly vying for what each considers to be an equitable exchange rate, with neither partner consistently besting the other.

The present reliance of the Efe on Lese cultivated foods suggests to some researchers that the Efe, and Pygmies in general—all of whom have some exchange system with horticulturists—never subsisted solely from hunting and gathering within the Ituri. Nevertheless, the oral traditions of both the Lese and Efe, some new archaeological evidence, and the large number of plants known to older Efe but now only seldom eaten, all suggest otherwise. When I contend that the forest could, and still can, provide all the resources needed by humans to survive, I do not mean that this is possible without a substantial change in the way the Efe currently obtain and process the items essential for subsistence.

Although a villager’s field provides the Efe with a large and concentrated source of food, tropical moist forests, such as the Ituri, may contain a wide variety of potential food species, but individual plants of each species are often widely dispersed. Thus, in order to exploit the forest’s patchy, seasonally available resources, the Efe would have to, and in fact do, live in small, nomadic bands. Forest foods are sparse and predation by herbivores on leaves and flowers is so severe that plants have responded by making their potentially edible parts difficult to digest, unpalatable, or downright poisonous. Many of the indigenous forest yams that could provide abundant carbohydrates to human foragers are generally laborious to locate and gather and require elaborate processing to make them edible. Only last year, Tufiembi, his two wives, a dog, and two hens all died from eating yams mistakenly identified as an edible variety. Tufiembi’s younger wife had peeled, scraped, boiled, and sliced the tubers, then left them soaking in ashes and water for a
The Pygmy woman sitting outside her leaf hut with her two young children, below, has few material possessions, but aluminum pots are prized objects. Stacked against the house are palm fronds that will cover the doorway to keep out wandering dogs. The child’s bloated stomach is not from lack of food but from the many parasites children carry. Right: Just before a dance, a mother paints designs on her children. Body painting, done with a mixture of fruit juice and charcoal, is the Pygmies’ only form of art.

David S. Wilkie

**The Pygmy woman.**

**Right:** Body painting, done with a mixture of fruit juice and charcoal.

**Below:** The Pygmy woman with her two young children.

day, but despite these precautions, enough toxins remained to kill her family and the animals that fed on the leftovers.

Although the Efe are adept foragers who can detect plants and animals that elude my unpracticed senses, gleaning food from the forest is not an easy task. Given the choice between foraging in the forest all day to obtain a basket of tubers that may require many hours of processing before they are edible or laboring for a few hours in a villager’s field in return for pounds of highly palatable, easily prepared cassava or plantains, Efe women understandably opt for the latter.

Many generations ago, their trading relationship with villagers must have been important enough for the Efe to become so versed in the villager tongue as to deny the need for, and thus largely forget, their own language. Today all Pygmies speak a dialect of the tribe of villagers with whom they are associated. Only vestiges of an Efe language remain in the names of forest animals and plants common to all Pygmy dialects of the Ituri. Equally essential to his involvement with the sedentary, horticultural Lese is Kau’s dramatic reduction of his free-lancing nomadism.

Ironically, even though his band may stay within about a mile of Ngofe’s village for eight or more months of the year, campsites are often changed every two to three weeks, reflecting a once more widespread pattern of movement. Reduction of nomadism means that areas near villages are hunted intensively, and Kau has told me that the density of game animals, although high enough for successful hunts, is lower than around campsites in the forest interior.

Kau seems noncommittal about the importance of his relationship with Ngofe. Yet when we spent a week or two in the forest, although we obtained plenty of meat and honey to eat, band members complained of hunger, the hunger for villager foods. This hunger, along with some intense pressure from the new regional administrator, has persuaded many Efe to clear and plant their own fields, an amazing departure from traditional practices.

The lives of the Efe are indeed changing. But how the exchange relationship influences the villagers remains unclear. Five years ago Melisombi left a village deep in the forest to join his relatives, who had moved to the road at the time of its construction about 1944. His Efe exchange partners followed him and are now camped in the forest nearby. In December of last year, when the heavy rains ended and it was time to prepare new fields, Melisombi called the Efe men to come each day and help cut and clear the section of secondary forest selected for its rich soil and absence of weeds. When asked what would happen if he had no Efe, Melisombi replied, “Shamba cutting would be a lot more work. My wife would spend more of each day weeding, and peanut and rice harvests would take much longer.” What about wild game? “The Efe don’t bring me much, I’d just go trapping.” Melisombi, like many Lese, regu-
larly travels the well-used trails that cross the deepest reaches of the forest to set vine-loop snares for birds and mammals. So how does Melisombi benefit from the exchange relationship? His Efe may reduce his horticultural labor or add protein and diversity to his diet. However, other more cynical Lese told me, “It is better to give the Efe food than to have them steal it; at least with a trading relationship you can expect to get something in return.”

We are just becoming aware of the complexity of this ever-changing relationship and must acknowledge that it has insinuated all aspects of Efe and Lese life. My most vivid memories of Kau’s wife, Ulokbi, are not of seeing her in the forest foraging the olivelike fruits of *Canarium schweinfurthii* that are so tasty with honey. Rather I picture her when she is returning from the shamba with a toddler in tow, a nursing baby in a simple cloth sling, and a groaning basket of cultivated food capped with firewood, its weight bending her back and creasing her forehead with its bark tumpline.

“Odzi na,” Ulokbi says, as our paths meet. Yes, I tell her, I too am returning from work. So we set off together with me in the lead. Across a log bridge, down mud-slick slopes, around felled-tree tangles and through the dense vegetation that signals we are in the zone of old and active fields. As the path opens out before us and we step into the village, I put to flight a shimmer of yellow, blue, and purple butterflies so common in late February with the onset of rains. As Ulokbi hurries away with her load, I hear Ngofe, in a hut to my right, telling Kau to go hunting tomorrow as it has been more than a week since he last brought meat to the village. Kau, standing outside, listens patiently, asks for some palm oil, doesn’t get any, and starts following me down the trail to my village. It is dark by the time I arrive, and the tree hyraxes welcome me home with their nightly cacophonous chorus.

Next morning, meandering through Angidulu’s rapidly overgrowing shamba,
A Pygmy hunter, below, aims a poison arrow at a monkey high up in the trees. Made of strips of wood that have been dipped in poison, monkey arrows are not retrieved. Metal arrows, however, are precious and are picked up after they are used. The hunters at right have just spotted a hive of bees. The man in front carries the honey ax, used to enlarge the hole in the hive, over his shoulder. The young Pygmy boy, bottom right, has just started to accompany his father on the hunt. Armed with a small bow, he will begin to learn hunting skills.

Photographs by Bryan Curtan.

my legs become soaked from the heavy dew that accumulates on the leaves in the relative cool before dawn. Once I've cleared the secondary fallow vegetation at the edge of the village and have traveled a short distance into the insect hum of mature forest, Kau's camp is ten minutes away. Last night, watching Kau as he left our village muttering about Ngofe's demand for meat and waving a burning log to light his way and ward off witches that were surely dogging his trail, I knew that I had to get to his camp early to join the men on a hunt. Yipping dogs and chattering voices tell me I'm getting close, so to announce my arrival, I call out, "Hodi hodi!" (Hello, I'm coming in).

The camp has five domed leaf huts erected in a rough circle enclosing a group social area. Outside most of the huts women sit boiling or roasting breakfast over fires kept alight throughout the night. I shake a few hands in greeting as I cross camp to join a group of men preparing for the hunt. Alukulu gets up, offers me his stool—a simple affair of four sticks splayed within a vine loop—and moves onto a log already occupied by his son. Beside me, Onde'a is involved in a lively monologue that seems to be about how marvelous it might be if you could hunt giant forest hogs from an airplane. The rest of the men, each a casual listener to Onde'a's story, are fire hardening bows and arrow shafts, sharpening metal arrowpoints on time-contoured quartzite, and tying on monkey-skin wrist guards, all the while keeping up a steady banter or eating sweet potatoes offered by the women. As the sun rises, the dew and chill of the morning dissipate. Without much apparent discussion, the dogs are beckoned, wooden bells are secured around their necks, and we're up and heading out of camp.

We move at a fast walk through forest dominated by tall, slender trees that first branch 60 to 80 feet above us and tower to heights of 130 feet or more. The forest floor consists of the suppressed offspring of these giants and has a threadbare carpet of broad-leaved herbs. Only where big, old trees have fallen or on the banks of rivers does enough sunlight reach ground level to produce the riot of growth that epitomizes Hollywood's image of the "jungle." For the most part, the forest is a cool, shade-dappled place, alive with insects. The pervading green stillness is punctuated only rarely by dashes of color from a red- or blue-feathered turaco or by the hoots and chirrups of guenon, mangabey, and colobus monkeys.
is one of the abundant but elusive forest duikers seen, and then most often only as a fleeing red flank or bobbing white tail.

Following a ridge, we cross an area with large granite erratics, a not unfamiliar feature of the Ituri landscape, and soon arrive at a rock overhang where all will gather prior to the hunt. Using a leaf fan, Alukulu ignites a smoldering ember he carried from camp. Bokande adds a mixture of leaves, all with magical properties, and smoke begins to curl around the rock and percolate upward into the leaf canopy. A dog is grabbed by the scruff of the neck and passed through the smoke. Karole rubs more of the hunting leaves on his bowstring, turning it a vivid green. Other men, also looking to enhance their chances of success, pass their bows and arrows over the fire.

