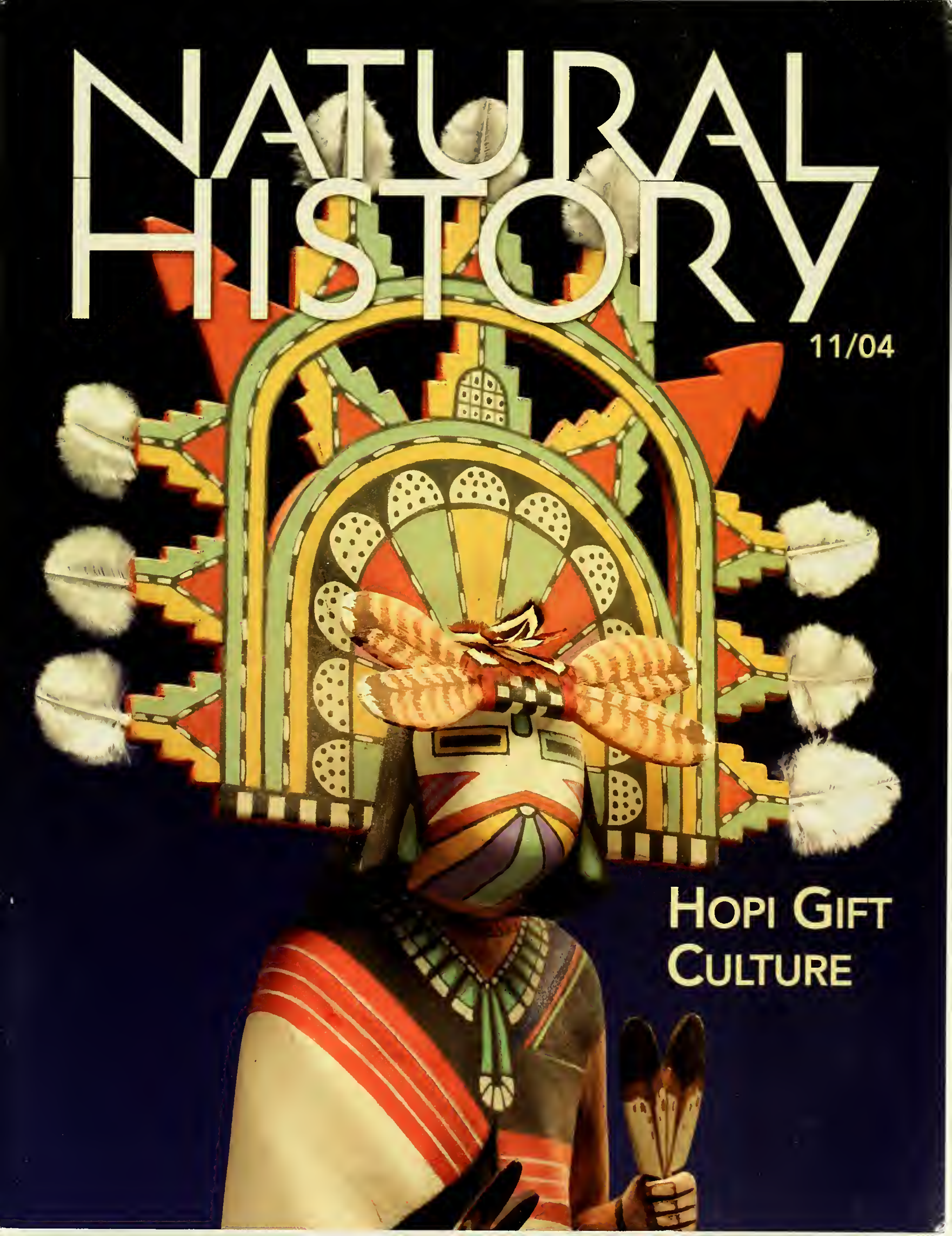
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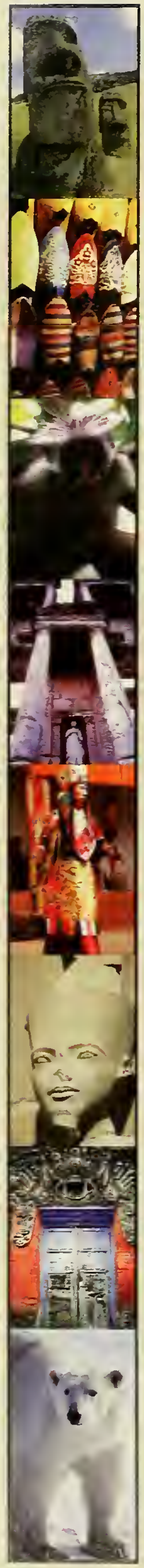

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■ The Russian White Sea Aboard *Hanseatic*
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■ Arctic Spitzbergen, Iceland & Greenland Aboard *Hanseatic* August 9–25, 2005

■ The Kimberly: An Adventure in the Australian Outback

■ Roy Chapman Andrews' Mongolia
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■ Safari Sketching in Southern Africa & Namibia
August 25–September 7, 2005

SEPTEMBER

■ Lost Cities of Central Asia: Archaeology in Uzbekistan & Turkmenistan — September 1–16, 2005

■ The Fossil Trail: Dinosaurs & Human Origins by Private Jet — September 3–24, 2005

■ Papua New Guinea & Australia: The Cultural Wonders of Australasia — September 4–19, 2005

■ The Viking Trail: Iceland, Greenland, Labrador & Newfoundland Aboard *Polar Star* — September 6–24, 2005

■ China & the Yangtze River Aboard *President*
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■ Villages & Empires of Hungary & Romania
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■ Newfoundland & Nova Scotia: From St. John's to Halifax Aboard *Polar Star* — September 22 – October 5, 2005

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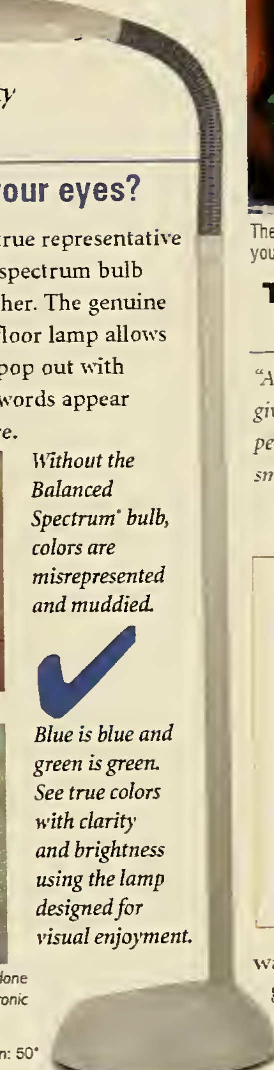

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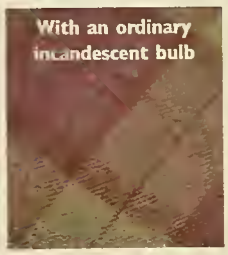

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NATURAL HISTORY

NOVEMBER 2004 VOLUME 113 NUMBER 9

FEATURES

ON THE COVER: Hopi *Katsina*
Photograph by Craig Chesek

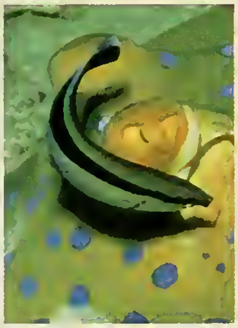
NATURAL HISTORY

DEPARTMENTS

6

44

46



14

64

51

22

PICTURE CREDITS: Page 10

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On the coast of Argentina, a unique collection of animal footprints made 12,000 years ago has been discovered. Paleontologist Teresa Manera de Bianco is battling technical challenges, rising sea levels and the inroads of thousands of tourists to protect the site for long enough to preserve the footprints in latex casts. She is one of the 2004 Laureates – five men and women whose groundbreaking endeavors have been selected by a panel of distinguished judges for their potential to expand human knowledge or improve the lot of mankind.

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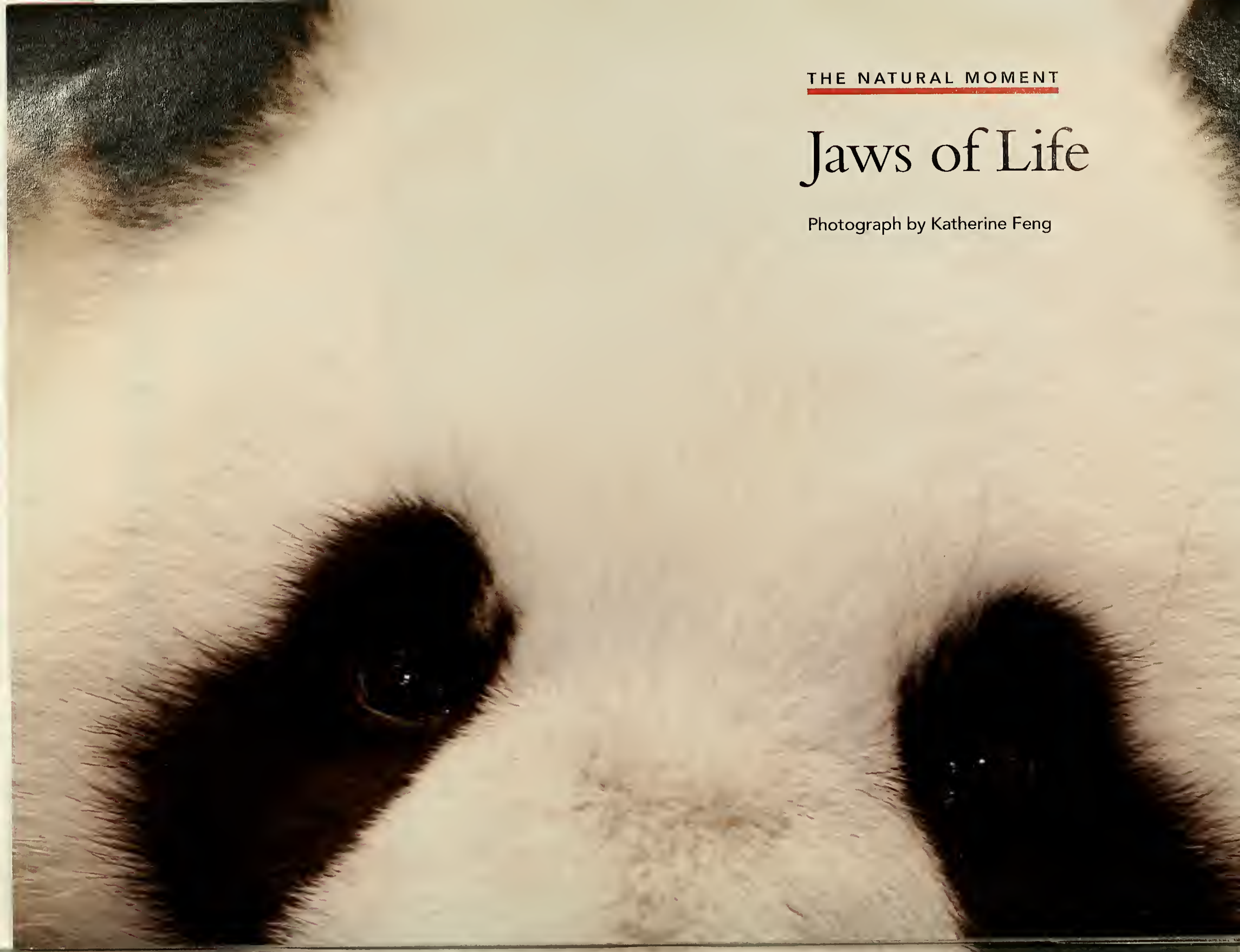
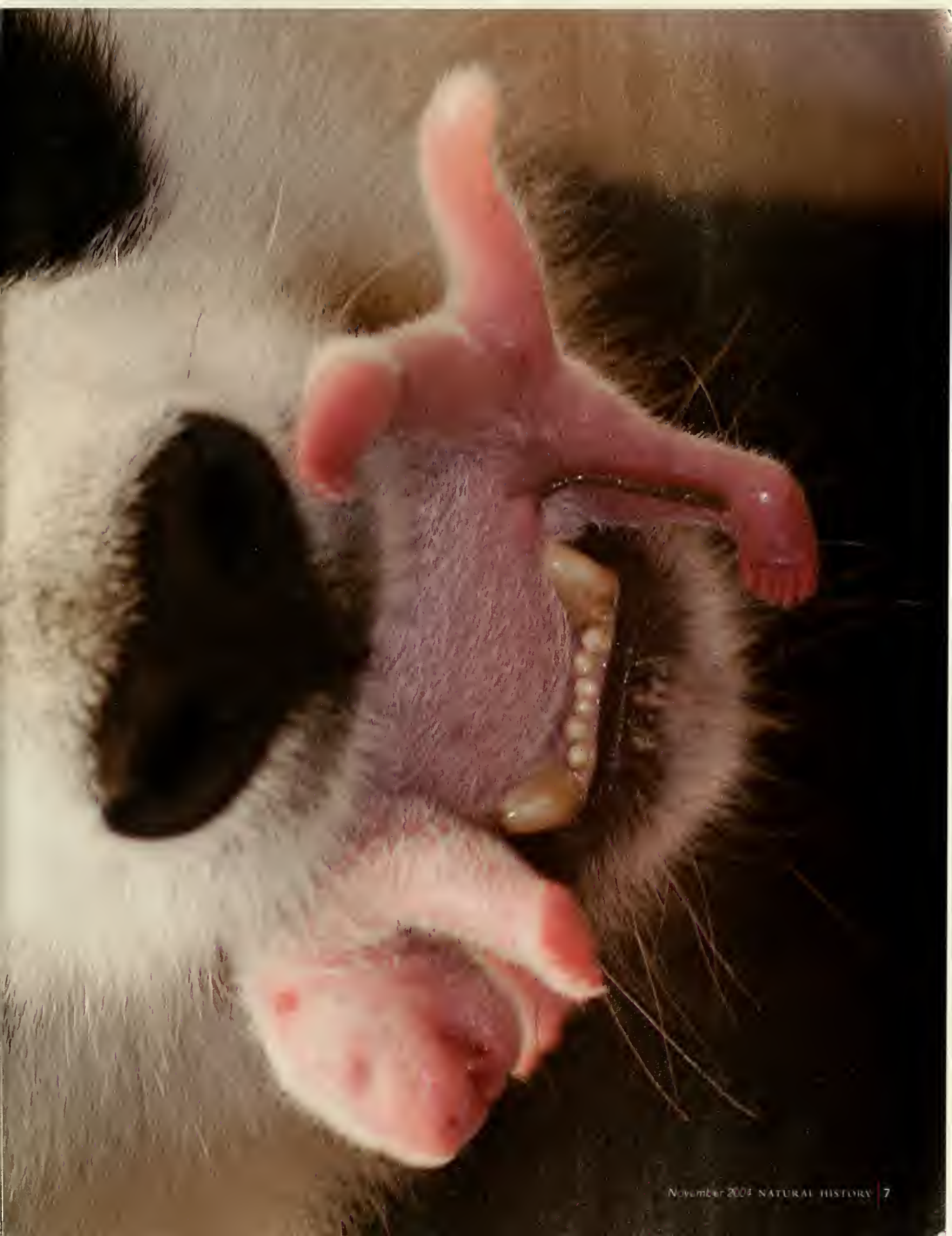
THE NATURAL MOMENT

Jaws of Life

Photograph by Katherine Feng





THE NATURAL MOMENT

See preceding two pages

Newborn giant pandas *(Ailuropoda melanoleuca)* emerge blind and achingly pink, looking as if they could use a few more weeks in the womb. One baby cub, named Ya Ao, is pictured on the preceding two pages with his mother, Gongzhu. Ya Ao was born this past August at the Wolong Nature Reserve in China's Sichuan province. Beyond Wolong's walls, the world's last remaining wild pandas—numbering 1,590, according to a June 2004 census—eke out a living in the dwindling bamboo forests of central China.