After another pipeful of tobacco the bowmen disperse at tangents into the forest to set themselves up in a rough semicircle five or six hundred yards ahead. They move quickly and quietly along the perimeter of the hunt area so as not to prematurely disturb the game to be flushed toward them by the dogs and beaters. The drive area is easily recognized by all the Efe, who can navigate in the forest as easily as Europeans negotiate city streets. A recent visitor exclaimed, “How do they do it? There are no landmarks, only trees!” But as these trees may live for hundreds of years, changing little in shape during an Efe’s lifetime, the reference points in their landscape may be more permanent than those in an ever-changing city.

With only Alukulu and three dogs left around the fire, Angiba leaves, and I follow. We use a trail that marks the edge of the drive area. Within ten minutes I hear
Alukulu starting the drive by calling “tcha-tcha-tcha” and “hu-hu” to the dogs. We continue along the trail for a few more minutes, then cut off into the forest looking for a good spot to wait for the beaters and dogs. Angiba notices two converging game trails that lead from the drive area and decides to set up nearby. Snapping several saplings at waist height, he increases his unobstructed shooting arc. We wait in silence, enduring the concerted attacks of biting tabanid flies that appear in droves at this time of year.

Punza yells that a medi, a blue duiker, has been flushed and the dogs are in pursuit. I hear them circling around to our right, and then the sound of dog bells shifts, rapidly approaching our position. A gray-blue blur dashes within twenty feet of us, Angiba looses an arrow in its direction, and egged on by shouts of “aas aas,” the dogs career by. We search for the arrow and unfortunately find it. The chase continues, duiker and dogs weaving and dodging. After fifteen minutes and no further sighting of the antelope, the now distant dogs are recalled. The men reassemble, replaying recent events, and after a brief rest, break up to start the next drive. The following few hours are as unprofitable as the first. Although a broken and bloodied arrow attests to a black-fronted duiker’s having been shot through, the animal remarkably avoided capture.

By four o’clock the dogs have holed and dispatched a dark mongoose, and we are congregated around a tree where bees have been spotted. “It’s ifa,” Kau tells me, which means it’s a hive of stingless meliponine bees; therefore, there is no need to build a fire to anesthetize the bees with smoke. Climbing vines to a cavity fifty or sixty feet up the tree, two boys enlarge the entrance hole and throw down chunks of comb. No honey this time, just grubs and pollen—a disappointment. Six o’clock approaches, and as dusk is brief at the equator, we head back with our meager catch. Some men have come up with a few mushrooms and giant snails, while others return only with wood for new arrow shafts or vine used to prepare monkey arrow poison. In all, many men hours have produced little to eat or trade.

As we hurry toward camp, Kau stops to collect a few leaves growing beside the trail. “I’ll dry them and rub them on my tongue, then next time we’ll kill lots of duikers,” he calls over his shoulder to me. Soon Ndikba detours through the village to leave the mongoose, wrapped in a leaf parcel, with Ngofe’s wife.

Back in camp everyone is somber. At least the women came back from the fields with plantains, so only a hunger for meat will remain tonight. Gradually the mood relaxes and tales of past hunting successes soften today’s failure. The men, sitting together and once again animated, are already planning where they will go hunting tomorrow. A pipe, filled with the last of the tobacco, is being passed around. It glows red, and once again Kau’s face is shrouded in smoke.
A tiny adult frog trapped in resin some thirty to forty million years ago was found in the Dominican Republic's La Toca mine, well known for the vertebrate animals preserved in its amber. Here the resin has had an X-ray effect, making skin and organs translucent and revealing underlying bones.
Two summers ago, an amber dealer phoned me at midnight with a remarkable claim. He wanted to show me a specimen he had acquired from the Dominican Republic, one of the world's amber hot spots. The amber, he said, contained a well-preserved frog.

After I hung up, my excitement dwindled as I remembered reading about frogs in fake amber. A lizard placed in recently produced resin had been presented to our museum at Berkeley as an authentic amber fossil, and there was a good possibility that this frog would be a fake as well.

About fifteen minutes later, I opened my door to the dealer, and we sat down to examine what at first looked like an unpromising package. Reaching into his pocket, he took out a crumpled paper sack; in it was a plastic box filled with cotton batting. He peeled away the top layer of cotton and removed a polished, oval piece of clear yellow amber. It did indeed contain a frog, the first I had ever seen in amber. A few quick tests proved that the amber was authentic. We were holding what would prove to be the most complete frog fossil ever reported and the oldest-known amphibian fossil from Mesoamerica (Mexico, Central America, and the Antilles). But beyond this, the frog would provide clues to the origin of the now-extinct amber fauna of the Caribbean and to the role played by continental drift in that part of the world.

Before the dealer left, we made an agreement. I would study and describe the amber frog, then return the specimen to him, along with the findings. He could then use the information as a basis for the future sale of the specimen.

The next morning, I telephoned herpetologist David Cannatella of the Museum of Vertebrate Zoology on the Berkeley campus and related the news. He came right over, and we examined the specimen in detail under a microscope. The frog was tiny, slightly under an inch long except for the extended left hind leg, but the degree of bone development showed that it was an adult. The skin and flesh were still intact, but the tissues had become partly transparent, so that the ribs, pelvic girdle, and leg bones could be seen. We marveled
at the finely preserved eyes and skin. David was able to identify the frog as a member of the genus *Eleutherodactylus*, many species of which inhabit the Caribbean islands today. How did this individual end up in a piece of amber? *Eleutherodactylus* frogs spend most of their lives in trees, not entering water even at breeding time. The eggs are deposited on moist ground or vegetation, and the tadpole stage takes place within the egg. Our amber frog had two broken legs and elsewhere in the amber were three leg bones of another frog. The fractures gave us a clue as to what happened when the frog was entombed some thirty to forty million years ago.

Our frog may well have been sitting in a tree waiting to catch some insects, while it was itself being regarded as a potential meal by some larger predator, possibly a bird. In our scenario, the frog was seized by one of its legs, which subsequently broke, and carried back to the predator's nest in a cavity of an amber-producing tree (a now-extinct species in the pea family, whose present-day relatives also produce resin). The bird dropped the frog, then picked it up by another leg, which was also broken in the struggle. Before the frog could be eaten, it fell again, this time landing in a mass of sticky resin that had flowed into the nest cavity. Loath to eat a resin-coated frog, the predator flew off in search of more appetizing prey.

As the resin hardened over millions of years, eventually becoming fossilized as amber, its natural compounds preserved the frog. In a process known as inert dehydration, sugars and terpenes in resin replace water in an organism's cells. Thus, the resin acts as a natural embalming agent. The ancients recognized these qualities of resin. Records show that the Egyptians used resin, usually myrrh, to embalm their dead, placing it in the body cavity, cranial cavity, and on the linen wrappings covering the body. Researchers examining these treated mummies have discovered intact nuclei and cell organelles in the underlying skin. Resin also prevents the growth of microorganisms and has remarkable antimicrobial qualities. In antiquity it was applied to wounds to prevent secondary infections and to hasten healing. In the case of the amber frog, the resin kept microorganisms from decomposing the creature's flesh.

Amber can be found throughout the world. The youngest deposits, four to five million years old, are in eastern Africa, while the oldest-known amber invertebrate fossils are 120 million years old and occur in Lebanon, Jordan, and Israel. (Resin less than four million years old, which has begun to harden but does not yet have the physical properties of amber, is called copal.) Perhaps the most famous amber deposits are those in the Baltic area of northern Europe. Since Paleolithic times, Baltic amber has been mined, made into jewelry and talismans, and incorporated into commercial products such as medicinal powders and salves and fine wood varnish.

My own interest in amber started when, as a boy, I first saw pictures of insects entombed in this fossilized resin. Later, I did my first amber collecting on the west coast of Jutland in Denmark—picking up small pieces of Baltic amber washed up on shore by waves of the North Sea. Baltic amber has become difficult to obtain, and most of the organisms it contains have been well studied. More exciting and rewarding to me now are the recently discovered amber deposits in the Dominican Republic. For a biologist, Dominican amber has many noteworthy characteristics. It is usually unclouded; any life sealed within the amber can be easily spotted and photographed, and the specimens, most of them beautifully preserved, are only rarely surrounded with the whitish decomposition deposit that often mars Baltic amber inclusions. But even more important,
Dominican amber provides us with a view of a now-extinct array of life forms in the New World tropics and represents the oldest-known fossils in Mesoamerica. Because of its tropical origin, Dominican amber contains members of many animal groups not represented or only poorly represented in Baltic amber, such as scorpions, whip scorpions, wind scorpions, anoline lizards, geckos—and frogs.

The amber mines of the Dominican Republic are located in two general areas in the country. The bulk of the amber, called northern or Santiago amber, comes from the northern mountain range, the Cordillera Septentrionale. Eastern or southern amber originates in the eastern portion of the country near El Valle and Bayaguana. A third and younger deposit is located in the center of the country near the village of Cotui. Dating of the amber is still not as exact as we would like. The northern amber is found in deposits dated at about forty million years old, yet the microfossils associated with these beds range in age from twenty-five to forty million years. Furthermore, some of the amber is found in secondary deposits and thus could be considerably older than the layer of sediment in which it is contained. The forty-million-year-old amber from the La Toca mine, where the amber frog was discovered, has been determined by nuclear magnetic resonance to be one of the oldest amber deposits on the island.

The mines themselves are usually holes or tunnels dug into the ground or the sides of mountains. Some may extend only a few yards into the earth while others may be quite long. La Toca consists of a narrow tunnel extending some sixty to ninety feet into the mountainside. The tunnels, which can be treacherous, are just large enough to allow miners with a few tools to crawl or stoop as they follow the dark, amber-rich veins of lignite, or brown coal, in sandstone and limestone deposits.

Once extracted, amber is usually sorted right at the mine entrance. Most amber is polished and made into jewelry, but pieces having insects or other animals within them are set aside and sold as fossils. Those with interesting inclusions can bring high prices; they are sold to middlemen who resell them to urban merchants, and most often they are eventually acquired by private collectors. According to a new Dominican law, no amber fossil can be sold or leave the country until it has been examined and its export authorized by personnel in the Museum of Natural History in Santo Domingo.

My goal in studying the inclusions in Dominican amber is to reconstruct the forest ecosystem of the Tertiary period—from about twenty-five to forty million years ago—in this part of the Caribbean. This is done by identifying the various plants and animals found in the deposits, using the help of many experts throughout the world. Because of their fine detail, amber specimens can be compared with present-day species to help evaluate patterns of microevolution, or evolution at or below the species level. Thus far, all life forms from Dominican amber that have been studied represent extinct species, and in some cases, extinct genera.

The findings to date demonstrate that a diverse assemblage of life, including vertebrates, existed at the time the resin was being deposited. The frog, anoline lizards, geckos, bird feathers, and mammalian hair discovered in Dominican amber represent the earliest record of these animals.
in the West Indies and cast light on animal distribution and colonization of the Caribbean. Islands such as those constituting the Greater Antilles—Cuba, Jamaica, Hispaniola (the island shared by the Dominican Republic and Haiti), and Puerto Rico—have puzzled biologists for centuries. We do not know where Proto-Hispaniola came from or when it started to move toward, or arrived at, its present position. However, geologists believe that all of the Proto-Greater Antilles resulted from the breakup of a contiguous archipelago located between North and South America in the Mesozoic or early Tertiary. The Proto-Greater Antilles were attached to a huge part of the earth’s crust, the Caribbean plate, which, through the action of plate tectonics, or continental drift, was pushed from west to east between North and South America during the past forty to sixty million years. Most scientists agree that the Greater Antilles probably arrived at their present location between ten and twenty-six million years ago, with Hispaniola becoming the island we now know some ten to fifteen million years ago.

Did life mainly colonize the islands from nearby continents by flying, rafting, or swimming (the so-called dispersalist view) or were the islands originally part of the continent that broke off, already carrying a full complement of continental flora and fauna with them (the vicariance hypothesis)? The fossils in Dominican amber attest to a vast array of life that existed on Hispaniola before it reached its present berth. Such fossils include many species with poor dispersal abilities (nonflyers, nonswimmers, organisms too heavy to be carried by wind, and those not likely to be rafted). This evidence supports the vicariance view: before becoming an island, the Proto-Dominican Republic had already acquired a flora and fauna with characteristics of both North and South American biotas; this plant and animal life traveled on the island of Hispaniola and, for a time, made up the major component of the island’s life after it arrived at its present location. This is not to say that dispersal, competition, and extinction did not occur; they were simply not the dominant forces in this instance.

The thrill of finding the tiny amphibian with the broken legs in the beautiful piece of Dominican amber has yet to wear off; in the meantime, the amber frog has made a contribution to our understanding of the forces that are responsible not only for the original amber flora and fauna but also for some of the related forms of life that have persisted even to the present day.
Bobcat Bill of Fare

Whether stealthily stalking a tiny vole or catching a wild ride on the back of a deer, this little predator is after just one thing—red meat

Text by Gary M. Koehler • Photographs by Michael S. Quinton

In central Idaho’s River of No Return Wilderness, winter lasts for half the year. In the mountains, snow can pile up to six feet and temperatures drop to twenty below zero. The 10,000-foot-high peaks of the Salmon River Mountains and the canyon valleys lying some 6,000 feet below seem quiet, as if all life is waiting patiently for the long, cold months to give way to a gentler spring.

But the appearance of peace is deceptive, for everywhere small creatures are working hard to eke out a living from the ungiving land. Mountain voles scurry about under the snow, searching the hummocks of grass for a succulent blade; flocks of mountain chickadees and juncos flutter among the firs, inspecting each crevice for a seed or insect; and ruffed grouse burrow under the snow to insulate themselves from the bitter cold. And wherever one of these animals is busying itself in search of a tidbit, chances are good that a bobcat is lurking nearby, preparing to pounce.

The bobcat may catch a mere flicker of a wing or the slight rustle of dead leaves. With its eyes riveted on the prospective lunch, the cat slowly crouches, its tufted ears lowered, its gray-brown and black dappled fur melting into the shadows, its short, black-barred tail twitching. Without so much as a whisper from its furred feet, the cat slips to within a pounce of its quarry. Although such a small morsel as a junco may not provide much of a meal for a twenty-five-pound male, or even a fifteen-pound female, every tidbit helps the bobcat survive the harsh Idaho winters.

For four years, I followed radio-collared bobcats in central Idaho. I have tracked them stalking prey that range from tiny voles—the cats’ main food in my study area, though each one is worth no more than a bite or two—to deer five times their weight. And I have tracked several bobcats for months only to discover that they themselves have fallen prey to their much larger cousin, the puma. Of the eight bobcats that died during my study, five were killed—though never eaten—by pumas.

In the course of my study, I have also learned how bobcats in my neck of the woods differ from bobcats elsewhere in
Weighing no more than an ounce or two, a songbird is not much of a meal for a twenty-pound bobcat. But during the harsh winters in central Idaho, the cats rarely find bigger prey and subsist largely on small birds and voles.
North America. Bobcats prowl almost every corner of the United States, from the subtropical jungles of Florida to the high mountains of the West to the woodlots of eastern suburbs. Using radiotelemetry, wildlife biologists have determined the travel patterns of this small cat and the space and cover needed to satisfy its secretive and solitary life style. In the forests and brush fields of the central and southern United States, prey—mainly cotton-tail rabbits, cotton rats, and sometimes a muskrat—is plentiful, weather conditions are generally mild, and bobcats are relatively common. Each cat may need only one to two square miles to provide it with enough food and cover. A bobcat may prowl its home turf, or home-range area, for its entire life, seldom venturing beyond its boundaries. Although females seldom share their turf with other females, they will share it with perhaps a couple of males, and they seem to tolerate the occasional passing of a juvenile that may be looking for a home turf. Since these home ranges overlap, a single square mile in the southeastern United States may support three or four bobcats. In logged areas of western Washington, where bobcats prey on mountain beaver, density is about one
Like all predators, bobcats spend most of their waking hours on the alert for prey. The cat at left, for example, is not stalking anything in particular, but its semicrouched posture and alert ears indicate the animal is ready to spring into action. Much more intensely focused, the cat below presses its body tight against a rock to avoid detection by a hoped-for meal.

animal for every one to two square miles—comparable to the densities in the Southwest, where rabbits scamper about the sagebrush. Bobcats also do well where farming has left fencerows, home for cottontails and snowshoe hares, and woodlots, where females can raise their kittens.

In Idaho, the story is somewhat different. Whereas a bobcat in Missouri might only need to catch a single rabbit to fill up its stomach for the day, a bobcat in Idaho might be obliged to catch two dozen voles to do the same. In my rugged study area, I estimate just one cat per ten square miles, a mere fraction of the density of other regions. In some parts of the mountains of central Idaho, bobcats may need up to thirty square miles to find enough food. Similar large home ranges and sparse populations are reported for northern Minnesota, where the deep, fluffy snow may make it difficult for bobcats to capture snowshoe hares and deer—their main prey there.

By following radio-collared animals, I learned that bobcats in Idaho also supplement their vole, grouse, and small bird menu with larger fare: a doe or fawn; a bighorn ewe or lamb. Reading tracks in the snow can be almost as revealing as
observing the animals themselves. I have "seen" a cat stalk to within a leap or two of a deer by crawling among the cliffs for a strategic position behind a rock or bush. Lying motionless as a rock, the cat suddenly erupts, hurling itself with a leap to the back of the deer.