A giant panda's life, in or out of captivity, isn't easy. At centers like Wolong, though, the life has vastly improved. Gongzhu got much-needed help last year when she rejected her first cubs at birth. Staff members raised the twin cubs in incubators while Gongzhu practiced with a cub doll and watched videos *(above)* of a properly maternal panda.

The second time around, Gongzhu needed no prompting. Photographer Katherine Feng made her striking close-up of Gongzhu holding Ya Ao in her mouth when the cub was just eight hours old and eight inches long—and still sporting his stringy umbilical cord (not to be confused with his tail)! Ya Ao is now starting to push himself around on his belly—not quite crawling—under Gongzhu's watchful eye. By next May, the healthy cub should taste his first solid shoot of bamboo.

—*Erin Espelie*

UP FRONT

Talking Points

With two children, two cats, and a dog living in a small apartment, all yammering for our attention, my wife and I don't have any trouble believing that animals can communicate. "Scratch my neck," is hard to miss when your cat nuzzles his head against your forearm. "I want to go for a walk" is impossible to ignore when your dog puts a cold, wet nose under your hands and lifts repeatedly. Stephen R. Anderson understands all that: he too, confesses to owning a cat. His only complaint, in "A Telling Difference" (page 38) is that too many people want to go way beyond all that, and insist that animals have—or could have—language, with the same infinite capacity for expression as we do.

Of course, he's fighting an uphill battle. My guess is that most people who read newspapers or watch TV (that is, almost all of us), but have no scholarly connection with language, assume that the capacity for—if not the reality of—language in at least some animals is settled science. In fact, the science leans quite the other way. The bugbear for bugs and bears and every other species except you-know-who seems to be syntax, the structural principles that keep a sentence from being a mere list of words. For some reason, syntax has remained beyond the reach of nonhuman animals, even beyond those clever dogs and apes that, of late, have become icons for those who want to believe, as Anderson puts it, that Doctor Dolittle was right.

• • •

Intercultural communication, or lack thereof, goes to the heart of today's debates about whether the conflicts between Muslim-majority states and the West are an unavoidable "clash of civilizations." The high stakes of such a clash make it relevant to recall earlier epochs of deep cultural misunderstanding. In the mid-nineteenth century, the Hopi people, threatened by neighbors such as the Navajo, and hoping for preemptive intervention by the fledgling government of the United States, sent a delegation to Washington. The emissaries brought with them a packet that combined gift, message, and magic into what must have been, to the Millard Fillmore administration, a bizarre collection of feathers, sticks, string, and other odds and ends. Needless to say, the intended political alliance never jelled, and today's Hopi live on a fraction of their ancestral lands.

The story had been all but forgotten, even by the Hopi themselves, until Peter M. Whiteley, a curator of anthropology at the American Museum of Natural History, began investigating the episode. What light could it shed, Whiteley wondered, on the idea of gift giving among the many societies that invest great significance in such exchange? Meanwhile, the museum has assembled a breathtaking collection of the beautiful, hand-worked objects that represent what Whiteley calls the "Ties That Bind" (page 28). An exhibition of those objects, "Totems to Turquoise: Native North American Jewelry Arts of the Northwest and Southwest," opens at the museum on October 30 and runs through July 10, 2005.

—Peter Brown

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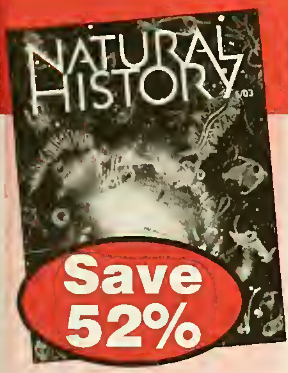

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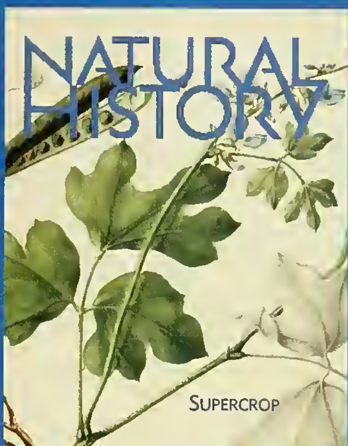

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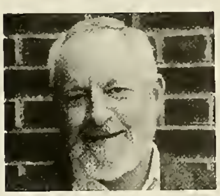

Anderson

KATHERINE FENG ("The Natural Moment," page 6), a veterinarian by training, is the first China Projects Specialist for GLOBIO, a nonprofit organization dedicated to educating children about global biodiversity through such projects as wildlife documentaries. With more than twenty years' experience working with animals, Feng is well known for her remarkable photographic images of the giant panda.

A curator in the Division of Anthropology at the American Museum of Natural History, **PETER M. WHITELEY** ("Ties That Bind," page 26) also teaches anthropology at Columbia University and at the Graduate Center of the City University of New York. His doctoral degree, from the University of New Mexico in Albuquerque, was based on fieldwork with the Hopi in the U.S. Southwest. He is the author of several books on Hopi culture and history, including *Rethinking Hopi Ethnography* (Smithsonian Institution Press, 1998), which won the 1999 Border Regional Library Association's Southwest Book Award.

LAWRENCE A. TABAK ("Mouth to Mouth," page 32) says the subject that has occupied most of his research career—the functioning of salivary proteins—has been intellectually stimulating, though something of a conversation-stopper at parties. (His young son, however, has no difficulty describing his father's profession: "My Dad is a spit guy," he says.) The elder Tabak is director of the National Institute of Dental and Craniofacial Research (NIDCR), at the National Institutes of Health in Bethesda, Maryland. **ROBERT KUSKA** is a science writer at NIDCR, and, like Tabak, an avid sports fan. His first book, *Hot Potato: How Washington and New York Gave Birth to Black Basketball and Changed America's Game Forever,* was published in June by the University of Virginia Press.

A professor at Yale University, **STEPHEN R. ANDERSON** ("A Telling Difference," page 38) studies how linguistics can be related to modern investigations of the nature of mind. He also does research on a variety of languages, including the Surmiran form of Rumantsch, a Romance language spoken in Switzerland. At a recent meeting of the American Association for the Advancement of Science, of which he is a Fellow, Anderson organized a symposium that applied linguistics and neurophysiology to the language used in describing wine. His article in this issue is based on his book *Doctor Dolittle's Delusion: Animals and the Uniqueness of Human Language,* which is being published this month by Yale University Press.

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Seeing Red

In their article "How Plants 'See'" (9/04), Marcelo J. Yanovsky and Jorge J. Casal report that grass plants can sense and respond to varying ratios of red to far-red light. To a plant, higher ratios signal that few other plants grow in the vicinity; the plant responds by producing more shoots than it would in a more populous neighborhood. But have the investigators expanded their experiments by shining supplemental red lights on only one side of a plant, to see if it would send out shoots on that side only?

Also, it is known that plants respond to information in pheromones. Has anyone tried to determine whether plants respond to sound, as well?

Daniel Smith
Cedar Rapids, Iowa

MARCELO J. YANOVSKY AND JORGE J. CASAL REPLY: In our experiments, we found no obvious indication that grasses produce fewer shoots in the direction of light with a relatively low red-to-far-red ratio (which is indicative of neighbors). Nevertheless, Ariel Novoplansky of Ben-Gurion University of the Negev in Israel reported several years ago that the purslane plant *(Portulaca oleracea)* avoids sprouting shoots towards plastic objects that reflect light with a low red-to-far-red ratio.

Whether plants interact with their neighbors via senses other than sight is still controversial. There is good evidence in the laboratory that plants can "smell" volatile signals from neighbors under attack by insects. It is still being debated whether this capability plays an important role in plant-to-plant communication under natural conditions, where the concentration of volatile signals could be much lower than the ones in the laboratory.

The evidence in favor of biologically meaningful responses by plants to sound is weak.

One of the illustrations in Messrs. Yanovsky and Casal's fine article is good art but bad science. On page 37 the root system of a tree is shown as the mirror image of its canopy, extending only as far and wide into the earth as the canopy does into the sky. In reality, tree roots extend far wider than the canopy does and lie mostly near the surface, where nutrients and favorable conditions are more readily available.

Earle W. Cummings
Geyserville, California

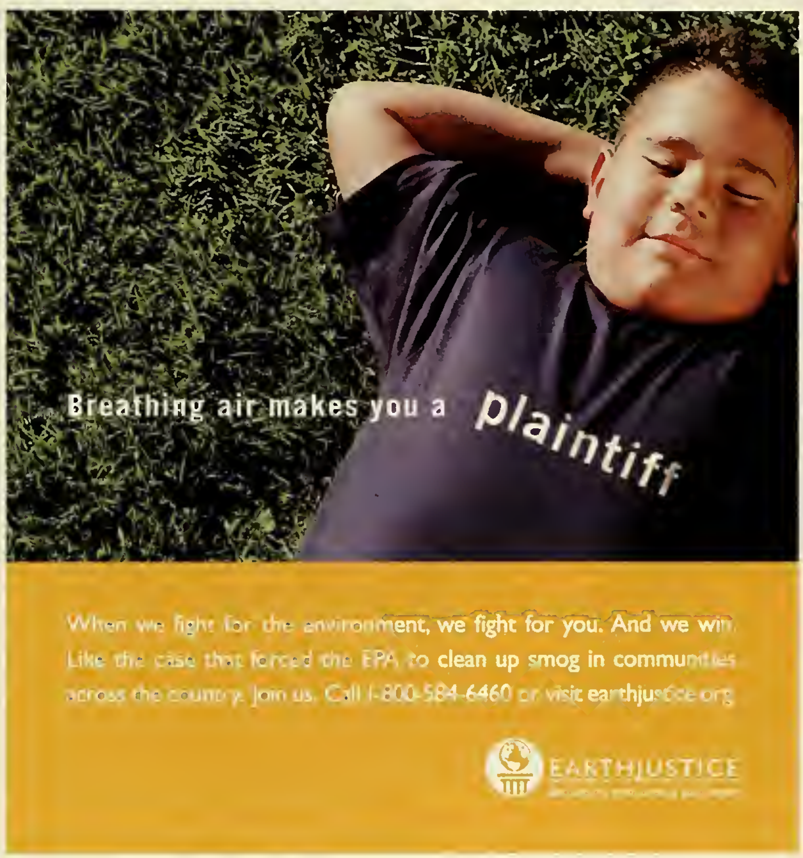
Round About

The numerous craters on asteroids Eros and 243 Ida, shown in the photographs illustrating Neil deGrasse Tyson's recent "Universe" column ("Vagabonds in Space," 7–8/04), point to a tremendous bombardment in the remote past. As a geologist, I am also struck by the asteroids' rounded shapes; one might expect, if they originated from a cooled planet or a larger asteroid, to see sheer faces and angular edges. Or were the fragments molten at the time of the breakup?

Duncan Goldthwaite
Metairie, Louisiana

NEIL DEGRASSE TYSON REPLIES: The absence of sharp, angular features on what are surely fragments of once-larger bodies cannot be entirely credited to local melting at the site of impact. Asteroids owe much of their roundness to the slow and steady erosion caused by collisions with tiny meteoroids, whose collective influence is much like that of sandblasting. Furthermore, all the dust resettles, filling in the low-lying areas on the surface. After a few billion years of this, you can't help looking like a potato.

Natural History *welcomes correspondence from readers. Please send e-mail to* nhmag@naturalhistorymag.com *All letters should include a daytime telephone number, and all letters may be edited for length and clarity.*



Whence the Dingo

The first Europeans to set foot in Australia found scads of odd-looking marsupials, but no placental mammals other than rodents, bats, and the dingo. An independent-minded, wild-living canid, the dingo physically resembles the pariah dog of India, also a feral canid. The islands of Southeast Asia, however, are much closer to Australia than India is, and populations of other feral dogs live there, too. So, did the dingo come from India or not?

Peter Savolainen, a molecular biologist at the Royal Institute of Technology in Stockholm, and his colleagues say no. They compared the mitochondrial DNA (mtDNA) of a large number of dingoes, from every state in Australia, with that of dogs and wolves around the world. A single mtDNA type, called A29, showed up in more than half the dingoes and only in dogs from East Asia and arctic North America. The mtDNA of all the rest of the dingoes differed from A29 by just one base pair, which could easily be the result of a mutation.

Based on the rate of change of mtDNA, the investigators propose the following scenario: Domesticated dogs accompanied people as they emigrated from southern China to islands in Southeast Asia about 5,000 years ago. The descendants of both reached Timor, New Guinea, and Australia by about 3,500 years ago. The dogs then reverted to a feral existence; the ones in Australia became dingoes. The small mtDNA variation among dingoes suggests that only a few dogs—perhaps just one pregnant female—survived the final ocean crossing that led to the colonization of Australia. ("A detailed picture of the origin of the Australian dingo, obtained from the study of mitochondrial DNA," *Proceedings of the National Academy of Sciences* 101:12387–90, August 17, 2004) —*S.R.*

Blackout Is Beautiful

Remember the blackout of August 2003, which shut down power plants across much of the northeastern United States and southeastern Canada? For one group of chemists and meteorologists, that was a matchless opportunity to directly measure, not merely estimate, the air pollution caused by the plants' burning of fossil fuels.

Lackson T. Marufu and his colleagues at the University of Maryland in College Park compared air samples taken over central Pennsylvania a mere twenty-four hours into the blackout, with samples taken earlier that day over unaffected Maryland, as well as samples collected in 2002 over the same spot in Pennsylvania under similar weather conditions. The investigators report that during the blackout, levels of airborne sulfur dioxide—a factor in respiratory illness, acid rain, and damage to architectural materials—dropped by more than 90 percent, and low-altitude ozone by about 50 percent. Haze and smog decreased drastically as well, extending visibility by more than twenty-five miles. Road traffic stayed about the same, as did the amounts of its typical pollutants. Apparently, fossil-fuel-burning power plants generate more pollution, relative to vehicles, than had been estimated. ("The 2003 North American electrical blackout: An accidental experiment in atmospheric chemistry," *Geophysical Research Letters* 31:L13106, July 15, 2004)

—*Stéphan Reebs*

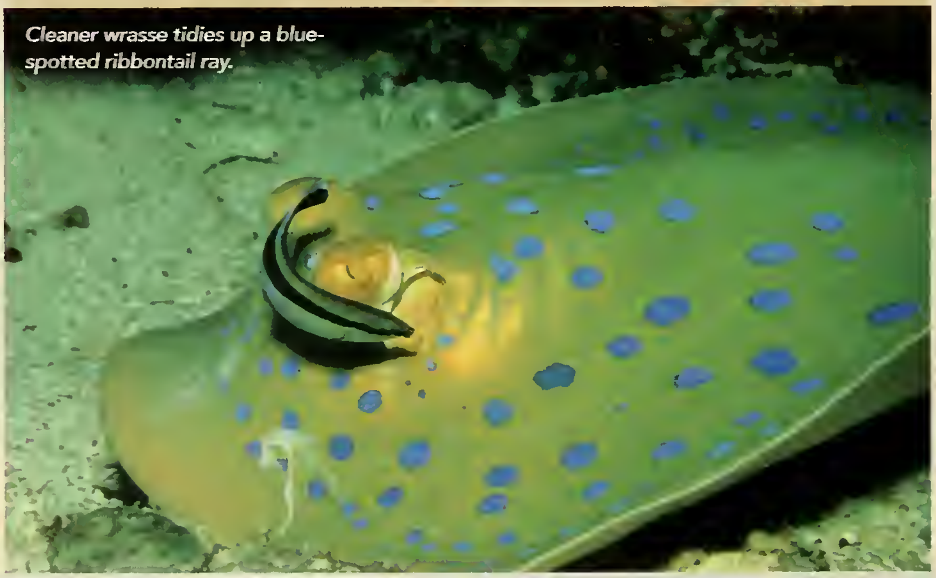
Hey There, Big Boy . . .