When a cat does pursue a larger animal, a rodeo is likely to develop. One cold wintry day I surprised a female bobcat and her kitten at a freshly killed deer. Although at first reluctant to leave their prize, both cats soon vanished into the bluffs as I approached to inspect the kill (they returned after I left and after several days had consumed the entire carcass). By following the tracks of the bobcat and deer back up the snow-covered slope, and by piecing together signs left in the snow and wounds on the deer carcass, I could tell that the bobcat must have had a wild ride straddling the back of the deer. In a desperate attempt to dislodge the cat, the deer bounded down the rugged slope, dodging around bluffs, bolting through bushes and up against trees. The ride ended some 300 feet below at the foot of the slope, where perhaps the deer stumbled, giving the cat time to grasp the deer's throat in its mouth for a suffocating bite. At other kills, I surmised that the bobcat may have delivered the coup de grâce by severing the deer's vertebrae or puncturing the skull with its canines. At other times the deer may just collapse, worn out by its struggle.

If a bobcat is successful in its hunt, the deer may provide dinner for a week to ten days. Unless, of course, coyotes, pumas, magpies, or ravens usurp its hard-won prize. To conceal it from marauders, bobcats often scrape snow, dirt, or branches over the carcass. But my experience with tracks suggests that more often than not, the deer gets away. Unlike more sociable predators, bobcats are solitary hunters. The coyote, for example—a predator that has flourished where the bobcat has just managed to survive—frequently hunts in small packs. Such a pack can chase a deer down a steep mountain slope to the frozen, slippery creek below, where the exhausted
Muskrats—not a regular part of an Idaho bobcat’s diet—often spend the winter burrowed in stream banks, coming up periodically in search of edible grasses. The muskrat at left apparently surfaced just in time to encounter the bobcat, which was most likely hunting for rabbits and mice along the streamside. The muskrat did its best to discourage the bobcat, lower left, but had little chance against the cat’s formidable canines and fast paw action, below.

In extremely severe winters, some bobcats may starve. Females and juveniles are particularly vulnerable. In Maine, biologists found that during especially severe winters female bobcats had less body fat than they did in milder winters. The body fat of males showed less variation, suggesting that females may have been having a harder time finding enough to eat. Throughout the year, females tend to take smaller prey than males do, but as the winter progresses, their survival, too, may depend on occasionally killing deer. Young animals, lacking the hunting skills of adults, are also vulnerable to starvation.

The abundance or scarcity of prey also affects the number of kittens produced and their chances of survival. For the mother bobcat, kittens are a tremendous investment. Her association with her mate ends after a brief courtship and breeding period in February or March, and she alone rears the young born two months later. The kittens (generally three per litter) will stay with the mother well into winter, leaving her care and tutelage only at nine or ten months of age. Again, coyotes provide a useful comparison. With larger litters (four to five pups are not
Sunning itself on a bluff and looking for all the world like the Cheshire cat, this bobcat provides a striking demonstration of how well it can blend into its rocky terrain.
Current Ranges of Four North American Predators

uncommon), help from the father and often from older offspring in feeding the young, and earlier dispersal of the pups (when six months old), coyotes have a greater potential for population growth.

Ted Bailey (see *Natural History*, October 1972) studied bobcats in the semidesert sagebrush region of southeastern Idaho and found that few kittens survived when cottontail and jackrabbit populations were low, while when rabbits were plentiful there were lots of kittens. But in the mountains of central Idaho, rabbits are rare. Here, where bobcats depend on voles and the occasional deer during the winter, I found few kittens in the population. Although bobcats fare nicely during summer on the abundant ground squirrels, birds, and mice, the skimpy winter menu may affect the females' ability to reproduce. Studies of lynx and coyotes have also shown that when prey is scarce, some females—particularly younger adults—may not reproduce at all, and of kittens that are born, few may survive through the summer.

Bobcats are found along the southern edge of the Canadian provinces, but seldom north of 50° latitude. Bobcats are not adapted to cope with deep snow and it is here the bobcat's domain gives way to that of the lynx. Although bobcats and lynx weigh about the same, lynx have feet as big as a 100-pound puma's—twice the surface area of a bobcat's. These large feet and longer legs allow lynx to snowshoe over the surface of the snow in pursuit of prey. Bobcats must expend much more energy trudging through the snow. In northern Washington, where I have tracked both lynx and bobcats, lynx stay up in the mountains above 5,000 feet when winter arrives, while bobcats move to lower elevations, where snow is not so deep. When the snow leaves in late spring, bobcats again hunt the mountaintops where the lynx roam. I have never observed bobcats and lynx together in the
Not much more than a few weeks old, these kittens, below, will stay close to their crevice home, waiting for their mother to return with a bird, mouse, or rabbit to supplement their milk diet. Right: Calmly sniffing grass (perhaps to detect urine sprayed by another bobcat as a territorial marker), this cat could have been the inspiration for early twentieth century naturalist Ernest Thompson Seton's description of the animal as "just a big pussy with a bob-tail."

wild, but the experience of researchers in Nova Scotia is suggestive. In the mid-1950s, bobcats moved onto Cape Breton Island, probably via a newly built causeway from the mainland. Until then, lynx were common over much of the island. The bobcats, however, soon laid claim to the lower elevations where snow was not so deep, and the lynx retreated to the higher plateaus.

Like all other cats, and unlike many other mammalian predators, the bobcat and lynx occupy a relatively narrow niche at the top of the food chain, their survival dependent on flesh. Other predators in the same regions—canids, bears, mustelids—also eat flesh but can do quite well scavenging carcasses or feeding on fruits and insects. Many of these other predators also have a better sense of smell than do cats, further enabling them to seek out a variety of food sources. Coyotes, for example, can even subsist on a melon patch if need be.

With their reliance on a meat diet, their generally solitary nature, and often a need for large home ranges, many felids are less able than other predators to cope with changes in their environment, especially those brought about by humans. Their relatively low reproductive rate—producing fewer young but investing more energy rearing each one—is also better suited to stable conditions. (Felids are best represented—both in numbers and in species diversity—in tropical regions, where prey and cover are relatively constant owing to mild seasonal differences and few natural, large-scale disturbances, such as fire.) For the most part, cats do not cope well with change, and as a result, trapping, trophy hunting, and habitat destruction have pushed many of the world’s cats to the brink of extinction.

But for the moment, the little bobcat seems to be in good shape, at least in some parts of its range. Debate exists over the effects of trapping, and perhaps no definitive answer is possible until more is known about actual population numbers. In the meantime, while not as ubiquitous as the raccoons that rattle garbage cans across the country every night or as often seen as the coyotes that sometimes visit suburban back yards, bobcats are teaching us that humans and predators can live together as neighbors.
The Flight of Pterosaurs

Were the first flapping vertebrates batlike or birdlike—or were they something completely different?

Text by Kevin Padian • Illustrations by Donna Braginetz

It is difficult to imagine what they were really like. They had wings of skin, like bats, but they were distant cousins to the birds. They walked like birds and had very similar structures and metabolisms, but instead of a network of feathers that slide over each other, opening and closing like diaphanous Venetian blinds to manipulate the air, they grew their outermost fingers longer than ski poles and stretched skin from their tips back to the body wall. They evolved from close common stock with the dinosaurs, but were as unlike them as are the birds, the living descendants of the Mesozoic monsters.

What were pterosaurs like in the air? If they were alive today, how would we tell one flitting past from a goldfinch or blue jay that just caught the corner of our eye? Could they really fly or were they just gliders? Did the birds really outcompete them into extinction? And what about those bizarre forms with the big crests on their heads and the tiny bodies—and the last of their line, the one with the wingspan of a two-seat airplane?

Sometimes, when the light and air and water are just right, as they might be in a shimmering Charles Knight landscape, I have thought I could almost see them. The sun is trying to burn off the warm mist of the benign Mesozoic hothouse where ferns and cycads flourish, and the air is heavy with the buzz of insects and the smell of moist earth.

The pterosaur enters the scene soaring, its belly barely an inch from the surface of the quiet Cretaceous sea. Seemingly immobile, its eyes are fixed on the water ahead, straining for a glimpse of a school of fish. As it rides the layer of air just above the water, the creature slows its flight almost imperceptibly, but then, almost as subtly, it begins a slow, shallow downstroke of its great wings. Its speed returns, and it continues to skim the boundary layer. Eventually tiring of the search, the pterosaur pulls back its neck, flaps in earnest, and circles high in the sky until it is lost from sight over the trees.

I have not been entirely frank. These are not the shores of the Cretaceous sea over what will one day be Kansas. I’m on the shore of a brackish lake in Oakland,
Pteranodon cruise over shallow waters for fish. These crested pterosaurs with a sixteen- to twenty-five-foot wingspan were common in the Late Cretaceous, some 100 million to 90 million years ago. Two hadrosaurs, or duck-billed dinosaurs, graze along the shore in the background.
California, just across the lawn from the courthouse. And I have not been watching _Pteranodon_, the long-beaked, crested aeronaut of the ancient Midwest, but a pelican. How great were the differences? The one I see is a bird, the one I imagine is a pterosaur, but there were many similarities in their bodies, flight, and way of life.