Imagine having to stick your head into the mouth of a lion in order to earn a living. Doubtless the first question that would spring to mind is, "When did this lion have its last meal?" Well, a small fish called the cleaner wrasse has much the same worry.

The wrasse, an inhabitant of the Indian and Pacific oceans, gets its dinner by plucking parasites off the bodies, and from inside the mouths, of "client" fishes. Some clients are large predators, so the three-inch-long wrasse presumably approaches them with some trepidation—and has presumably found ways to reduce the chances of getting eaten. Perhaps, thought Alexandra S. Grutter, a behavioral ecologist at the University of Queensland in Brisbane, Australia, cleaner wrasses can distinguish a hungry client from a satiated one, and tailor their behavior accordingly.

Grutter created encounters between cleaner wrasses and predatory coral trout in an aquarium and noted the results. Faced with a coral trout that had not been fed for several days, the wrasses oscillated a few inches to the side of the trout's body, albeit rarely near the tail and never near the mouth. Sometimes the wrasses even touched the predator in a gently stimulating way. Around satiated clients, however, the wrasses oscillated less often. The oscillations may gingerly test the hungry client's true intentions, or help ward off the predator's natural aggression before it can experience the presumably pleasant feeling of being cleaned. ("Cleaner fish use tactile dancing behaviour as a pre-conflict management strategy," *Current Biology* 14:1080–83, June 22, 2004)

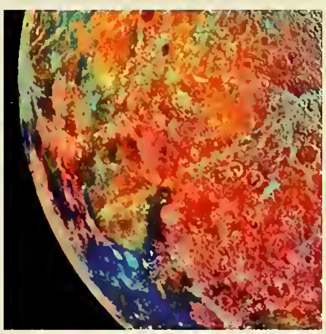
—*S.R.*



Cleaner wrasse tidies up a blue-spotted ribbontail ray.

Lost Planets on the Moon

Since the mid-1960s, geologists have known that lunar chemistry is controlled, in part, by the Sun. Our star constantly spews streams of ionized elements, known as solar wind, which bombard the surface of the Moon. Those bombardments explain why certain elements occur in near-surface lunar rocks at roughly the same proportions as occur in the Sun.



One notable exception is the element xenon: lunar concentrations of some of its isotopes are well above the accepted solar estimates. The prevailing explanation has been that orphan, or excess, xenon gas formed deep within the Moon and then slowly escaped to the surface. But that didn't smell right to Minoru Ozima, a geochemist at the University of Tokyo, and his colleagues. All the isotopes of xenon occur on the Moon, but some of them—the ones that form through the decay of relatively short-lived iodine and plutonium isotopes—are present in greater-than-normal concentrations. If those xenon isotopes escaped from within the Moon, they must have remained inside for several hundred million years before being evenly released to the lunar surface. To Ozima and his co-workers, that explanation for the excess xenon seems highly unlikely.

Xenon produced from plutonium and iodine occurs at greater relative concentrations inside the planets than it does inside the Sun. The investigators speculate that if, early in the tumultuous history of the solar system, numerous rocky planetesimals were absorbed by the Sun, the Sun's outer layers would have been enriched with that kind of xenon. The xenon could then have blown onto the Moon, along with the solar wind. ("Orphan radiogenic noble gases in lunar breccias: Evidence for planet pollution of the Sun?" *Icarus* 170:17–23, July 2004)

—*Dave Forest*

The Prehistory of Housekeeping

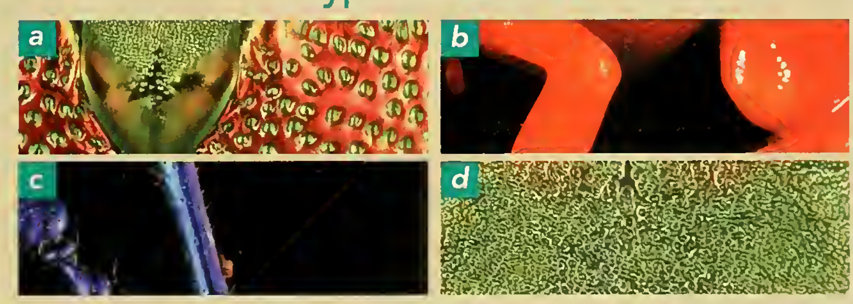
Future archaeologists, we're often told, will be able to deduce a lot about us by looking at the contents of our garbage dumps. Contemporary investigators have taken almost the same approach to Wadi Hammeh 27, a 12,000-year-old site in the Jordan Valley. The big difference is that Wadi Hammeh 27 didn't actually have a garbage dump: it dates to an era before people acquired the habit of ridding their houses of trash.

Between about 13,000 and 9,000 years ago in the ancient Middle East, formerly mobile hunter-gatherers began to settle down for at least part of the year, as they turned increasingly to farming and to living in villages. By about 8000 B.C., their descendants generally lived in permanent settlements whose dwellings show evidence of housekeeping: floors that were regularly swept, and debris jettisoned in the lanes between houses.

At Wadi Hammeh 27, Tania Hardy-Smith and Phillip C. Edwards, both archaeologists at La Trobe University in Melbourne, Australia, examined the prodigious quantities of stuff the occupants had left strewn all over the insides of the huts: bones of butchered (and thus eaten) animals, burnt human skulls, flakes of debris left by tool making. Some usable tools and ornaments were stashed near the walls, possibly in now-vanished containers; only one little heap of detritus was placed outside a dwelling. Hardy-Smith and Edwards conclude that the site was seasonal, not permanent, and that its occupants thus hadn't felt compelled to dump their garbage, a practice most sedentary cultures (except, perhaps, Teenage Modern) regard as indispensable. ("The garbage crisis in prehistory: Artefact discard patterns at the Early Natufian site of Wadi Hammeh 27 and the origins of household refuse disposal strategies," *Journal of Anthropological Archaeology* 23:253–89, September 2004)

—*S.R.*

Cryptic Creatures



Only three of these pictures are close-ups of the same animal. Which one doesn't belong?

(Answer on page 20)

Fly or financier, every animal needs some resident bacteria.

Let the Germs In

If a pregnant woman could wave a magic wand to ensure that her soon-to-be-born child would never have contact with bacteria, should she do it? Probably not.

Ted Brummel, a biologist at Sam Houston State University in Huntsville, Texas, and several colleagues found that when fruit flies were raised in a permanently germ-free environment, and given only food that was irradiated or laced with antibiotics, their life spans were more than 30 percent shorter than the life spans of flies raised under nonsterile conditions. The investigators also discovered that the first four to seven days after metamorphosis are critical to longevity: exposure to bacteria for those few days alone is excellent insurance against an early death.

What the pregnant woman should consider is that resident bacteria are necessary for normal digestion in virtually all animals, including people. In addition, such bacteria help the immune system distinguish the benign from the dangerous. ("*Drosophila* lifespan enhancement by exogenous bacteria," *Proceedings of the National Academy of Sciences* 101: 12974–79, August 31, 2004) —*S.R.*

SAMPLINGS

Ups and Downs

It's amazing how much information you can get from the inside of an old tree. When porcupines eat the inner bark of jack pine trees during the harsh Quebec winter, they leave long-lasting, oval "feeding scars" in the trees' growth rings. Ilya Klvana, an ecologist at the University of Quebec at Rimouski, and his colleagues surveyed the feeding scars within a fifty-acre area, noting the year each scar was made and the variations in the number of scars for each year since 1868. Those data enabled the investigators to compile a 133-year record of porcupine populations in the forests of eastern Quebec, where porcupines are the dominant vertebrate plant-eaters.

Peeping porcupine

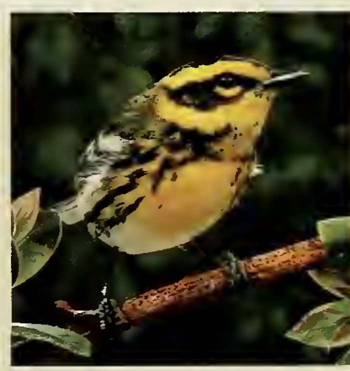
And guess what? Porcupine numbers have been following a regular pattern that closely tracks the cycles of solar activity. Every eleven years or so, while undergoing its periodic bout of severe magnetic turbulence, the Sun shoots out radiant energy and erupts in a bad case of sunspots. Given the Sun's starring role in Earth's climatic drama, and given the population fluctuations of many organisms, ecologists have long sought persuasive evidence of a correlation between the cycles of the Sun and those of terrestrial populations. Klvana and his colleagues seem to have come up with the goods.

The investigators propose that, as with the periodic climatic disturbance known as El Niño, solar activity might be acting as an "environmental pacemaker," giving rise to cyclic changes that ripple through seasonal precipitation and temperatures, herbivore populations, plants, and, ultimately, entire ecosystems. ("Porcupine feeding scars and climatic data show ecosystem effects of the solar cycle," *The American Naturalist* 164:283–97, September 2004) —*Nick W. Atkinson*

Cold Fission

Zoologists of late have been debating whether many new vertebrate species evolved at the time of the last ice age—the Pleistocene epoch, between 2 million and 10,000 years ago. According to the standard view, the advances and retreats of the ice sheets, and the global cooling trends that accompanied them, caused habitats to become fragmented and populations to be isolated—conditions that typically foster the emergence of new species. Yet most studies, done on faunas that lived south of the ice itself, showed no proliferation of species. Now, by examining birds whose ancestors actually inhabited the icebound regions, Jason T. Weir and Dolph Schluter, both evolutionary biologists at the University of British Columbia in Vancouver, have gathered some strong new support for the old view.

The investigators selected pairs of closely related bird species from the Americas and measured how much the DNA of one species in each pair differed from the DNA of the other species. Those data enabled Weir and Schluter to calculate when each member of the pair branched off along its own path to specieshood. The calculations show that every one of the closely related species now living in boreal (northern coniferous) forests originated during the Pleistocene. By contrast, only about half the paired bird species now living in sub-boreal climes split from each other during that epoch (the other half have more ancient origins). Where glaciation was more intense, the authors suggest, selective pressures were greater and the populations more isolated: a surefire formula for speciation. ("Ice sheets promote speciation in boreal birds," *Proceedings of the Royal Society of London* B 271:1881–87, September 22, 2004) —*S.R.*



Female Townsend's warbler

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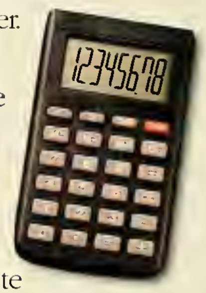

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The Importance of Being Constant

The fundamental things apply . . . as time goes by.

By Neil deGrasse Tyson

Rimma Gerlovina and Valeriy Gerlovin, π, 1991

Mention the word "constant," and your listeners may think of matrimonial fidelity or financial stability—or maybe they'll declare that change is the only constant in life. As it happens, the universe has its own constants, in the form of unvarying quantities that endlessly reappear in nature and in mathematics, and whose exact numerical values are of signal importance to the pursuit of science. Some of these constants are physical, grounded in actual measurements. Others, though they illuminate the workings of the universe, are purely numerical, arising from within mathematics itself.

Some constants are local and limited, applicable in just one context, one object, or one subgroup. Others are fundamental and universal, relevant to space, time, matter, and energy everywhere—thereby granting investigators the power to understand and predict the past, present, and future of the universe. Scientists know of only a few fundamental constants. The top three on most people's lists are the speed of light in a vacuum, Newton's gravitational constant, and Planck's constant, the foundation of quantum mechanics and the key to Heisenberg's infamous uncertainty principle. Other universal constants include the charge and mass of each of the fundamental subatomic particles.

Whenever a repeating pattern of cause and effect shows up in the universe, there's probably a constant at work. But to measure cause and effect, you must sift through what is and is not variable, and you must ensure that a simple correlation, however tempting it may be, is not mistaken for a cause. In the 1990s the stork population of Germany increased, and the German at-home birth rate rose as well. Shall we credit storks for airlifting the babies? I don't think so.

But once you're certain that the constant exists, and you've measured its value, you can make predictions about places and things and phenomena yet to be discovered or imagined.

Johannes Kepler, a German mathematician and occasional mystic, made the first-ever discovery of an unchanging physical quantity in the universe. In 1618, after a decade of engaging in mystical drivel, Kepler figured out that if you square the time it takes a planet to go around the Sun, then that quantity is always proportional to the cube of the planet's average distance from the Sun. Turns out, this amazing relation holds not only for each planet in our solar system, but also for each star in orbit around the center of its galaxy, and for each galaxy in orbit around the center of its galactic cluster. As you might suspect, though, unbeknownst to Kepler, a constant was at work: Newton's gravitational constant lurked within Kepler's formulas, not to be revealed as such for another seventy years.

Probably the first constant you learned in school was pi—a mathematical constant denoted, since the early eighteenth century, by the Greek letter π. Pi is, quite simply, the ratio of the circumference of a circle to its diameter. In other words, pi is the multiplier if you want to go from a circle's diameter to its circumference. Pi also pops up in plenty of other places, including the areas of circles and ellipses, the volumes of certain solids, the motions of pendulums, the vibrations of strings, and electrical circuits.

Not a whole number, pi instead has an unlimited succession of nonrepeating decimal digits; when truncated to include every Arabic numeral, pi looks like 3.14159265358 979323846264338327950. No matter when or where you live, no matter your nationality or age or aesthetic proclivities, no matter whether you vote Democrat or Republican, if you calculate the value of pi you will get the same answer as everybody else in the universe. Thus constants such as pi enjoy a level of internationality that politics does not, never did, and never will—which is why, if people ever do communicate with aliens, they're likely to talk in mathematics, the lingua franca of the cosmos, and not English.

Because pi is an "irrational" number, you can't represent it as a fraction made up of two whole numbers—2/3 or 18/11, for instance. But the earliest mathematicians, who had no clue about the existence of irrational numbers, didn't get much beyond representing it as 25/8 (the Babylonians, about 2000 B.C.) or 256/81 (the Egyptians, about 1650 B.C.). Then, in about 250 B.C., the Greek mathematician Archimedes—by engaging in a laborious geometric exercise—came up with not one fraction but two, 223/71 and 22/7. Archimedes realized that the exact value of pi, a value he himself did not claim to have found, had to lie somewhere in between.

Given the progress of the day, a rather poor estimate of pi also appears in the Bible, in a passage describing the furnishings of King Solomon's temple: "a molten sea, ten cubits from the one brim to the other: it was round all about . . . and a line of thirty cubits did compass it round about" (1 Kings 7:23). That is, the diameter was ten units, and the circumference thirty, which can only be true if pi were equal to 3. Three millennia later, in 1897, the lower house of the Indiana State Legislature passed a bill announcing that, henceforth in the Hoosier state, "the ratio of the diameter and circumference is as five-fourths to four"—in other words, exactly 3.2.

Decimal-challenged lawmakers notwithstanding, the greatest mathematicians—including Muhammad ibn Musa al-Khwarizmi, a ninth-century Iraqi whose name lives on in the word "algorithm," and even Newton—steadily labored to increase the precision of pi. The advent of electronic computers, of course, blew the roof right off that exercise. As of the early twenty-first century, the number of known digits of pi has passed the one-trillion mark, surpassing any physical application except the study by people of whether or not the sequence of numerals will ever look random.

In 1897 the lower house of the Indiana legislature declared that pi is 3.2.

Of far more importance than Newton's contribution to the calculation of pi are his three universal laws of motion and his single universal law of gravitation. All four laws were first presented in his masterwork, *Philosophiæ Naturalis Principia Mathematica*, or the *Principia*, for short, published in 1687.

Before Newton published the *Principia*, scientists (concerned with what was then called mechanics, and later called physics) would simply describe what they saw, and hope that the next time around it would happen the same way. But armed with Newton's laws of motion, they could describe the relations among force, mass, and acceleration under all conditions. Predictability had entered science. Predictability had entered life.

Unlike his first and third laws, Newton's second law of motion is an equation: $F = ma$. Translated into English, that means a net force (F) applied to an object of a given mass (m) will result in the acceleration (a) of that object. In even plainer English, a big force yields a big acceleration. And they change in lockstep: double the force on an object, and you double its acceleration. The object's mass serves as the equation's constant, enabling you to calculate exactly how much acceleration you can expect from a given force.

But suppose an object's mass is not constant? Launch a rocket, and its mass drops continuously until the fuel tanks run out of fuel. And now, just for grins, suppose the mass changes even though you neither add nor subtract material from the object. That's what happens in Einstein's special theory of relativity. In the Newtonian universe, every object has a mass that is always and forever its mass. In the Einsteinian, relativistic universe, by

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contrast, objects have an unchanging "rest mass" (the same as the "mass" in Newton's equations), to which you add more mass according to the object's speed. What's going on is that as you accelerate an object in Einstein's universe, its resistance to that acceleration increases, showing up in the equation as an increase in the object's mass. Newton could not have known about these "relativistic" effects, because they become significant only at speeds comparable to the speed of light. To Einstein, they meant some other constant was at work: the speed of light, a subject worthy of its own essay at another time.

As is true for many physical laws, Newton's laws of motion are plain and simple. His universal law of gravitation is somewhat more complicated. It declares that the strength of the gravitational attraction between two objects—whether between an airborne cannonball and Earth, or the Moon and Earth, or two atoms, or two galaxies—depends only on the two masses and the distance between them. More precisely, the force of gravity is directly proportional to the mass of one object times the mass of the other, and inversely proportional to the square of the distance between them. Those proportionalities give deep insight into how nature works: if the strength of the gravitational attraction between two bodies happens to be some force F at one distance, it becomes one-fourth F at double the distance and one-ninth F when the distance is tripled.

But that information by itself is not enough to calculate the exact values of the forces at work. For that, the relation requires a constant—in this case, a term known as the gravitational constant, labeled G, or, among people on the friendliest terms with the equation, "big G."

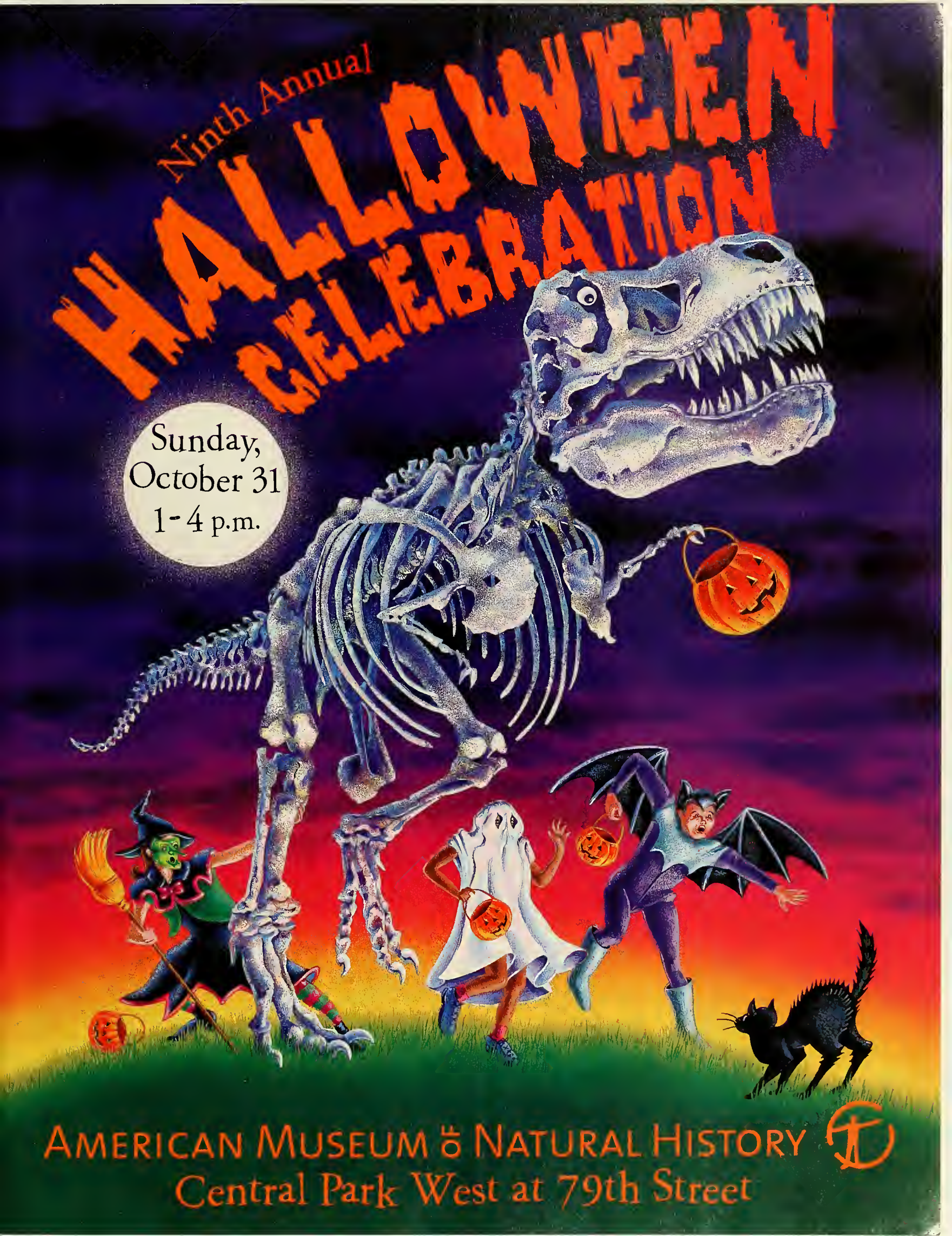
Recognizing the correspondence between distance and mass was one of Newton's many brilliant insights, but Newton had no way to measure the value of G. To do so, he would have had to know everything else in the equation, leaving G fully determined. In Newton's day, however, you could not know the whole equation. Although you could easily measure the mass of two cannonballs and their distance from each other, their mutual force of gravity would be so small that no available apparatus could have detected it. You could easily measure the force of gravity between Earth and a cannonball, but you had no way to measure the mass of the Earth itself. Not until 1798, more than a century after the *Principia,* did the English chemist and physicist Henry Cavendish come up with a reliable measure of G.

To make his now-famous measurement, Cavendish used an apparatus whose central feature was a dumbbell, made with a pair of two-inch-diameter lead balls. A thin, vertical wire suspended the dumbbell from its middle, allowing the apparatus to twist back and forth. Cavendish enclosed the entire gizmo in an airtight case, and placed two twelve-inch-diameter lead balls kitty-corner outside the case. The gravitational pull of the outside balls would tug on the dumbbell and twist the wire from which it was suspended. Cavendish's best value for G was barely accurate to two decimal places at the end of a string of zeroes: in units of cubic meters per kilogram per second squared, the value was 0.000000000067.

Coming up with a good design for an apparatus wasn't exactly easy. Gravity is such a weak force that practically anything, even gentle air currents within the case, could swamp gravity's signature in the experiment. In the late nineteenth century the Hungarian physicist Loránd Eötvös, using a new and improved Cavendish-type appara-

(Continued on page 24)

Answer to "Cryptic Creatures" puzzle (page 15): b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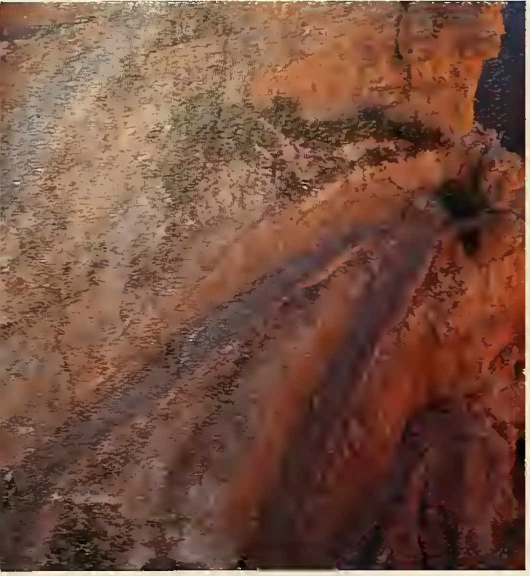


South Kaibab Trail, in Grand Canyon National Park, slopes at thirteen degrees.

BIOMECHANICS

The Biomechanist Went Over the Mountain

The best way up a hill is steeper than the best way down.

By Adam Summers ~ Illustration by Tom Moore

I turned forty recently. Of all the gifts I received, the most surprising and rewarding birthday present came from my wife: a three-day hike in the Sierra Nevada. My declaration of midlife vigor included a scamper up to 11,000 feet—a chance to go over a literal mountain rather than the metaphorical hill. But the thin air made me take plenty of time to rest on trailside rocks, which inevitably led the biomechanist in me to reflect on the mechanics of hill climbing.

It seemed that the steeper sections of the trail quickly exhausted my reserves, but that the less steep sections did not get me up the hill fast enough to make satisfactory progress. As it turns out, I'm not the first to have noticed this: studies of human locomotion—not to mention numberless hikers before me—have come to the same conclusion.

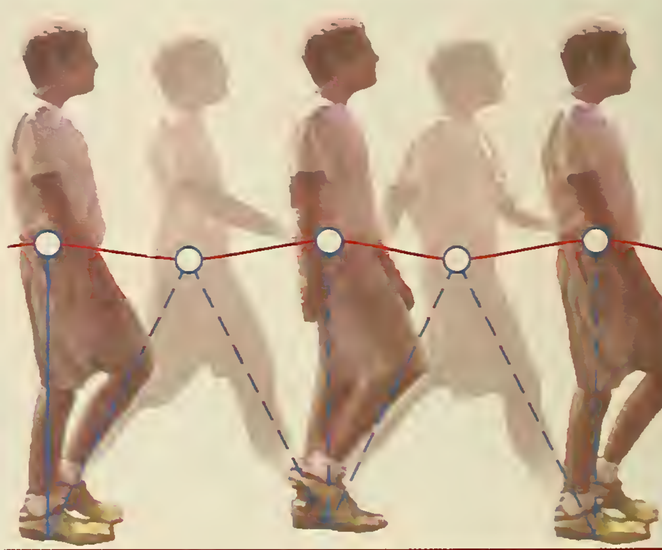
Some of the first serious investigations of human walking were done in the late 1930s by Rodolfo Margaria, an Italian physiologist, who measured its metabolic costs at various inclines. His data showed that the optimum grade was, unsurprisingly, downhill. At an incline of about minus ten degrees, roughly the same angle as the wheelchair-access ramp at many curbs, people use the least amount of oxygen to walk a given distance with their natural gait.

What may be surprising is that the energy expenditure isn't minimized at a steeper incline. After all, isn't it obvious that getting downhill faster should also be metabolically easier? Well, it's not, and the reason the ten-degree incline is the easiest lies in the mechanics of walking.

Walking is a cyclic movement, and in any cyclic movement there is the possibility of energy storage and reuse. Your center of gravity (which lies approximately two inches in front of the small of your back) rises and falls with each step. It is highest when one foot is planted firmly on the ground directly beneath you. Then it drops as your body swings forward with the next step and rises again as your other leg passes through the vertical. Each stride represents the sweep of an energy-saving, inverted pendulum.

Imagine that your center of gravity is a steel ball attached to a steel rod, which can represent your planted leg, because during that part of the cycle your knee hardly bends. Your planted foot is the pivot of the pendulum. If you trace the path of the steel ball through a stride, it follows the arc of a single sweep of a pendulum.

In a pendulum system the kinetic



Video sequences of a man walking (right) show the bobbing course of his center of gravity (white circle along red curve). As he walks on flat ground (near right), his center of mass acts like the mass at the end of an inverted pendulum (broken lines), storing some of the energy of motion of each step as the mass rises and releasing the energy as it falls. Some of the energy of motion remains available for subsequent steps as the slope he climbs increases to a five-degree angle (middle right), but all the energy is used up in finishing the current step when the angle is fifteen degrees (far right).

energy of the ball as it passes through the lowest part of its swing is traded for the gravitational potential energy of height as it rises to the top of its arc. As the ball falls, the potential energy is then converted back into kinetic energy. Your planted leg, because it acts as the radius of a circle, translates the downward force of gravity into a force pushing you forward. As you might expect, your forward speed is lowest when your planted leg is directly below your center of gravity, and highest when you are striding. At that moment, your forward leg, now planted, acts as the radius of a new circle and translates some of the momentum of your center of gravity into upward motion, preparing you for another gravity-aided step forward.

About 60 percent of the energy spent changing the altitude of a walker's center of gravity is conserved. Walking on a slight downhill grade adds energy to the system; that energy offsets some of the energy lost to heat generated in the muscles. (On steeper downhill grades the pendulum motion is lost. The cost of each step rises, though not by much.)

But what about uphill? Alberto E. Minetti, an Italian biomechanist at Manchester Metropolitan University in England (and featured twice before in this column), recast Margaria's data in real-world terms. Minetti noted that walkers don't usually choose the slope at which each step costs the least because they are usually glad to trade a quick gain in altitude for the cost of a little extra fatigue.