Ordinarily, as a paleontologist, I am not much on drawing analogies too closely. That's what got us into trouble in the first place with pterosaurs, back in the late 1700s when they were first discovered in Germany. What was this animal that looked like a bird but whose physical traits showed it to be reptilian; that had wings of skin like a bat but was found in marine limestones? These were the first questions asked about the "ptero-dactyle," or "wing-finger," by Baron Georges Cuvier and some of the best zoological minds of the day. Although explanations abounded, when the dust cleared, scientists generally accepted the animal in question as a flying, bat-winged reptile. This image marked the birth of the ptero-dactyle as a kind of bat-lizard that bore leathery wings running down to its ankles and between its legs, that hung from cliffs, scrambled clumsily on the ground, glided erratically from one high point to another, and dived for fish, frequently dying in the process and leaving its bones to fossilize by the hundreds in the quiet lagoons of Jurassic Germany.

This reconstruction was perfectly natural and built on the best knowledge available at the time. Today, with our so-called liberated view of dancing sauropods and warmblooded carnivores, we would see things differently. But as Stephen Jay Gould often points out in his _Natural History_ columns, that doesn't make these earlier scientists wrong and us right. We are dealing with animals that no human has ever seen, and that have no exact living counterparts. History informs our understanding; the restoration of a fossil animal does not have to be accurate, only familiar, to be accepted by the mind's eye. The eighteenth-century naturalists didn't know what pterosaurs were; they had never seen a dinosaur; and to most of them, whales and the exotic mammals of Africa and Asia were as real (or unreal) as griffins and unicorns. But they knew lizards, and they knew bats. Here was a lizard that flew, and such an animal made sense, even if it was nothing like anything living today.

Why quibble today with this bat-lizard paradigm? Why isn't it a perfectly valid analogy to describe pterosaurs? The only reasonable answer is that it doesn't explain all the facts, or at least not as well as another paradigm may. All analogies have their limits, and—as the philosopher of science Thomas Kuhn points out—a paradigm works until a sufficient body of evidence (and a consensus of scholars) forces its replacement with a new paradigm. Despite platitudes about the objectivity of the scientific method, this is the way science often works.

In the case of pterosaurs, we can pick out a few bits of traditional wisdom for analysis. The simplest is the idea that they were mere gliders, not active flappers. As far as I can tell, this notion proceeded from the assumption that being reptiles (and like living reptiles, coldblooded), pterosaurs would not have been able to sustain flight without building up a tremendous oxygen debt in short order. But the evidence of the skeleton, recognized by some paleontologists for more than a century, forces us to reject this idea.

If you look at the flight apparatus of the pterosaur skeleton, you'll see that the areas of flight muscle attachment on the bones of the breast and upper arm are vast—comparable to, or greater than, those of a bird of equivalent size and much larger than those of any bat. No glider has such areas of attachment, and indeed why should it? Moreover, when you actually fit the pterosaur bones together and articulate the wing in its shoulder socket, you see that it is capable of two motions: it can go up and down, and it can rotate down and forward. The first motion is used by bats and birds in medium- to high-speed flight. The second, however, is used in "getting up steam," that is, low-speed flight where a great deal of energy is expended—for example, in taking off and landing. These motions—both up and down and down and forward—are those of the flight
Below, left: Front views of chest and shoulder girdles for birds, pterosaurs, and bats. In pterosaurs, as in birds, the muscles that control both upstroke and downstroke originate at the ample sternum. Bats have a much different arrangement: the downstroke muscles originate from the ribs and sternum; the upstroke from the scapula. Below: Unlike the feathered wings of birds, those of bats are supported by bony fingers, or phalanges; pterosaur wings were stiffened by a network of structural fibers.

stroke, which defines powered flight.

In addition, most of the pterosaur's bones are not just hollow and extremely thin walled but also pneumatic. Holes in the bone walls, usually near their ends, admit the air sacs of the respiratory system into the cavities of the bones. Lightening the skeleton is one explanation for this arrangement, although it would be equally useful for a gliding animal. Another explanation is that the increased surface area allows more gas exchange with the blood, which is necessary for the high-exercise metabolism of flight. A third explanation is that the blood is cooled by this exposure to air. This is true for birds, which also have pneumatic foramina leading into air sacs within the bones. Possibly all these explanations are at least partly correct, and none of them apply to gliders. The last two apply to warmblooded animals, which have high metabolic rates. This suggests, with the strongest possible skeletal evidence, that pterosaurs had the kind of advanced physiology that we associate with birds and mammals. The remains of an insulatory covering, a kind of furry coat very likely modified from scales, recently discovered with the skeleton of a pterosaur from the Soviet Union further support the argument for a high, steady metabolism.

So pterosaurs were active flappers, which takes them out of the category of gliding squirrels and lizards and puts them in with bats and birds. But which group makes the better model for understanding pterosaurs? They had wings of skin like bats, but were more closely related to birds. What else is known about their wings?

One thing we know from preserved wing impressions is that the wing membrane in pterosaurs was invested with a series of long, thin, closely spaced and intercalated stiffening fibers, possibly of keratinlike scales and feathers. These fibers (or actinofibrillae, as they are now called) radiated through the wing along the same pattern as the feather shafts of birds and the fingers of bats, so they must have been designed to maximize strength. Besides, they are never found broken or bent, but only gathered in the wing folds.
Therefore they must have been structural elements, which explains why there is no strong cord along the trailing edge of a pterosaur wing.

The shape of the wing itself was long and narrow, like a gull's or perhaps a swallow's in the smaller forms, and an albatross's in the largest ones. Of the preserved specimens, there is only one in which the wing itself, identified by the structural fibers, extends at all to the legs. In this small Pterodactylus, fibers ran partway down the thighs. Some paleontologists cite evidence from other specimens that show clear impressions of soft parts leading to the lower legs and even ankles. I agree that these represent soft parts, but I am unable to recognize them as parts of the wing without the structural fibers. We have evidence of soft parts between the toes and even around the neck bones, where the wings obviously weren't. So our criterion for deciding how far along the body the wings stretched must be fairly rigorous. The slight attachment of the wing to the thigh in the newly described specimen of Pterodactylus suggests that the leg could be flexed to modify the curve of the wing and change the position of its trailing edge. Although not a very fundamental component of design, this surely would have been handy in increasing the animal's maneuverability.

The question of wing attachment—limited to the body wall or extending to the hind limb and ankle?—takes on an added dimension when one realizes that it bears on how the hind limb must have operated. Consider a bat, with its legs incorporated into the wing membrane. Its legs stick straight out to the sides, and flex in the plane of the wing. They must do so or else they would frustrate the whole aerodynamic flow over the wings. This is one reason why nearly all bats can only manage a clumsy skittering on the ground, and it at least partly explains why they hang upside down. Birds have no such trouble, because their hind limbs are free of the wings. They can walk and fly perfectly well, with the advantage of two separate locomotor systems.

Pterosaurs had the same advantage as birds. At least, their hind limbs seem to agree on that point. If you take a pterosaur leg, you can swing it into the same position as a bat's, but only if you dislocate the hip socket. Pterodactyloid pterosaurs do have a ball-and-socket hip joint somewhat like a bat's, but so do humans. Perhaps the thigh swung outward a bit if the wing membrane was partly connected to it, but the situation is not at all like it is in a bat. The head of the thigh bone in pterosaurs points at about 45° inward, upward, and backward to enter the hip socket. In bats, if you hold the thigh bone in the same way, the head just sticks straight upward from the shaft. So the motion at the hip is completely different. But this joint alone will not tell the story. The rest of the leg has to be considered.

Pterosaurs were powerful flappers. Two right-side views and one front view depict a pterosaur shoulder girdle and upper arm during the down-and-forward flight stroke. As it moved downward, the arm also rotated forward in the shoulder socket, drawing air both under and over the wings and providing the thrust and lift needed to become airborne.

If you look at the femur, or thigh bone, of a pterosaur, you'll see that it is curved like a bird's. Its knee joint bends in only one plane, like a bird's or a human's. This is also true of its ankle, which resembles nothing so closely as the end of the drumstick of a bird. It is a double roller joint, connected to a foot that rotates in just one plane, like the knee. Both joints are much more restricted in birds and pterosaurs than they are in sprawling animals such as lizards and crocodiles, and they do not have the rotational freedom that they do in bats.

This is further borne out by the fibula, or smaller shinbone. The fibula is on the outside of the tibia in the lower leg. In sprawling animals, which rotate their
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A pterosaur wing connected to the upper leg, below (right), rather than the ankle, allowed the leg to move freely. The traditional model, below (left), does not accord with the anatomy of the pterosaur hind limb, bottom, which in size, shape, proportion, and relative position is much more birdlike than batlike.

limbs when they walk, the tibia and fibula are of about equal size. In those cases where animals (mammals and dinosaurs, including birds) have taken to standing erect, tucking the limbs under the body, and moving them in more or less a straight line, the weight is borne by the tibia because it is closer to the center of gravity. It becomes larger, and the fibula becomes smaller because it has lost its role in rotating the leg. The toothpicklike bone you encounter in a chicken leg is the fibula, which has been reduced to a splint. The same thing happened in pterosaurs. The fibula is so small that it doesn’t reach the ankle. So there could have been no rotation at the knee or ankle. The fibula is also splintlike in bats, but in a different way: it reaches the ankle, but doesn’t reach the knee. I suspect this may have something to do with hanging upside down, but the important thing is that it is completely opposite of what is going on in birds and pterosaurs. Indeed, nothing in the leg of bats is even remotely like the legs of the other two groups. When you fit the pterosaur’s leg together, it works like a bird’s, right down to the elongated foot bones, the divergent toes, and the sharp, but not overly large or curved, claws. Even the proportions are similar.