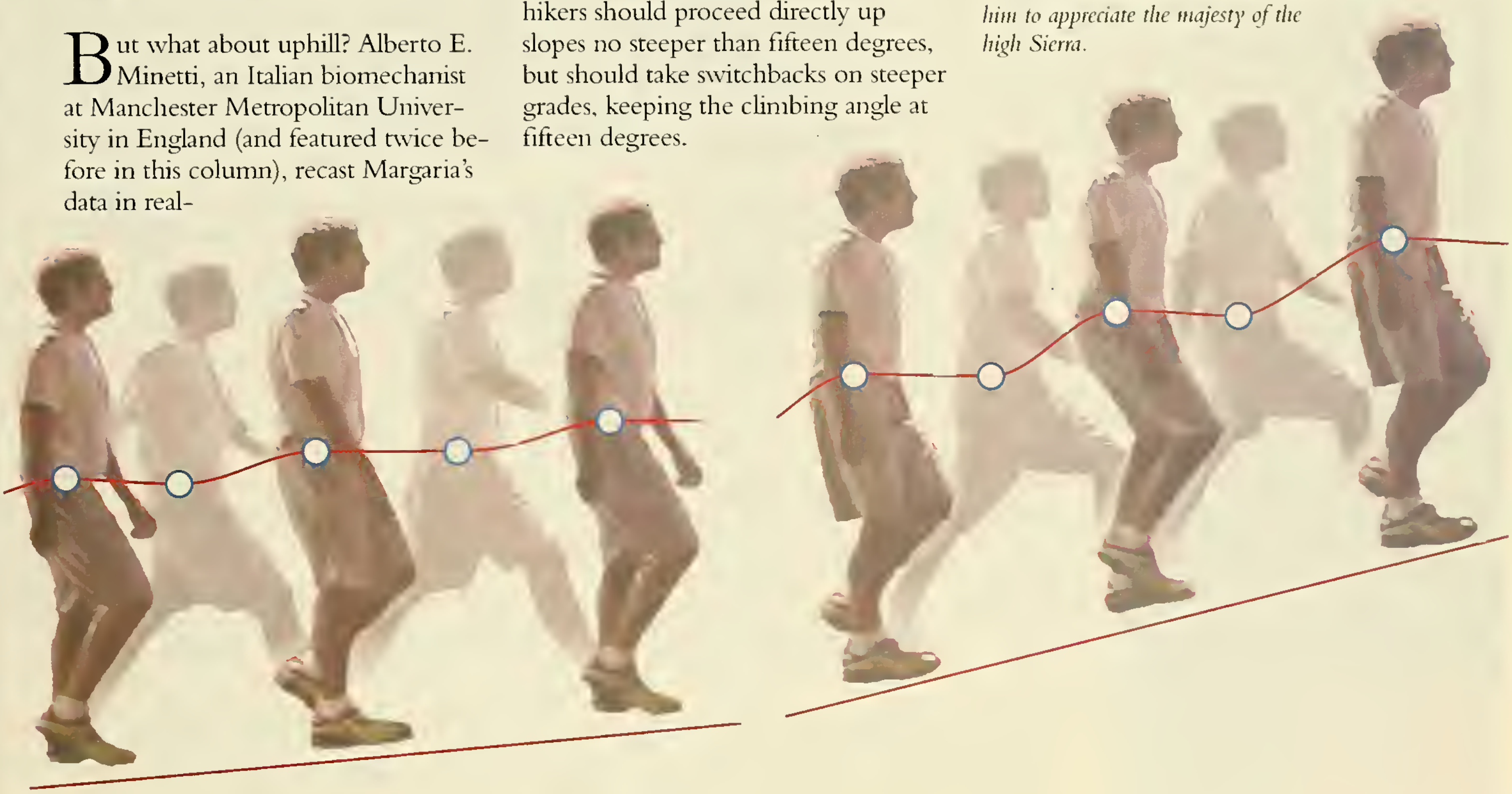
In my case, according to my topographic maps, I needed to climb 1,108 feet on the final push to the summit. The shortest route would be the "directissima"—a vertical ascent, much as a spider might do it. Such a route—because metabolic rate rises rapidly with increasing slope—would be hugely expensive. What about a gentler slope—say an angle of about five degrees? That grade would barely rise, but I would have to walk nearly two-and-a-half miles to gain those 1,100 feet. The net cost of taking the "easy" way would be high simply because I would have to walk so far to reach the summit.

Minetti discovered the best solution. When the slope of the route is about fifteen degrees, a rise of about a foot for every four feet of horizontal travel, the energy required to gain a certain altitude is minimized. Hence to minimize the energetic cost of climbing, hikers should proceed directly up slopes no steeper than fifteen degrees, but should take switchbacks on steeper grades, keeping the climbing angle at fifteen degrees.

Minetti's conclusion is borne out in a somewhat surprising and satisfying way: from data gleaned from topographic maps of trails connecting mountain towns, in mountain ranges from the Dolomites to the Himalaya. Sure enough, as I panted by the side of the trail in the Sierra Nevada, a Park Service sign informed me that the 1,100 foot climb to Twin Peaks would cover a mile, making an incline of about twelve degrees, near enough the optimum slope but emphatically not metabolically free.

It's nice to know that, metabolically, there is a best way to climb higher. But I think there's another practical implication of Margaria's and Minetti's work. If the best grade up is fifteen degrees, and the best grade down is only ten, the most efficient round trip can't take you down the same way you came up. So you get two hikes every time you climb a slope. That rule notwithstanding, the Park Service would prefer that you stick to the path.

ADAM SUMMERS (asummers@uci.edu) *is an assistant professor of ecology and evolutionary biology at the University of California, Irvine. He is deeply grateful to Sharalyn for pushing him to appreciate the majesty of the high Sierra.*



 (Continued from page 20)

tus, made mild improvements in *G*'s precision. This experiment is so hard to do that, even today, *G* has acquired only a few additional decimal places. Recent experiments conducted at the University of Washington in Seattle by Jens H. Gundlach and Stephen M. Merkowitz, who redesigned the experiment, derive the value 0.00000 0000066742. Talk about weak: as Gundlach and Merkowitz note, the gravitational force they had to measure is equivalent to the weight of a single bacterium.

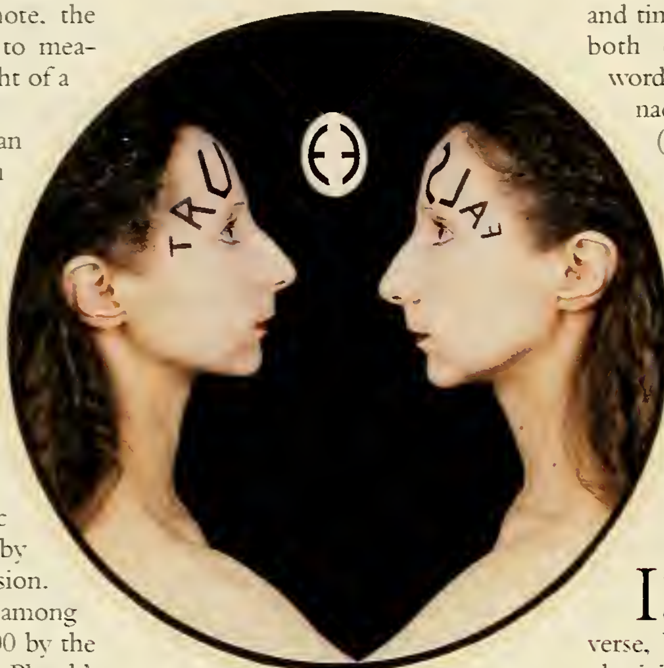
Once you know *G*, you can derive all kinds of things, such as Earth's mass, which had been Cavendish's ultimate goal. Gundlach and Merkowitz's best value for that is just about 5.9722×10^{24} kilograms.

Many physical constants discovered in the past century link with forces that influence subatomic particles—a realm ruled by probability rather than precision. The most important constant among them was promulgated in 1900 by the German physicist Max Planck. Planck's constant, represented by the letter *h*, was the founding discovery of quantum mechanics, but Planck came up with it while investigating what sounds mundane: the relation between the temperature of an object and the range of energy it emits.

An object's temperature directly measures the average energy of motion of its jiggling atoms or molecules. Of course, within this average some of the particles jiggle very fast, whereas others jiggle relatively slow. All this activity emits a sea of light, spread over a range of energies, just like the particles that emitted them. When the temperature gets high enough, the object begins to glow visibly. In Planck's day, one of the biggest challenges in physics was to explain the full spectrum of this light, particularly the bands with the highest energy.

Planck's insight was that you could account for the full sweep of the emitted spectrum in one equation only if you assume that energy itself is quantized, or divided up into itty-bitty units that cannot further be subdivided: quanta.

Once Planck introduced *h* into his equation for an energy spectrum, his constant began to appear everywhere.



Rimma Gerlovina and Valeriy Gerlovin, *True-False*, 1992

One good place to find *h* is in the quantum description and understanding of light. The higher the frequency of light, the higher its energy: Gamma rays, the band with the highest frequencies, are maximally hostile to life. Radio waves, the band with the lowest frequencies, pass through you every second of every day, no harm done. High-frequency radiation can harm you precisely because it carries more energy. How much more? In direct proportion to the frequency. What reveals the proportionality? Planck's constant, *h*. And if you think *G* is a minuscule constant of proportionality, take a look at the current best value for *h* (in kilogram-meters squared per second): 0.0000000000000000000000000000000066260693.

One of the most provocative and wondrous ways *h* appears in nature arises from the so-called uncertainty principle, first articulated in 1927 by the German physicist Werner Heisenberg. The uncertainty principle sets forth the terms of an inescapable cosmic trade-off: for various related pairs of fundamental, variable physical attributes—location and speed, energy and time—it is impossible to measure both quantities exactly. In other words, if you reduce the indeterminacy for one member of the pair (location, for instance), you're going to have to settle for a looser approximation of its partner (speed). And it's *h* that sets the limit on the precision you can attain. The trade-offs don't have much practical effect when you're measuring things in ordinary life. But when you get down to atomic dimensions, *h* rears its profound little head all around you.

It may sound more than a bit contradictory, or even perverse, but in recent decades a lot of physicists have been looking for evidence that constants don't hold for all eternity. In 1938 the English physicist Paul A.M. Dirac proposed that the value of no less a constant than Newton's *G* might decrease in proportion to the age of the universe. Today there's practically a cottage industry of physicists desperately seeking fickle constants. Some are looking for a change across time; others, for the effects of a change in location; still others are exploring how the equations operate in previously untested domains. Sooner or later, they're going to get some real results. So stay tuned: news of inconstancy may lie ahead.

Astrophysicist NEIL DEGRASSE TYSON *is the Frederick P. Rose Director of the Hayden Planetarium in New York City. His latest book, with Donald Goldsmith, is* Origins: Fourteen Billion Years of Cosmic Evolution *(W.W. Norton, 2004), the companion book to the PBS* NOVA *miniseries* Origins.

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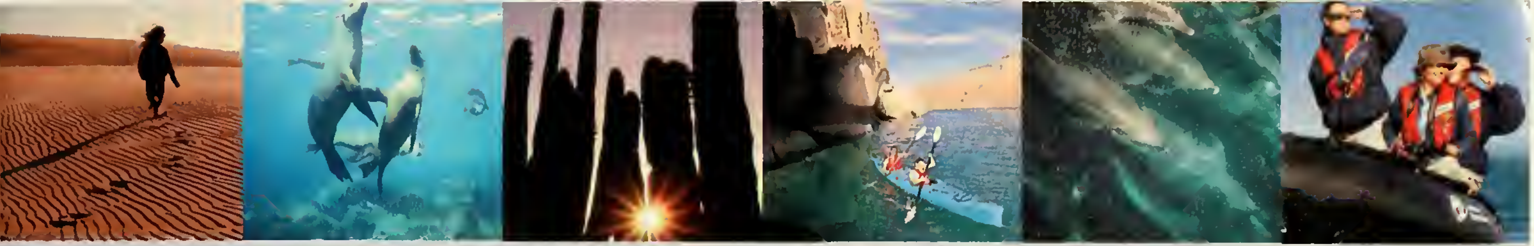

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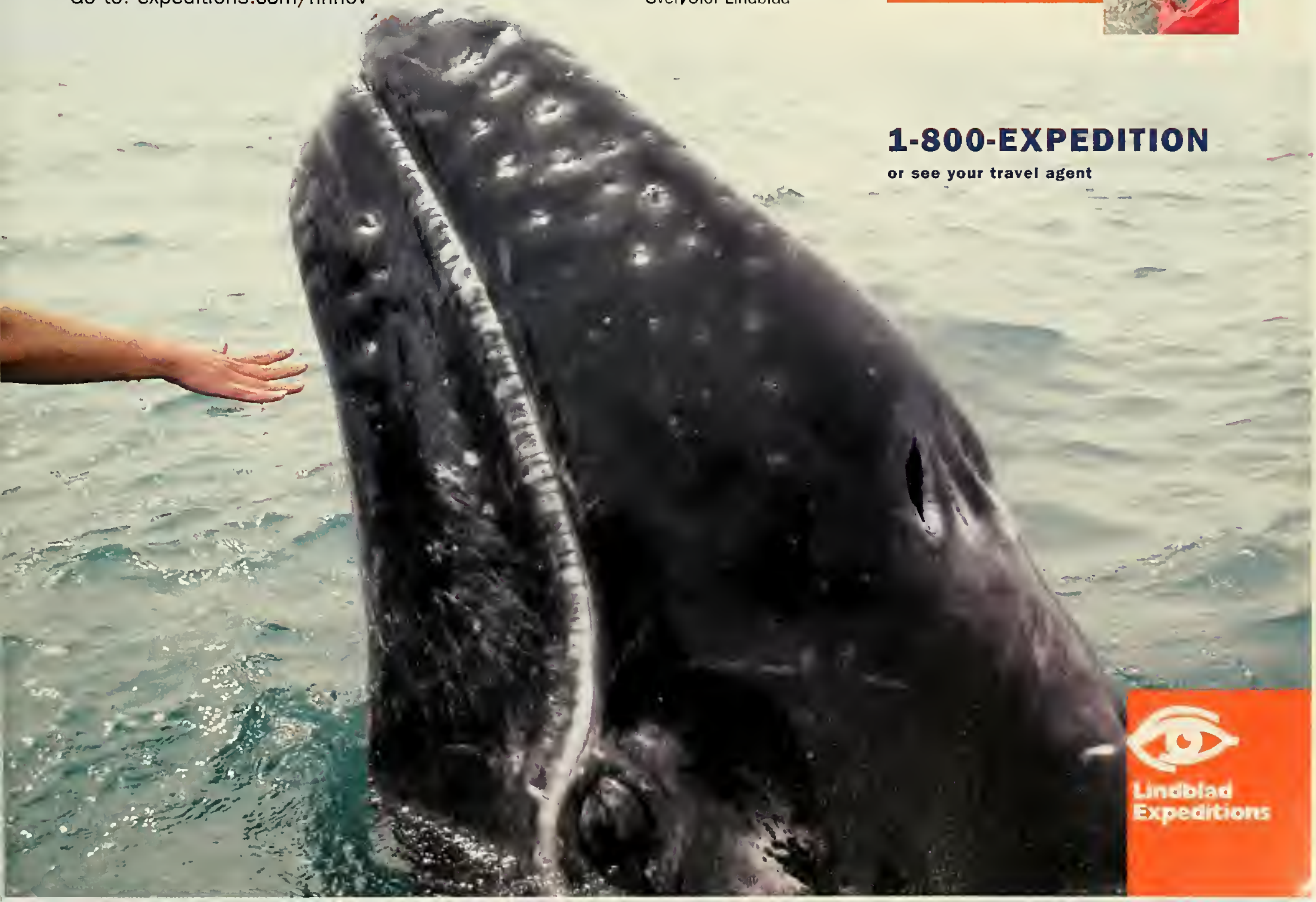

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NATURAL HISTORY
NOVEMBER 2004

Ties That Bind

Hopi gift culture and its first encounter with the United States

By Peter M. Whiteley

Hopi village chief in the 1930s wears a necklace made of traditional luxury items: coral, shell, and turquoise. The high value of the necklace suggests it may have been a gift from one of his relatives.

In 1852, shortly after the United States had nominally annexed Hopi country, in northern Arizona, the Hopi people arranged for a diplomatic packet to reach President Millard Fillmore at the White House. Part message and part magical gift, the packet was delivered by a delegation of five prominent men from another Pueblo tribe, the Tewas of Tesuque Pueblo in New Mexico, who wanted to gain legal protection from Anglo and Hispanic settlers who were encroaching on their lands. The delegation traveled for nearly three months, on horseback, steamboat, and train, from Santa Fe to Washington, D.C., more than 2,600 miles away. The five men spoke fluent Spanish, the dominant European language of the region at the time—which made them ideally suited to convey the gift packet and its message to the president.

Bracelet by the contemporary Hopi artist Preston Monongye and the Navajo-Hopi artist Jesse Monongya features stylized kernels of speckled corn, a varietal that Hopi farmers developed to thrive in the desert upland region they inhabit. The Hopi traditionally consider corn the "mother of life."