Given that they had such birdlike legs, could pterosaurs run to take off? This is a difficult question because to become airborne, most of the power must be supplied by the wings or the animal will never stay off the ground. The legs are working just to build up some initial speed and to relieve the arms of some of the strain of acceleration. This low range of speed (zero to twenty-six feet per second) is precisely the range at which the greatest energy must be expended by the wings and at which any help the legs can offer is most welcome.

Pterosaurs ranged in wingspan from the size of a sparrow to the size of some small aircraft (about thirty-five feet for the giant *Quetzalcoatlus* of the Late Cretaceous of Texas). The largest pterosaurs, including everything from the sixteen-foot *Pteranodon* upward, no doubt did relatively little flapping once in the air. Like the albatross, condor, and other large birds, they must have spent most of their time soaring. Like gliding, soaring is fixed-wing flight, but unlike gliding, soaring uses the energy of rising air currents to slow descent and channel forward motion—much like falling down an “up” escalator, with which it has often been compared. Flapping continuously at such large sizes is simply too costly in energetic terms. This forces a change in the way of life to that of an airborne hunter, which uses sharp eyes to focus on potential prey from far above the ground where air currents are most reliable. The prey may be carcases, schools of fish, or small game, but the cost expended in hunting is relatively low. The giant *Quetzalcoatlus* was said by some to have been a vulturelike scavenger, but its tapering, chopsticklike jaws stand in sharp contrast to a buzzard’s prehensile meathooks. Paleontologist Wann Langston, who knows its remains better than anyone, finds some suggestive resemblances to a heron or egret. Perhaps this largest of pterosaurs, with a six-foot head and nine-foot neck, spent its time plucking frogs and fishes from the shores of shallow inland lakes.

Pterosaurs arose with dinosaurs during the Late Triassic some 225 million years ago and dominated the skies for the next 160 million years. For about the latter half of that time, they shared the air with birds, which first appeared in the Late Jurassic. Yet there is no evidence for competition between the two: they are almost never found in the same sediments. Birds are far more poorly known until the very end of the Cretaceous, when the other dinosaurs and the last pterosaurs died out.

Why then did pterosaurs become extinct? It is very hard to say. We know of at least forty genera over those 160 million years, but there must have been more. They were clearly declining in diversity during the Late Cretaceous. Their bones
This robin-sized Pterodactylus is the only well-preserved pterosaur fossil that clearly shows both wings attached to the upper thighs. By flexing its legs, a Pterodactylus could control the position of the wings' trailing edges and increase its ability to maneuver in the air.

Courtesy of the Naturhistorisches Museum, Wien, Austria.

were so thin that preservation is highly unlikely, although in good deposits they come by the hundreds. Mostly we have records of water-loving forms, comparable to shorebirds and seabirds of today. Forests are poor places for slender, airy bones to stand a chance of becoming fossilized, because scavengers and decomposers are pervasive and almost no creature enjoys an undisturbed burial. We are probably missing at least 80 percent of the actual diversity of pterosaurs, in my estimate, and we may never know them. By the end of the Cretaceous, only the giant Quetzalcoatlus was left.

So, even to consider the kinds of evolutionary and aerodynamic problems that pterosaurs faced, we sometimes need to turn to living forms to see what they do, and how. I watch the pelican circling about thirty feet above the lake by the courthouse. Suddenly it stops, dives straight down with its neck outstretched, and plunges in the most inelegant fashion just beneath the water. Sometimes it emerges with a fish, sometimes not. I ask myself whether Pteranodon could have done that, whether it had a pouch below its beak to store fish, whether it had a gizzard to help process its catch. And I know that means it's time to return to the specimens, to analyze and compare, to measure and reconstruct, until it all makes just a little more sense.

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Five Lunar Phases

by Thomas D. Nicholson

This month, on the East Coast of North America last-quarter moon occurs on the 1st, new moon on the 9th, first quarter on the 16th, full moon on the 23rd, and a second last quarter on the 30th. On the West Coast, however, they are all a day earlier, falling just before midnight, including the first, which fell on November 30, leaving the West Coast with just four phases in December, while the East Coast has five. Lunar phases are always three hours earlier in Pacific Standard Time than Eastern Standard Time.

The moon's phases actually occur at the same moment everywhere, when the moon reaches a certain position relative to the sun. The instant when the moon is new (when it passes between the sun and the earth) occurs at different local times depending on differences in longitude.

Differences in latitude, however, have little effect on the timing of most celestial events, specifically those that are not caused by the earth's rotation. The moon's phases in December occur at exactly the same time in Lima, Peru, and New York, New York, because these cities are at roughly the same longitude. The time and date when seasons begin (winter begins on December 21 everywhere in North America but on the 22d in eastern Russia), the timing of solar eclipses, and the phenomena of Jupiter's moons do not change as one travels north or south.

The timing of events caused by the earth's spin, such as sunrise and sunset, works differently and is affected by latitude. The sun rises in New York six hours after it does in Rome, and three hours before it rises in San Francisco, but because they have similar latitudes, the local time of sunrise is about the same at all three places. But sunrise in New York and Lima is at different times (even though they are within the same time zone) because of their different latitudes. Intercontinental travelers on north-south flights experience little or no time change (or jet lag) and do not need to adjust their watches, but the time of the risings and settings of heavenly bodies does vary with changing latitude, one effect of the earth's tilted axis.

Events in the calendar below, given in Eastern Standard Time, should be adjusted for time-zone differences. Where no time standard is specified, local time is used and will be about the same everywhere in North America, but it could vary about a half-hour or so for observers not near the center of their time zone or for those who are far from latitude 40° north.

December 1: Last-quarter moon is at 1:49 A.M., EST, some two hours after moonrise near Leo's bright star Regulus. Mercury, at superior conjunction (in line with and beyond the sun), enters the evening sky.

December 2: The moon is at apogee, its farthest position from the earth.

December 4–5: Venus is in the east at dawn, with Spica and the late crescent moon above and to its right. Regulus is high in the south, with Gemini's twin stars, Pollux and Castor, and the Bull's Aldebaran in the west. All form a line across the sky tracing out the zodiac from Libra to Taurus.

December 7: The old, thin crescent moon and Venus are low in the southeast at dawn. Today's sunset is the year's earliest in the Northern Hemisphere.

December 9: The new moon, in Ophiuchus, occurs at 12:36 A.M., EST.

December 12: The young crescent moon is low in the southwest at dusk, too far below the equator and too close to the sun to be seen before tonight.

December 14: The Geminid meteor shower is best viewed early this morning, with dark skies in the after-midnight hours. Its fifty or so meteors per hour can match August's Perseid shower, but they are usually not as bright.

December 15–16: The moon is nearest the earth (perigee) at 11:00 P.M., EST, on the 15th and reaches first quarter at 12:40 A.M., EST, on the 16th.

December 16–17: Moving through Pisces, the moon approaches Mars on the 16th and moves away on the 17th.

December 20: The gibbous moon and a brilliant Jupiter are near the Pleiades cluster in Taurus this evening, with reddish Aldebaran lower down.

December 21: The sun arrives at the winter solstice in Sagittarius at 10:28 A.M., EST, and winter begins in the Northern Hemisphere.

December 22–23: The moon moves out of Taurus into Gemini on the 22d, just before it is full at 12:29 A.M., EST, on the 23d. Scattered moonlight will spoil the Ursid meteors.

December 24: Pollux and Castor are lined up with the moon this evening. Watch the moon gradually drift away from these stars during the night as they all move westward across the sky.

December 26: Saturn is in conjunction with the sun, entering the morning sky.

December 27: Regulus and the moon are close in the east as they rise about 9:00 P.M., after the star was occulted in the Far East. The moon moves away from Regulus during the night.

December 29: The moon is at apogee for the second time this month at 11:00 P.M., EST.

December 30–31: Last-quarter moon, at 11:57 P.M., EST, on the 30th, is in Virgo. The moon, with Spica below it, is well up in the east during the morning of the 31st.

Editor's Note: The Sky Map in the October issue shows the evening stars and constellations for this month and gives the dates and times for its use.
Rice with pork chops, cauliflower, and beans
A Small World in a Cooking Pot

The ingredients in a Spanish paella reflect the conditions of rural country life

by Raymond Sokolov

At this summer’s Oxford Food Symposium, it was business as usual: two days of learned confabulation and international food, produced and consumed in and around St. Antony’s College. This year’s focus was on culinary houseware, "the cooking pot," and the weekend’s most elaborate cooking event was an improvisational paella cooked by Lourdes March.

March is a well-known cookbook author in Spain, admired for her learning and precision in the service of Spanish regional dishes. As a Valencian, it was inevitable that she should think about paella and about rice. Valencia’s principal food product and the basis of paella and dozens of other dishes from the area. Her book El Libro de la Paella y de los Arroces (literally, The Book of Paella and the Rices) is both a treatise and a treasure for the practical cook.

At the symposium, March took up the cudgels once again on behalf of paella, perhaps the most misunderstood and most often badly cooked of the world’s great dishes. There are several reasons for this unhappy state of affairs, reasons that spring, as she says, from the history and nature of paella itself.

Although even Valencian traditionalists cook paella for large crowds, paella is not suitable for most restaurant kitchens because it must be cooked over a wood fire. And the tending of that fire requires the constant attention of the cook. In an a la carte restaurant, where many paellas are prepared at different moments for different tables and different diners, even if there were a wood fire, it would never be suitable for several different paellas at different stages of preparation. And if the restaurant were going to succeed at all, it would have to be making its paellas in individual pans, not one large one for all comers. Such an omnium-gatherum of a paella would have to be made ahead of time, and paella cannot be properly served except immediately after it is finished, when all flavors have mixed and been absorbed by moist, al dente, individually separate grains of medium-grain rice.

The importance of the pan cannot be overstressed. The basic meaning of the word paella is pan. March traces the word back to Greek pateras and Latin patella. She argues that paella (the food) is a symbolic and actual merging of two great cultures insurgent upon the Iberian Peninsula and its peoples. The Romans brought the pan and the Moors brought rice. Valencians put the Islamic rice in the flat, two-handled Roman metal pan and took to cooking the rice with simple, available foods: vegetables and chicken and rabbit. To produce a perfect paella, the pan had to be the perfect diameter, just large enough so that all the liquid is absorbed at just the moment when the rice is fluffed and almost soft but still chewy.

Here are the standard relations between number of guests and paella diameters: For two to three people, thirty centimeters; for four to five people, forty centimeters; for six to eight people, fifty centimeters; for ten people, fifty-five centimeters; for fifteen people, sixty-five centimeters; for forty to fifty people, ninety centimeters. All paella pans are shallow, from one and a half to two and three-quarter inches deep, to permit the rice to cook through evenly. In the old days, guests really did eat right out of the pan, with boxwood spoons. March, I think correctly, sees this as proof of Moorish origins for paella. Round metal tables and wood spoons are survivals of medieval dining still prevalent in the Moslem world.

But it is in Spain that the peculiar combination of ingredients we know as paella Valenciana came together and turned into a classic dish, the emblem of a nation. And the classic ingredients for the classic dish are remarkably simple—rice, rabbit, chicken, green beans, limas (of a large variety called garrofón in Spain), rosemary or rosemary-fed snails, tomatoes, saffron, paprika. They reflect the conditions of country life in the rice fields of Valencia, as does the classic paella fire, which reflects the region’s meager firewood supply. Vine cuttings and tree prunings are what you want for a paella fire in a paella barbecue (paelleria), not big branches or logs.

“Please, no troncos,” Alicia Rios admonished me, as I tried to scrounge together a fire from the woodshed in a garden outside Oxford. Rios is March’s great friend and collaborator. She also lives in Madrid and is a food historian. So she knew that the bonfire I was assembling would be impossible to fine-tune as a paella fire must be fine-tuned. Twigs and vine cuttings allow quick adjustments. Fortunately, the woodshed had vine cuttings. Rios was pleased. She would have been even happier if there had also been apricot twigs, but the fire prospered anyway and she contented herself with teaching us the tongue-twisting Spanish word for apricot tree, albaricoquero.

In a rudimentary way, our very mild disagreement over method pushed the paella a bit closer to Valencian tradition. The paella is a man’s province, and its preparation is always a matter of discussion.
The most significant issue in the unending paella debate is not, however, the fire, but the ingredients. The recipe given here for Valencian paella is traditional. It is not the paella that has traveled across oceans and become famous; it contains no shellfish, no lobsters, no shrimp, no churro, no pork chop, no peas. The paellas that do contain all these things are in the same glamorous and inauthentic category as bouillabaisse with langoustes or New England clambakes with lobster. All three substitute abundance, variety, and luxury ingredients for the simplicity and gustatory logic of the homely originals on which they are based. In each case, the original "ascetic" version is, in my experience, obviously superior. The idea makes sense, coheres in the mind and in the mouth. With paella, in particular, when all the primeval conditions are met, and the wood flavor of the fire in the paelleria has pervaded the rice, along with the broth from the beans and the chicken and rabbit and spices, you have a symphony of a dish, instead of a flashy pizza delux.

By holding back and limiting the ingredients, traditional paella cooks intensify the effect of the little world they are making inside a single pan. This is not the only use that the Spanish make of the paella pan, but it is the classic achievement because it capitalizes on the limitations of what can be done in a finite space with rice and liquid and a few other solid ingredients. Paella then is quantum cookery, the triumph over a restricted, inelastic cooking space, in which dry (rice and lima beans) is transformed into moist and what begins as liquid is totally absorbed.

Although the experience of preparing and consuming a true paella is joyous and free, to get to this point in today's world requires a deliberate act of adhesion to a life and to conditions now lost even in Valencia. No wonder the dish has not traveled elsewhere in its original form.

There is, however, a whole category of rice dishes that are equally traditional in Valencia and that are inclusive where classic paella is exclusive, various where paella tends toward the monochromatic, unrestrictive in its cooking space and liquid where paella is almost dry. The multifarious dishes are the arroces caldosos, literally "soupy rices." They are rice stews and really ought to be made in flameproof earthenware pots called pucheros, but the

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**Lourdes March's Paella Valenciana**

(Adapted from a recipe distributed at the 1988 Oxford Food Symposium)

1/2 pound dried, large lima beans, soaked in cold water overnight
1 cup olive oil
1 3-1/2 pound chicken cut in serving pieces
1 2-1/2 pound rabbit, cut in serving pieces
1 1/2 pound green beans, trimmed
1/2 pound tomatoes, peeled and finely chopped
2 teaspoons paprika
2 sprigs rosemary or 12 snails
Salt
Saffron
5 cups medium-grain rice (available where Hispanic ingredients are sold; do not wash)

1. Boil the limas in one quart of water for 1 hour. Drain, reserving both limas and their cooking liquid.

2. Meanwhile, pour oil in a paella pan forty-five centimeters in diameter. Place over the paellero or barbecue where it will cook and level it properly. Set the fire and light. When oil is hot, fry chicken and rabbit pieces, turning them frequently. Then sauté green beans and tomatoes for a few minutes. Reduce heat and immediately pour in five quarts of water and the cooking liquid from the limas.

3. Increase heat and bring to a boil. Then reduce heat to medium and maintain at this level until the meat and other ingredients are cooked, 45 to 60 minutes, depending on tenderness of meat.

4. Add rosemary or saffron. Taste stock and add salt if necessary. Add a small amount of saffron.

5. Check the broth level. It should be just at the height of the paella's handle rivets. Remove if there is too much or add boiling water if there is too little. Then increase the intensity of the fire and add rice. Spread it as evenly as possible. Simmer for 10 minutes, then reduce heat to medium and cook gently for 8 to 10 more minutes. Toward the end, taste rice. When it is al dente, slide the paella to one side of the fire and let stand for 5 minutes so that the rice grains end up loose, unbroken, done, and with superb flavor. Now only your fellow diners' opinions are required, their praise or criticism.

Yield: 10 servings

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**Arroz con Costillas de Cerdo, Coliflor y Alubias (caldoso)**

(Rice with Pork Chops, Cauliflower, and Beans)

(From El Libro de la Paella y de los Arroces, by Lourdes March, Alianza Editorial, Madrid, 1985)

1/4 pound white beans, soaked overnight
main point is that the finished dish has a broth with rice and other ingredients floating in it. There is too little broth to call an arroz caldoso a soup; it's just soupy. Spanish cuisine has many dishes in this category. Almost no one outside Valencia talks about them, but that has not prevented this versatile food idea from cropping up all over the Spanish-speaking world under one name or another. When Puerto Ricans cook asopao de pollo, their "souped" chicken with rice, they are making an arroz caldoso. So are Filipinos when they prepare arroz caldo con pollo.

I have been making arroz caldoso lately with the Valencian-style, medium-grain rice sold in the Hispanic sections of many supermarkets, with delicious results. But I am also gearing up for a Valencian paella.

The twigs I saved from an apricot tree blown down in the freak October blizzard of 1987 are perfectly seasoned. Now all I'm waiting for is the arrival of Lourdes March and Alicia Rios, bringing snails fed plump on rosemary.

Raymond Sokolov is a writer whose special interests are the history and preparation of food.

2 tablespoons olive oil
1/2 pound pork chops, boned and sliced thin
2 cloves garlic, peeled
1/4 pound tomato, peeled and chopped
Pepper, saffron, and salt
1/2 pound cauliflower
1 cup medium-grain rice (do not wash)

1. Combine beans with two quarts of water, bring to a boil, reduce heat, and simmer for 30 minutes.
2. While the beans simmer, heat the oil in a skillet and brown the pork strips in it, at medium-high heat. When the pork has taken on an appealing brown color, add the whole garlic cloves and the chopped tomato, as well as a half-teaspoon of pepper. Simmer for 2 minutes and then stir into the beans.
3. Let the beans cook for another 20 minutes. Then add a pinch of saffron, salt to taste, and cover the pot. Reduce heat and cook at a slow simmer until the beans are almost cooked.
4. Correct seasoning. Then break the cauliflower up into flowerets and add them to the pot. Raise the heat to high. Let the pot come to the boil. Throw in the rice all at once, stir quickly, and cook, uncovered, over medium heat, for 16 to 18 minutes.
5. Remove from heat and let rest for a minute or two before serving.