At the time, no U.S. government official had visited the Hopi (and few would do so before the 1890s). Their "unique diplomatic pacquet," in the words of the nineteenth-century ethnologist Henry Rowe Schoolcraft, offered "friendship and intercommunication . . . opening, symbolically, a road from the Moqui [Hopi] country to Washington." The packet was in two parts. The first part comprised two *pahos*, or prayer-sticks, at either end of a long cotton cord, dyed for part of its length [*see lower illustration on pages 28 and 29*]. Separating the dyed from the undyed part of the cord were six varicolored feathers, knotted into a bunch. The *pahos* "represent the Moqui [Hopi] people and the President [respectively]," Schoolcraft wrote; "the cord is the road which separates them; the [bunch of feathers] tied to the cord is the meeting point."

As well as encoding a message, the *pahos* were an offering of a kind that Hopi deities such as Taawa, the Sun god, traditionally like to receive. By giving the president *pahos* worthy of the Sun, the Hopi signaled their expectation that he would reciprocate. Just as the Sun, on receiving the appropriate offerings, would send rain clouds for sustaining life and growth, so, too, the president would send protection for Hopi lives and lands—in this instance, protection from assaults by neighboring tribes such as the Navajo.

The second part of the packet comprised a cornstalk cigarette filled with tobacco ("to be smoked by the president") and a small cornhusk package that enclosed honey-soaked cornmeal. According to the Tesuque delegation, the honey-meal package was "a charm to call down rain from heaven." When the president smoked the cigarette, he would exhale clouds of smoke, which would sympathetically attract the clouds of the sky. Then, when he chewed the cornmeal and spat the wild honey on ground that needed rain, the Tesuque statement concluded, "the Moquis assure him that it [the rain] will come."

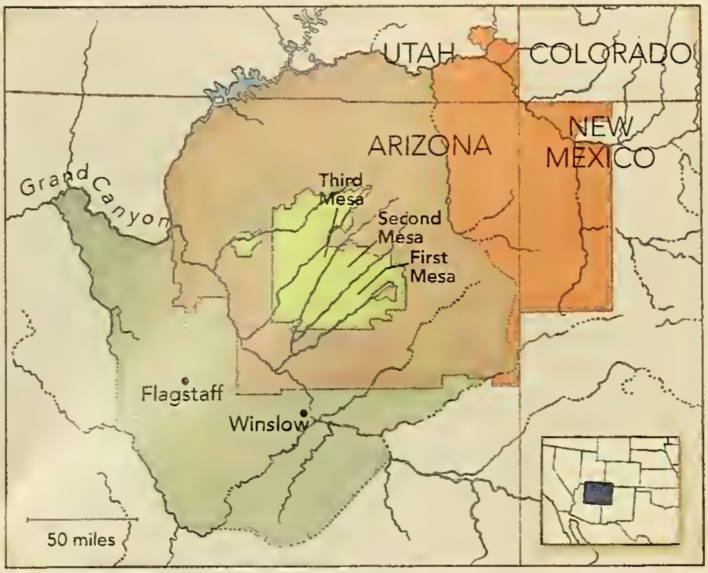
In sum, the packet was three things at once: message, offering, and gift of magical power. In conveying those elements, the Hopi sought to open diplomatic relations with the U.S.

But their intent appears to have been lost on their recipient. As so often happens when two cultures make contact, deep misunderstandings can arise: What does a gift mean? What, if anything, does the gift giver expect in return? Do the giver and the recipient both assign the same value to the gift? In twenty-five years of ethnographic fieldwork with the Hopi, it has been my goal to learn something of their history and culture. Recently I turned my attention to certain important events, such as the Millard Fillmore episode, that might shed light on how Hopi society changed as the U.S. developed. In that context Hopi gift giving and the ways it functions as a pillar of Hopi social organization have been central to my studies. One lesson of my work shines through: When nations exchange gifts, all the parties would do best to keep in mind the old adage, "It's the thought that counts."

Given the differences between Hopi and Western traditions and culture, perhaps it is not surprising that the Hopi idea of "gift" is only loosely equivalent to the Western one. In 1852 the Hopi people were still little affected by outside populations, and Hopi land use spread across much of northern Arizona and even into southern Utah [*see map on next page*]. At that time, the Hopi lifestyle was traditional, based on farming, foraging, and some pastoralism. Even today, important elements of the subsistence economy persist, though wage labor and small business provide supplemental income.

The Hopi typically divide their work according to gender. Work done by men (such as farming and harvesting of crops) is perceived as a gift to the women; work done by women (such as gardening, gathering of piñon nuts, grasses, wild fruits, berries, and the like) is perceived as a gift to the men. Women also own and manage the distribution of

Hopi basket dance is performed by girls (with butterfly hairdos at front, left) and adult women arranged in a semicircle, as shown in this 1920s watercolor by Hopi artist Fred Kabotie. At the end of each song, the two girls within the circle throw gifts to men (not shown), who grab for the prizes. The baskets held by the women may be the most valuable gifts, but the men sometimes strive just as hard for lesser gifts, such as a plastic cereal bowl, because the act of giving and receiving is the essential point.



Today's Hopi Reservation, about seventy-five miles east of the Grand Canyon, is surrounded by Navajo lands. The aboriginal Hopi territory, known as Hopitutskwa, is a much larger area that includes much of the land now allocated to the Navajo. Today the Hopi are concentrated in the villages of First Mesa, Second Mesa, and Third Mesa.

their household's goods and crops. In fact, Hopi women control most of the material economic life, whereas Hopi men largely control the ritual and spiritual aspects.

The Hopi take part in an elaborate cycle of religious ceremonies, to which a range of specialized offices and privileges is attached. But individuals gain those distinctive social positions not through material wealth but rather through gender and kinship relations, which are ordered in a matrilineal manner. In fact, clan heads and chiefs of religious societies are typically worse off materially than the average member of the clan. Hopi leaders are supposed to be materially poor, and a wealthy individual is often criticized as *qahopi*, un-Hopi, for failing to share. Wealth and status among the Hopi is thus phrased in ritual terms: a poor person is one without ceremonial prerogatives, not one without money. So averse are the Hopi to material accumulation that in May 2004, for the second time, they voted against casino gambling, despite substantial poverty on the reservation.

Does such a primacy of value placed on ceremonial roles explain the evanescent nature of the gift given to President Fillmore? In what world of meaning did the packet represent great value? Indeed, what's in a gift?

Anthropologists have been making hay of that last question ever since 1925, when the French anthropologist Marcel Mauss published his groundbreaking *Essai sur le Don* (translated into English as "The Gift"). Mauss convincingly argued that in small-scale societies (10,000 or fewer persons) gifts are "total social facts." What he meant is that, in gift- or barter-based social systems, divisions of social life into discrete domains—such as economy, politics, law, or religion—are meaningless; each sphere interpenetrates and overlaps the others.

As in strict barter, an exchange in Hopi culture that begins by making a gift to someone does not involve money, but it does require reciprocity. Thus goods, services, or knowledge "given" to an individual or a group are answered with something of equivalent value. "Gifts" develop an interconnectedness between Hopi individuals in a way that outright purchases cannot. Furthermore, the Hopi offer gifts in a much broader range of circumstances than people in Western cultures do, and the value of those gifts extends to the religious realm, tying individuals and groups to each other and to the realm of the spirits.

Probably the key to understanding a gift-based system such as that of the Hopi is to recognize that

Artist's conception of a gift carried to Washington in 1852, when the Hopi people sought to initiate diplomatic relations with the United States (the original gift has been lost). One part of the gift was a message proposing a meeting between the two peoples: Two pahos, or prayer-sticks with turkey feathers, represented, respectively, the Hopi people (left) and U.S. President Millard Fillmore (far right on opposite page). The bunch of six feathers tied into the long cotton cord between the pahos indicated the proposed meeting place: Fort Defiance, the seat of the U.S. government in Arizona and the place where six directions (northwest, northeast, southwest, southeast, zenith, and nadir) come together. Attached to each paho was a folded cornhusk that held a small feather, some cornmeal, and a sprig of mountain sagebrush that stood for the Hopi people and lands; the small yellow warbler feather attached to each pair of sticks represented a prayer.

such systems are built on kinship. "Kinship"—the godzilla that has driven multitudes of college students screaming from anthropology 101—is, in this regard at least, straightforward. It means simply that the great majority of human social activity is framed in terms of reciprocal family ties. Where all personal relationships are cast within the "kinship idiom," there are no members of the society who are not kin to me, nor I to them.

Kinship terms encode behavioral expectations as well as familial role. As anthropologists never tire of saying, such terms are primarily social, not biological: obviously if I call fifteen women "mother," as the average Hopi can do, I do not assume that each woman physically gave birth to me. But my "mothers" all have rights and duties in relation to me. And, reciprocally, I have duties and rights with respect to them: in fact, their duties are my rights, and my duties are their rights in the relationship. That is what reciprocity is all about. You give me food, I plant your cornfield, to give a crude example. But, in a kinship society, such a basic structure of mutual expectations forms the foundation for an entire apparatus of courtesy and manners, deference and respect, familiarity or distance. Those expectations are concretely expressed by gifts—spontaneous and planned, routine and special, trivial and grand. Gifts are thus communications in a language of social belonging.

So averse are the Hopi to material accumulation that in May 2004 they voted against casino gambling.

So-called gift economies entail a certain kind of sociality, or sense of what it means to belong to a community. In such an economy, one gives a gift to mark social relations built on kinship and altruism, but without the expectation of direct repayment. According to some arguments, gifts are also given to foster a sense of community, as well as sustainable interrelations with the local environment. In fact, in some respects the giver still "owns" some part of the gift, and it is the intangible connection between the two parties, mediated by the gift, that forms the basis of interpersonal relationships.

In contrast, in exchange economies, commodities dominate social interchange. Competitive markets, governed by the profit motive, connect buyer and seller, and social relations are characterized by individualism. A gift, once given, belongs entirely to the recipient; only when the item given has sentimental value does it keep the bond between giver and recipient alive.

That is not to say the Hopi did not engage in the more impersonal, "Western" forms of material exchange. In the Hopi language, as in English, several words describe how an item is transferred from one person to another: *maqa* ("to give"); *hùuya* ("to barter or trade"); and *tu'i* ("to buy"). Those words all antedate the arrival of Europeans—and anthropological classifications. Barter and purchase, as well as gifts, have all long been present in Hopi life. Furthermore, gift exchange in the West can also function as it does among the Hopi, as part of kinship obligations or ordinary social life.

What is distinctive about Hopi custom is the fact that the gift economy is responsible for the great majority of exchanges. Furthermore, there is no such thing as a free gift. The strong interpersonal bonds created by a gift make giving almost de rigueur at ceremonial events. Gifts, particularly gifts of food or utensils, are transmitted during ceremonies of personal milestones (at a birth or a marriage), as well as at public gatherings.

For example, at the annual so-called basket dances, girls and women distribute a variety of objects they have collected for the occasion. The dances illustrate the Hopi lack of acquisitiveness. The women form a semicircle and dance and sing [*see illustration on page 27*]; after each song two girls fling gifts into the crowd of men assembled outside the circle. Among the gifts are valuable baskets and buckskins, though inexpensive utensils and manufactured items are also popular. Each man zealously grabs for the flying objects, and if two men happen to catch the same item, both wrestle with the object, often until it has been totally destroyed.

Although gift giving has been a pillar of Hopi society, trade has also flourished in Hopi towns since prehistory, with a network that extended from the Great Plains to the Pacific Coast, and from the Great Basin, centered on present-day Nevada and Utah, to the Valley of Mexico. Manufactured goods, raw materials, and gems drove the trade, supplemented by exotic items such as parrots. The Hopis were producers as well, manufacturing large quantities of cotton cloth and ceramics for the trade.

"Clowns Getting Ready," a 1930s watercolor by Fred Kabotie, details the costumes of Hopi ritual clowns. The clowns portray the excesses of humanity before morality and Hopi values emerged.

To this day, interhousehold trade and barter, especially for items of traditional manufacture for ceremonial use (such as basketry, bows, cloth, moccasins, pottery, and rattles), remain vigorous.

For hundreds of years, at least, the Hopi traded with the Rio Grande Pueblos to acquire turquoise, *heishi* (shell necklaces), and buckskins; one long string of *heishi,* for instance, was worth two Hopi woven cotton mantas. Similarly, songs, dances, and other ritual elements were often exchanged for an agreed-upon equivalent.

The high value the Hopi placed on the items they acquired by trade correlate, in many respects, with the value Europeans placed on them. Silver, for instance, had high value among both Westerners and Native Americans as money and as jewelry. *Siiva,* the Hopi word both for "money" and for "silver jewelry," was borrowed directly from the English word "silver." Paper money itself was often treated the way traditional resources were: older Hopi men bundled it and stored it in trunks, stacked by denomination.

It was not until the 1890s, however, that silver jewelry began to be produced by the Hopi. A man named Sikyatala learned silversmithing from a Zuni man, and his craftsmanship quickly made silver jewelry into treasured adornments. Those among the Hopi who cared for it too much, though, were criticized for vanity; one nickname, Siisiva ("[wearing] a lot of silver"), characterized a fop.

Some jewels, such as turquoise, traditionally had a sacred value, beyond adornment. Even today, flakes of turquoise are occasionally offered to the spirits in religious ceremonies. Turquoise and shell necklaces appear in many ritual settings, frequently adorning the costumes of *katsinas* (ceremonial figures) and performers in the social dances.

How much the Hopi value turquoise becomes apparent toward the close of a ritual enactment known as the Clown Ceremony. The "clowns"—more than mere entertainers—represent unbridled human impulses. Warrior *katsinas* arrive to punish the clowns for licentious behavior and teach them good Hopi behavior: modest and quiet in conduct, careful and decorous in speech, abstemious and sharing about food, and unselfish about other things. The clowns fail miserably (and hilariously) at their lessons. Eventually the warrior chief presents an ultimatum: stop flaunting chaos or die. The clown chief then offers him a turquoise necklace as a "mortgage" on the clowns' lives. The warrior chief accepts, the clowns receive a lesser punishment, and community life goes on—not with perfection, but with a human mixture of the virtuous and the flawed.

In Hopi tradition, the first clan among the Hopi, and the one that supplied the *kikmongwi*, or village chief, was Bear. When other clans arrived, their leaders approached the *kikmongwi* to request entry into the village. He asked what they had to contribute, such as a beneficial ceremony. So challenged, each clan performed its ceremony, and if successful, say, in producing rain, its members were invited to live in the village, assigned an area for housing, and granted agricultural lands to work in the valley below. In return, the clan agreed to perform its ceremony, as part of a cycle of ceremonies throughout the year, and to intermarry with the other clans of the community, a practice called exogamous marriage. In that way, the Snake clan brought the Snake Dance, the Badger clan introduced principal *katsina* ceremonies, and the Fire clan brought the Warriors' society to the Hopi village. The villages thus came to be made up of mutually interdependent clans.

One of the essential principles expressed here, and the very cornerstone of Hopi society and sociality, is the exchange of mutually beneficial gifts—ceremonies for land, people in exogamous marriage—and the relationships reconfigured by those exchanges. And the same model is extended to the supernatural world: the gods must be propitiated with offerings of ritual gifts, and thus reminded of their dependence upon and obligations to mortal people.

The items sent to President Fillmore conform to the archetypal Hopi offering. Seeking to incorporate the president into the Hopi world, the appropriate strategy was to give him valuable presents that sought something in return, and to make sure he understood what that meant. Addressing him with prayer-sticks the way they might address the Sun father, the delegation sought to engage him within the gifting and kinship idiom. The instructions delivered with the packet—even across a succession of translations—spoke clearly of the Hopi intent. As with the turquoise mortgage of the *katsina* clowns, the idea of reciprocity is central. If the president wants more of, say, rain-magic, he must give back: he must receive the gift and its political proposal, and provide something in return.

Ancestral Pueblo (Anasazi) woman, depicted on a replica of a kiva wall, wears garments and ceremonial face paint that continue to characterize Hopi women, particularly when they are participating in rituals. The scarlet macaw in each hand of the woman represents a favorite item for which the Hopi traded from at least the fifteenth century, when the original kiva wall was painted.

Alas, the magico-religious sensibility of the Hopi worldview and the offer of serial reciprocity clashed with Manifest Destiny and the assimilationist ideology of Fillmore's presidency. Historical records make it clear that he did not smoke the cigarette, nor chew nor spit the honey-meal, and, so far as we know, he sent no formal reply. None of the objects has survived.

What the five men of the Tesuque delegation received no doubt perplexed them as much as the packet they delivered perplexed the president: Each man was given a Millard Fillmore peace medal, a Western-style business suit, and a daguerreotype portrait (all now lost, as well). They also got a tour of standard destinations in Washington, including the Patent Office and the Smithsonian Institution, where they were introduced to the "wonders of electricity," according to a contemporary newspaper account in the *Daily National Intelligencer.* In their meeting with Fillmore they heard the president say he "hoped the Great Spirit would bless and sustain them till they again returned to the bosom of their families."

Certainly Fillmore expressed the goodwill of the U.S. toward the Pueblos in general and to the Tesuque party in particular—who, in all probability, conveyed that sentiment to the Hopi. But the dissonance between gift and exchange economies helps explain why the Hopis did not achieve their goals. (The U.S. did not protect the Hopi from intrusions by the Navajo or by anyone else.)

The Hopi sought to embrace the president in their own sphere of sociality and mutuality—to extend kinship to him. But in a social system like the president's, where gifts are not total social facts, the political belongs in a separate domain from the religious or the economic, and kinship is secondary. The gift of a jeweled sword, for instance, might have impressed Fillmore more, but for the Hopi, its strictly symbolic value—as an item for display, but with no political, religious, or social value—would not have ensured a return, a social connection built on mutual exchange. More, by Hopi standards, presenting such a gift might have seemed inhospitable and materialistic, indeed, undiplomatic and even selfish. Thus does understanding fail between nations. □

Mouth to Mouth

Saliva transfer can help animals communicate, medicate, or even kill. Evolution has given rise to a variety of salivary mixtures that are being mined for ways to help save human lives.

By Lawrence A. Tabak and Robert Kuska

That familiar refrain in country-and-western songs, "You don't miss it 'til it's gone," is a good way to describe saliva. It's taken for granted, sometimes mocked, and often shunned in polite conversation. But in scientific circles there is good reason to speak with excitement about the subject of saliva. Ordinary spit, according to several lines of recent research, turns out to be far more than just a way to wet your lips.

In fact, saliva is a remarkably complex biological fluid with an extraordinary natural history. It addresses a laundry list of obvious but necessary functions: lubricating the mouth, moistening dry food, assisting in digestion, protecting the teeth from decay, wetting the taste buds, and buffering the inside of the mouth against continuous assault from microorganisms. But beyond those basic functions, saliva exhibits tremendous variation in nature, often with special adaptations that can correspond to the dietary habits of the various species.

Giraffes, for instance, have evolved thick, mucus-like saliva that enables them to chew thorns without

Saliva is brimming with functional proteins. Pig saliva (above) includes pheromones, such as 5-alpha-androstenol, that communicate sexual desire. Female pigs swoon if they get a whiff of the steroid, which is emitted by male pigs (and, conveniently, also by truffles.) Despite all of the extra stuff, water is the primary component of saliva. Camels (left) conserve water by circulating it only to necessary systems: the blood, the stomach, and their frothy saliva.

Giraffe saliva makes a thick coating on the animal's tongue. A diet of thorns thereby becomes easier to swallow.

damaging their mouths. Creatures that drink blood—vampire bats, mosquitoes, and many ticks—have evolved amazingly efficient anticoagulant agents in their saliva to help them feed on their hosts. The Komodo dragon, the world's largest lizard, has more than fifteen infectious agents suspended in its saliva. When the powerful bite of the Komodo doesn't topple its victim, the salivary pathogens can finish the job [*see "The Lizard Kings," by Samuel S. Sweet and Eric R. Pianka, November 2003*]. Pigs and many other animals rely on pheromones secreted in their saliva to woo their mates.

Such a broad range of functions collected and mixed in one fluid is particularly intriguing to evolutionary biologists. Salivary glands have evolved quite rapidly, compared with other organs. They could well be one of the primary ways many species adapt to their environments, outcompete their rivals, and fill new ecological niches. Furthermore, salivary glands are pervasive in creatures large and small. If the glands were not advantageous, they would probably have been lost somewhere along the way.

The study of saliva, however important it is to evolutionary biology, also holds great promise for medical science. For one thing, the rich variety of proteins that occur in nonhuman saliva promise treatments for diabetes, strokes, and other diseases. But studies of human saliva are pointing to what could be even more exciting possibilities: Saliva can serve as a useful qualitative diagnostic tool, enabling tests for disease antibodies to be done without the risk and discomfort of drawing blood. And saliva itself, produced by genetically modified salivary glands, might someday serve as a twenty-four-hour internal pharmacy, dispensing individually tailored medications to people who need them.

Saliva is notable not only for the variety of its ingredients, but also for the diverse structures of the glands that produce it. Other important secretory glands of the digestive system, such as the liver and the pancreas, are similar in structure across various life forms, from fishes to mammals. The genetic blueprint for those glands could probably not be modified very much without unduly affecting their vital contributions to life. In contrast, as studies of more than 300 mammalian species have shown, the structural diversity of the salivary organs is striking. Even within single families of organisms there is often a great deal of variability among the salivary glands of different species.

In spite of that variety, mammals generally have the same three sets of salivary glands, which are each composed of clusters that resemble grapes still attached to their stems. Secretory cells inside the grapelike nodules release the initial salivary fluid, made up of water and some proteins. The fluid passes along the "stem," or narrow duct, of the cluster, where other cells modify its salt balance before it passes into the mouth.

Human beings have four kinds of salivary glands, including the three kinds common to other mammals. Parotid glands, which are opposite the front lower molars, nearly parallel to the ear lobes, secrete a thin, watery substance that is rich in antibacterial proteins and compounds that help remineralize the teeth. Submandibular glands, egg-shaped structures embedded below the floor of the mouth just above the throat, produce a more viscous fluid that helps lubricate the throat and mouth. Sublingual glands, a pair of almond-shaped structures also located below the floor of the mouth, produce secretions much like those of the submandibular glands. Finally, a fourth kind of salivary gland occurs in humans, comprised of hundreds of smaller, minor salivary glands cover the tongue and lining of the mouth. Some of them form small bumps on the inner lip. Their secretions play a major role in helping lubricate the mouth and protecting against infections.

The sum of these secretions, the pooled product called whole saliva, is about 99 percent water, but it also comprises a diversity of biochemicals that one gland alone could not produce efficiently. Variations on this theme between and even within species tell a compelling story of evolution's inventiveness.

For decades, the biologists Carleton J. Phillips of Texas Tech University, in Lubbock, and Bernard Tandler of Case Western Reserve University, in Cleveland, Ohio, have studied salivary glands in various species of bats. Among all the mammals, the 800-odd species of bats—nearly a quarter of all existing mammalian species—have been superlative at adapting to a wide range of food sources, from fruit, nectar, and pollen, to insects and blood.

Phillips and Tandler have documented many variations in the protein content and the physical structure of salivary gland cells throughout the bat order. Most bats possess not one but two sets of submandibular glands, and some also have salivary glands at the corner creases of their mouths. Those additional glands have assumed a broad range of functions. In the white-winged vampire bat *(Diaemus youngi)*, for instance, the extra pair of glands ejects a foul-smelling liquid, not unlike a skunk's spray, that wards off unwanted advances. In frog-eating bats *(Trachops cirrhosus)* another salivary gland produces toxin-inhibiting proteins that seem to counteract the deadly poisons present in frog skin.

The simplest model that can account for the emergence of such adaptations is the appearance, at various points on an organism's genes, of single mutations that alter the function of cells and tissues. Some such changes are beneficial, some have no effect, and some are detrimental to the organism in which they take place. What separates the genetic wheat from the chaff, of course, is natural selection. Mutations that enabled bats to exploit new and hitherto dangerous food sources would have spread throughout the populations as the animals possessing them reproduced, presumably at greater rates than the bats without the mutations.

But Phillips and Tandler hypothesized that such simple mutations could not have happened fast enough to give rise to the diversity of bats that exist today. Instead, they proposed, the bats' DNA must have been undergoing changes on a larger scale, making their evolution a far more dynamic process. Such large-scale genetic alterations would have been a highly useful response to, say, some environmental change that forced a population to switch to a new food source. In that event, the bats' salivary glands may have needed to evolve rapidly if the animals were to thrive in their newfound dietary niche.

To explore this idea, the investigators turned to the heterogeneous family of Phyllostomidae, the New World leaf-nosed bats. Originally made up of insect-eaters, the family has adapted to diets of fruit or blood. The question that intrigued Phillips and Tandler was: how do the salivary glands that evolved among fruit-consuming phyllostomid bats differ in structure and function from the glands that evolved in their insect-eating cousins.

Saliva and the glands that produce it could be the leading edge of rapid evolutionary adaptation to new food sources.

When fruit bats were first adapting to their current diets, they placed new and stressful demands on the salivary glands. For one thing, the glands had to combat the unfamiliar bacteria that invaded the existing community of organisms after the dietary shift. Furthermore, on their original insect-based

*Saliva of the common vampire bat (*Desmodus rotundus*) includes an anticoagulant, dubbed Draculin, that might help clear obstructed arteries in people.*

diet, the bats had subsisted on foods rich in protein. Fruits, however, are extremely low in protein, and they also contain tannins that inhibit digestion. So when they switched to a fruit-based diet, fruit bats had to eat copious quantities of food, and process it quickly, just to ingest enough protein to survive. The salivary glands might have had to cope with novel nutrients, which meant they suddenly had to manufacture many new proteins.

Phillips and Tandler suggest that what enabled the bats to adapt could have been the sudden activation of previously dormant genes in the salivary glands. Or, large blocks of genes in the gland cells' DNA could have been duplicated, creating new templates on which natural selection could work. Such changes could dramatically alter the activity of these cells, making the evolutionary process run much faster than it could if it depended solely on simple genetic mutation of existing, active genes.

Another group of animals whose saliva has been key to survival is the tick. As any dog owner is all-too-well aware, the tick relies on nutrients from the blood of its host. And it turns out that the saliva of ticks has evolved several ways of counteracting the host's natural defenses against damage to blood vessels.

When the slow-feeding ixodid tick latches onto its host, for instance, it begins a two-step cycle of feeding: it alternately sucks a bit of blood, then releases a bit of saliva. Within the saliva are proteins that prevent blood platelets from aggregating to seal the wound, a first line of the host's defense. Other proteins in the tick's saliva deactivate key proteins in the host's immune system that would normally trigger inflammation at the site of the wound. Thus, instead of sounding the alarm that something has invaded the bloodstream, the cells of the immune system remain silent. A tick bite that would normally cause the host to ache and itch thereby remains unnoticeable, allowing the tick to feed undetected for several days.

The fast-feeding argasid tick deploys a different strategy. Its saliva carries proteins that cause rapid bleeding when they enter the victim's bloodstream. The salivary proteins give the tick a chance for a big gulp of blood before making a relatively quick getaway.

Given the variety and rapid evolution of salivary proteins, could such proteins even play a role in establishing new species? The idea remains controversial, but it seems to be supported by research into the role of a molecule known as androgen-binding protein (ABP), present in the saliva of the house mouse common in Asia and Europe.

Studies show that the female house mouse prefers to mate with males possessing the biochemical variant of ABP that exactly matches her own. In fact, male house mice often mark their territory with saliva, which could serve to advertise their ABP profiles to potential mates.

The genes that encode ABP frequently but subtly mutate from generation to generation. Occasionally those changes slightly alter the physical structure of the protein itself. Consequently, when mice with altered ABP profiles (detectable in their saliva) choose to mate with each other, their offspring would be correspondingly distinct. If this mechanism actually leads to speciation, is it also unique to house mice? Or does it, perhaps, occur among other animals as well? Given the ubiquity and importance of saliva, it's possible that more than one species has split off thanks to spit.

Ixodid tick (above, shown magnified roughly thirty-three diameters) can feed for days without detection because proteins in its saliva inhibit an inflammatory reaction in the host. Argasid tick (left, on human skin) gorges more quickly with the help of salivary proteins that make its host bleed rapidly.

Nature's efforts to tinker with saliva are also attracting medical investigators. In 1995, for instance, workers in Venezuela isolated, from the saliva of the common vampire bat *(Desmodus rotundus)*, an unusual compound that blocks blood clotting in a highly specific way. Memorably, they dubbed it Draculin. The substance is now under study in the United States as a possible new treatment to fight the onset of stroke.

Last year one pharmaceutical firm, Eli Lilly and Co., based in Indianapolis, Indiana, and its collaborators reported hopeful results from a clinical trial of a drug extracted from the saliva of the Gila monster [*see "Venomous Lizards of the Desert," by Daniel D. Beck, July/August 2004*]. The animal eats as few as three big meals a year, and its salivary proteins help maintain steady levels of blood sugar for long periods. The rationale behind the study, and the drug that is the focus of the clinical trial, is that this property of Gila monster spit could also help control blood-sugar levels in humans, and thus treat people with type 2 diabetes.

What about our own saliva? The National Institute of Dental and Craniofacial Research (NIDCR), in Bethesda, Maryland, has launched a new initiative to create the first comprehensive catalog of every salivary protein. Such a catalog would serve as a "molecular parts list" for future research. The institute is also exploring how and in what contexts saliva might replace blood for testing the presence of alcohol, illegal drugs, and blood-borne proteins, such as HIV antibodies.

It is a fact—albeit a little-known one—that salivary glands secrete proteins into the circulatory system as well as into the digestive tract. Building on this fact, one NIDCR biologist, Bruce J. Baum, is leading a research team that has begun to transfer specific genes into salivary glands. With minimal coaxing, the cells of those glands should be able to act as natural protein factories, pumping the proteins encoded by the transferred genes into the bloodstream at steady levels. Thus it could come to pass that an injection made directly into the salivary gland might be able to treat diseases that result from mutations in single genes, among them type 1 diabetes, growth-hormone deficiency, and hypoparathyroidism.

Do its potential therapeutic benefits make spit seem just a bit less unpalatable? We hope so. And we certainly won't be surprised if a fluid that people turn away from today comes to be appreciated for what it is: one of nature's favorite genetics laboratories, and a source of lifesaving medical advances. □

A Telling Difference

Animals can communicate, but evidence that any of them can emulate human language remains elusive.

By Stephen R. Anderson

Doctor Dolittle, the fictional hero of Hugh Lofting's novels, was said to be able to talk with animals. Whether he, or any of his would-be imitators in real life today, could actually speak with an animal is an entirely different question.

Clearly animals can communicate; communication is virtually universal among living things. Cats meow; songbirds sing; whales call. A dog wagging its tail can be providing information about how it feels and what it wants. Surely, though, such communication is not of a piece with the languages people use. Describing any of those behaviors with the word "talk" would be nothing more than a (feeble) attempt to be clever.