Yield: 4 servings

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At the American Museum

Winter Celebrations
December is Winter Celebrations Month at the American Museum of Natural History’s Leonhardt People Center. This year, Eastern Europe and the Americas are highlighted. Performances will include winter music and folklore of the Balkans, winter dances presented by the Bosilek Bulgarian Folk Dance Ensemble, and Puerto Rican agujalados (traditional Christmas carols) played by Sergio Ortiz and his Conjunto Cudiamor. There will also be a Hanukkah celebration, a miniature reconstruction of Christmas in a Colombian village, demonstrations of the crafts of making piñatas and Polish Christmas tree ornaments, and more. These weekend events are free and open to the public. For more information call (212) 769-5168.

Origami Tree
More than 3,000 silver star mobiles will form a halo around the twenty-five-foot-tall Origami Holiday Tree at the Museum through January 6. The tree, decorated with folded-paper models of animals past and present, is on view for the sixteenth consecutive year and represents more than 250,000 hours of volunteer time. Museum volunteers at a nearby table will teach visitors how to fold their own origami ornaments.

At the Planetarium
“The Star of Christmas,” the holiday Sky Show at the Hayden Planetarium, takes viewers back in time to the first Christmas. What was the luminous object that led the Wise Men to Bethlehem? Was it a star, a comet, a meteor—or something else? Scientists, theologians, and historians have all contributed to the search for answers. The program runs from Wednesday, November 23, through Monday, January 2. On December 13 and 15, the New York Philharmonic Chamber Ensemble will present “Haydn at the Hayden,” in which the eighteenth-century composer meets twentieth-century lasers. For more information on Planetarium programs call (212) 769-5920.

Tiger Moon
Glimpses into the secret lives of tigers will be provided by a program in the Main Auditorium at 7:30 p.m. on Monday, December 19. Field biologists Mel and Fiona Sunquist will share their adventures from a two-year study of wild tigers in Nepal’s Royal Chitwan National Park. Tracking the movements of the elusive tigers with radio collars, the Sunquists have discovered important new information about the habits and life styles of these rare beasts. Tickets are $5 for members and $8 for nonmembers.

Kwanzaa
Kwanzaa, a Swahili word meaning “the first fruits of the harvest,” is a week-long holiday celebrating the richness and diversity of African cultures and the African-American diaspora. Now in its 22nd year, Kwanzaa runs from December 26 through January 1, with each of the seven days dedicated to one of the nguzo saba, or seven principles: umoja (unity), kujichagulia (self-determination), ujima (collective work and responsibility), ujamaa (economic cooperation), nia (purpose), kuumba (creativity), and...
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Old World titmice, like North American titmice and chickadees, are acrobats, nimbly grasping twig tips and bobbing upside down while they savor spring buds, insects, and seeds. But in winter, feeding can involve combat and can test the birds' spirit as well as agility. The stakes are high; in central Europe starvation is sure to overtake many of these year-round residents.

Titmice are characterized by an audacity that leads them, in the guise of tameness, to fraternize with humans and even to enter houses. In the 1770s, British naturalist Gilbert White noted that the great tit, "driven by stress of weather, much frequents houses; and, in deep snows, this bird... draws straws lengthwise from out the eaves of thatched houses, in order to pull out the flies... concealed between them." More recently, daring, savvy titmice in Britain have become notorious as cream-tippling vandals of foil-capped milk bottles. In winter, titmice of various species, roving in mixed flocks, are quick to avail themselves of feeders stocked with seeds and suet.

In this early morning, dead-of-winter scene, a blue tit grapples with a weightier great tit. Among the many blue tits that had gathered at a nearby feeding table, only this individual had the cheek to charge time and again into the flock to rout the great tits. With a toehold on its adversary, this blue tit demonstrated its talent as an aerial pugilist.

—J. R.

Photograph by Manfred Danegger
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While still a wildlife management student at the University of Massachusetts, David S. Wilkie, along with coauthor Gilda A. Morelli (page 32), was invited by Drs. Robert P. Bailey and Irven Devore of Harvard University to participate in a multidisciplinary study of the Efe Pygmies living in the Ituri Forest of northeastern Zaire. During their first trip to the Ituri, Wilkie and Morelli realized that they could not look at the Efe’s foraging practices without also examining how their relationship with Lese horticulturists affected the daily activities of men and women. Wilkie, a research assistant professor in the Department of Anthropology at the University of Utah, is an ecologist by training, but is more and more attracted toward how humans interact with their surroundings to affect ecosystems.

Coauthor Morelli, a research assistant professor in the Department of Psychology at the University of Utah, is currently studying the process by which Efe infants form attachment relationships with their mothers and other women care givers. The authors recommend reading People of the Tropical Rain Forest, edited by J. S. Denslow and C. Padoch (Los Angeles: University of California Press, 1988), to which Wilkie has contributed a chapter on the Pygmies, or Children of the Forest, by Kevin Duffy (New York: Dodd, Mead and Company, 1984).
George Poinar, Jr.'s main field of study at the University of California, Berkeley, where he has served on the faculty since 1964, is not amber (page 42) but invertebrate pathology and nematology (the study of parasitic worms). Fortunately, he has been able to incorporate his near lifelong fascination with amber into his research on insect diseases and fossil nematodes. Of special interest to Poinar are amber pieces that document symbiotic relationships—an amber-entombed beetle carrying mites, for example—and he described some of these ancient associations in his article, “Sealed in Amber,” in the June 1982 issue of Natural History. Poinar, who enjoys photographing his amber finds, has visited amber-rich areas in Chiapas, Mexico, and along the Baltic coast and has led an expedition to the rich amber mines of the Dominican Republic. He plans to use the variety of plant and animal life found in amber to reconstruct life in a Tertiary forest. Amber lore is the subject of Patty C. Rice’s Amber: The Golden Gem of the Ages (New York: Van Nostrand Reinhold Co., Inc., 1980) and Rosa Hunger’s The Magic of Amber (Radnor: Chilton Book Co., 1979).

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Kevin Padian (page 58) launched his study of pterosaur evolution and flight some ten years ago: "I was trying to figure out some particulars of the origins of dinosaurs when I stumbled on a sixtyyear-old paper that suggested one track for the origin of pterosaurs. I started to examine the question and realized that pterosaurs were probably the closest relatives to dinosaurs and that typical reconstructions of pterosaurs were probably incorrect." An associate professor of paleontology, Padian (right, with Nicholas Hotton III of the Smithsonian Institution) received his doctorate from Yale and joined the faculty at the University of California, Berkeley, nine years ago. In addition to pterosaurs, his research involves the origin of dinosaurs, fossil footprints, and the history of evolutionary thought. He plans to continue a study of the beginning of the age of dinosaurs with a trip to China next year. For more information, Padian refers readers to "Pterosaurs," by Wann Langston, Jr., in *Scientific American* (February 1981), and "the best book available on dinosaurs," David Norman's *The Illustrated Encyclopedia of Dinosaurs* (New York: Crescent Books, 1985).

From 1981 to 1985, Gary M. Koehler (page 48) and his wife, Mona, plunked themselves down in the middle of Idaho's River of No Return Wilderness. Their goal was to radio collar and track wild bobcats, but in the process they also had the experience of raising a kitten to adulthood. Most of the time, Koehler reports, the young bobcat conducted itself like an ordinary, if particularly large and handsome, docile tabby cat, but at suppertime, its wildness surfaced—growling, snarling, baring its fangs, lashing out with its paws, claws unsheathed, the kitten defended its meal. At present, Koehler, a research associate with the Wildlife Research Institute in Moscow, Idaho, is studying lynx in the Cascade Mountains of north-central Washington. In the future, he hopes to do research on wild cats in Asia. For more on bobcats, readers might turn to *Bobcat Year*, by Hope Ryden (New York: Viking Press, 1981). Based on Ryden's personal observations of a female bobcat raising a litter, this book takes the reader through the seasons of a year in the life of a bobcat. Theodore Bailey's story "The Elusive Bobcat" (*Natural History*, October 1972) gives a nice picture of this cat's territorial behavior.

Each November, Manfred Danegger (page 76) starts to stock his bird feeding table in the forest near his home in southern Germany. He gets a few customers then, but it's not until January, when full-blown winter cold sets in, that the action at the feeder heats up. Then Danegger dons down clothing and stations himself behind a blind with a camera. During the long, cold hours of waiting and watching he gets to know the many individuals that patronize his feeder when their natural food sources are pinched by snow and frost. The small blue tit that struggles with a larger great tit in this month's "Natural Moment" was absolutely fearless against her adversaries at the feeder, Danegger says. "She was dear to me, and I named her *kleine Hexe* [little witch]." Danegger has been a serious nature photographer for twenty-five years, and his work has appeared in a variety of books and magazines. To catch the clash of the titmice, he used a Pentax 645 with a 300-mm lens and electronic flash.
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