But people do use words such as "talk" to describe certain kinds of animal communication. In fact, since the 1970s many claims have been made about the potential abilities of apes to talk with people in sign languages or via other means. What is the nonspecialist to make of such claims? Are animals simply handicapped by their vocal anatomy? Could they, like Dr. Dolittle's friends, one day be taught to converse with us, via some vocal or nonvocal channel, and perhaps even to pass along their newly acquired linguistic "culture" to their offspring? Or is the evidence presented so far, purportedly in support of such claims, at best irrelevant to them, and at worst a gross overstatement of what the data really mean?

One evening I returned home to find my wife correcting papers. When I asked her what we were doing for dinner, she said, "I want to go out." Her words left no doubt that she wanted us to go to a restaurant, where we would have dinner.

When I came home the following night, I found my cat Pooh in the kitchen. She looked at me, walked over to an oriental rug in the next room, and began to sharpen her claws on it. Pooh knows I hate that, and as I went to stop her, she ran to the sliding glass door that leads outside. I yelled at her, but my wife said, "Don't get mad; she's just saying, 'I want to go out.'"

Voilà! Both my wife and my cat can say, "I want to go out." But do they both have language? Surely that is at best an oversimplification. Each can behave in such a way as to convey information to me. But the means by which they do this are radically different.

One way of approaching the distinction between communication and language is to note that communication is something we—and lots of other animals—do, whereas language is a tool that people can use to do that. People can, of course, communicate without language, though the range of information we can transmit by such means is limited. The same is true of the communication by animals and other organisms: it can transmit some fairly complex information or requests, but it still falls far short of something that is uniquely human: language.

Psychologists and others seeking to establish that such and such an animal either has language or at least has the cognitive ability to acquire language need to be able to say what language is. Their approach is commonly to make a list of characteristics and show that their animal does indeed exhibit all of them, or at least that they can teach it enough to pass a battery of tests.

That strategy poses a number of problems. Any specific set of characteristics is liable to need constant revision, because as linguists learn more about language, its characteristics change. Nevertheless, at least two of them—the use of arbitrary symbols for nouns and verbs, and the use of syntax—are critical to assessing language ability.

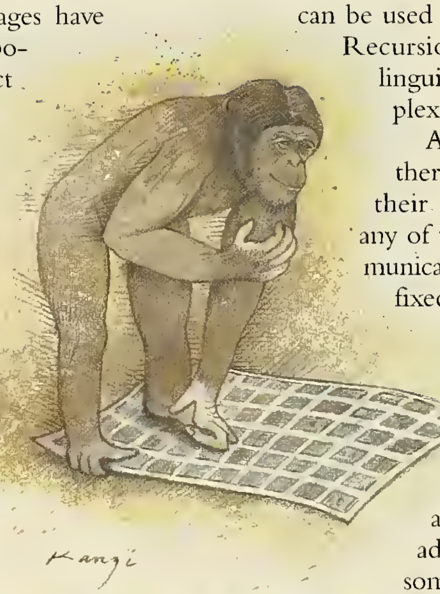
Investigators exploring the cognitive capacities of other species, particularly the people who study the putative language abilities of apes, have often complained about what seems to them a double

Animals communicate—without language—for a variety of purposes. The vocal sac of a male frog, ready to mate, expands; a randy male sage grouse's feathers ruffle. Threats provoke communication: a cobra hisses; a porcupine bristles its quills, and a dog responds by barking and baring its teeth. Some animal communication is inadvertent, such as the scents exuded by and covering scavenging ants.

standard. E. Sue Savage-Rumbaugh, a biologist at Georgia State University in Atlanta, objects that linguists "keep raising the bar."

> First the linguists said we had to get our animals to use signs in a symbolic way if we wanted to say they learned language. OK, we did that, and then they said "No, that's not language, because you don't have syntax." So we proved our apes could produce some combinations of signs, but the linguists said that wasn't enough syntax, or the right syntax. They'll never agree that we've done enough.

But linguists are not being capricious. What gives human language its power and its centrality in our lives is its capacity to articulate a range of novel expressions, thoughts, and ideas, bounded only by imagination. In our native language, you and I can produce and understand sentences we have never encountered before. Human languages have the property of including such a potentially infinite number of distinct sentences with discrete meanings because they are organized in a hierarchical and recursive fashion. Words are not just strung out one after another. Rather, they are organized into phrases, which themselves can be constituents of larger phrases, and so on—in principle, without any limit.



Kanzi, a bonobo that can communicate via a symbol-laden keyboard, is at the center of the debate about whether nonhumans can acquire language.

To see why that property is so important, suppose language did not have any syntax. Suppose that knowing how to speak a language were really just knowing a collection of words—lots of words, perhaps, but still a finite collection. In that case, speakers could talk only about a fixed range of things—namely, what they happen to have words for. Imagine you and I were at a baseball game, and our communication were restricted, somehow, to just such a finite collection of words. If the language did not have a specific word for "the third person in from the aisle in the front row of the upper deck," without syntax I could not refer to that specific individual. I might be able to say something like "catchperson!" and point to the spectator I meant. But with the resources of English, even without special words, I can tell you that "the third person in from the aisle in the front row of the upper deck caught Bonds's home run, but the guy behind him grabbed it away from him." You can understand all that instantly and unambiguously, even if neither one of us, or the individuals referred to, are present. And the reason I can put this expression together, and that you can understand it, is that we share the syntax of English.

What gives us the power to talk about an unlimited range of things, even though we only know a fixed set of words at any one time, is our capacity for putting those words together into larger structures, the meanings of which are a function of both the meaning of the individual words and the way the words are put together. Thus we can make up new expressions of arbitrary complexity (such as the preceding sentence!) by putting together known pieces in regular ways.

Furthermore, the system of combination is recursive. What that means is that language users only need to know how to construct a limited number of different kinds of structures, because those structures can be used repeatedly as building blocks. Recursion enables speakers to build linguistic entities of unlimited complexity from a few basic patterns.

Among animals in the wild, there is simply no evidence that their communication incorporates any of these structures. Instead, communication is limited to a rather small, fixed set of "words." Vervet monkeys, for instance, distinguish among a small number of different predators (eagle, leopard, and snake) and warn their fellow monkeys with a few distinct calls of alarm. Some groups have even adapted certain calls to announce something like "unfamiliar human coming"; others have developed a call for warning of dogs accompanying human hunters. Impressive as those behaviors may be, such an augmentation of the call system happened slowly, and the system itself remains limited. What's more, vervets have no way of saying anything about "the leopard that almost sneaked up on us yesterday."

The most persuasive claims about animal language come not from observing animals in the wild, but from attempting to teach various species of great apes to communicate via sign language or electronic consoles of symbols. Perhaps the best-known such project is Francine (Penny) Patterson's effort to teach American Sign Language (ASL) to a gorilla named Koko. Koko is, by Patterson's account, the ape that "really" learned sign language, using it the

way humans do—swearing, using metaphors, telling jokes, making puns. Unfortunately, we have nothing but Patterson's word for any of that. She says she has kept systematic records, but no one else has been able to study them. And without a way to assess Koko's behavior independently, the project is the best illustration imaginable of the adage that "the plural of 'anecdote' is not 'data.'"

Koko was a year old when Patterson began working with her in 1972. Patterson initially trained Koko by molding the gorilla's hands into the desired form, as she exposed the animal to whatever the sign symbolized. Koko caught on after a while and began to imitate. By the age of three and a half, Koko reportedly had acquired about a hundred signs, and by age five, almost 250.

Monkeys can say nothing about "the leopard that almost sneaked up on us yesterday."

Patterson also spoke aloud while signing, and it is reasonably clear that Koko's input was a kind of pidgin signed English rather than genuine ASL. That circumstance turns out to be a problem affecting several of the ape-language projects. Real ASL is a fully structured natural language, as expressively rich as English is. Hardly any of the investigators pursuing this research, however, have been fluent in ASL. As a result, the apes have not really been exposed to ASL, and so it is not surprising that they have come far short of learning it.

Since 1981, information about Koko has come only in forms such as *NOVA* or *National Geographic* television features, stories in the popular press, children's books, Internet chat sessions with Koko (mediated by Patterson, who acts as both interpreter and translator for the gorilla), and the ongoing public relations activities of Patterson's Gorilla Foundation. Such accounts make bold claims about how clever and articulate Koko is, but in the absence of evidence it is impossible to evaluate those claims.

And the information in the popular accounts does not inspire great confidence. Here is dialogue from a *NOVA* program filmed ten years after the start of the project (with translations for Koko's and Patterson's signing in capital letters):

> KOKO: YOU KOKO LOVE DO KNEE YOU
> PATTERSON: KOKO LOVE WHAT?
> KOKO: LOVE THERE CHASE KNEE DO
> OBSERVER: The tree, she wants to play in it!
> PATTERSON: No, the girl behind the tree!

Patterson's interpretation, that Koko wanted to chase the girl behind the tree, is not self-evident, to say the least.

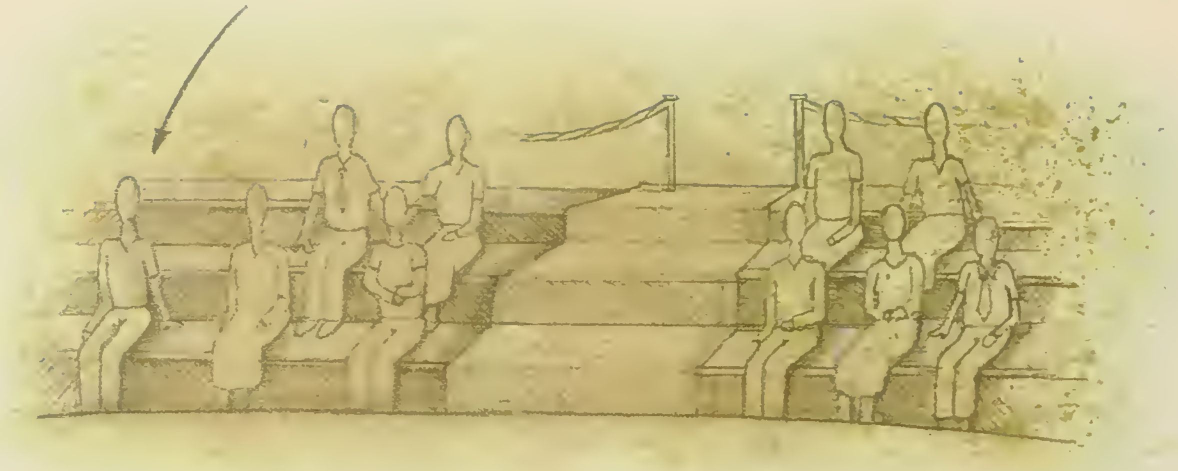
Sue Savage-Rumbaugh, whom I quoted above, has undertaken—along with her husband Duane Rumbaugh and others—what has proved to be the most substantial attempt so far to teach language to apes. Their subject, a bonobo named Kanzi, presents the most serious and genuine challenge to those who doubt the linguistic capacities of any nonhuman animal. Kanzi displays fascinating cognitive abilities that have not been documented before in any nonhuman primate. Yet he still falls well short of what an animal would have to do to truly acquire the structural essence of a human language.

What sets Kanzi's experience apart is that no one tried to teach him ASL or any other naturally occurring language. Instead, Savage-Rumbaugh and her team taught him a completely artificial symbol system, based on associations between meanings and arbitrary graphic designs called lexigrams. The lexigrams were available to the animal on a computer keyboard. Thus instead of issuing a series of signing gestures with his hands, Kanzi was expected to press the keys corresponding to what he (presumably) meant to say.

Actually, the research did not begin with Kanzi, but with his mother, Matata. At first, Matata was to have been trained to use the lexigram keyboard, but she turned out to be a rather poor student. The experimenters spent many long training sessions pressing lexigram keys on a keyboard connected to a computer, and indicating the intended referent. The computer responded by lighting up the key and uttering the spoken English word, but the training seemed to get nowhere.

Then something remarkable happened. Matata's infant son, Kanzi, was too young to be separated from her during the training sessions. When he was about two-and-a-half years old, however, Matata was removed to another facility for breeding. Suddenly Kanzi emerged from her shadow. Even though he had had no explicit training at all, he had learned to use the lexigram keyboard in a systematic way. He would make the natural bonobo hand-clapping gesture to provoke chasing, for instance, and then immediately hit the CHASE lexigram on the keyboard.

From then on, the focus of study became the abilities Kanzi had developed without direct instruction. In his subsequent training, the keyboard was carried around, and the trainers would press lexigrams as they spoke in English about what they and the animals were doing. While tickling Kanzi,



Syntax enables people to talk about things for which there are no specific words, such as "the person in the front row, third in, to the left of the aisle." Without syntax, the best one could do is point and say "person."

the teacher said, "Liz is tickling Kanzi," and pressed the three keyboard keys LIZ TICKLE KANZI. Kanzi himself used the keyboard freely to express objects he wanted, places he wanted to go, and things he wanted to do. The experimenters also tested Kanzi in more structured interactions, and Kanzi could still identify objects with lexigrams and vice versa.

By the time he was about four years old, Kanzi had roughly forty-four lexigrams in his productive vocabulary, and he could recognize the corresponding spoken English words. He performed almost flawlessly on double-blind tests that required him to match pictures, lexigrams, and spoken words. He also used his lexigrams in ways that clearly showed an extension from an initial, highly specific reference to a more generalized one. COKE, for instance, came to be used for all dark liquids, and BREAD for all kinds of bread—including taco shells.

Certainly further questions can be (and have been) raised about just what the lexigrams represent for Kanzi. Nearly all the lexigrams for which his comprehension can be tested are associated with objects, not actions, and so it is hard to assess the richness of his internal representations of meaning. Nevertheless, the lexigrams do appear to function as symbols, independent of specific exemplars or other contextual conditions. And there is no question that he has learned a collection of "words," in the sense that he has associated arbitrary shapes (the abstract lexigram patterns) with an arbitrary sound (the spoken English equivalent), and he has associated each of those with a meaning of some sort.

Assessing Kanzi's use of syntax is another matter. A major difficulty is that one must evaluate two different systems, those of language production and of language recognition. Kanzi's production centers on the keyboard; his recognition. on spoken English. To be sure not to underestimate Kanzi's abilities, one must examine both systems for evidence of syntactic understanding.

Kanzi uses his keyboard, but he does not produce enough multi-lexigram sequences to permit a detailed analysis of their structure. That is not to say he does not produce complex utterances. In addition to his keyed-in lexigrams, he expresses himself with a number of natural, highly iconic gestures, with meanings such as "come," "go," and "chase." He also employs pointing gestures to designate people, and he frequently combines a lexigram with a gesture to make a complex utterance.

Such combinations, taken out of context, might look like evidence for internalized rules of syntax. Kanzi does exhibit some reliable tendencies, such as combining words in certain orders: an action word precedes an agent word, a goal precedes an action, an object precedes an agent. But the full data make a semantic analysis of those orderings beside the point, because virtually all Kanzi's complex utterances follow a single rule: lexigram first, then gesture. The combining principle is intriguing, but it is not evidence of syntax, because it has nothing to do with the role that the "words" involved play in the meaning of a communication. It is as if, in English, we wrote the first word of the sentence, spoke the second, and emailed the third. Comparing the way the words were expressed, however, would tell us nothing about their meaning.

Because of such problems in interpreting his productions, arguments for Kanzi's command of syntax rely instead on his comprehension of spoken English. Investigators compared Kanzi's understanding with that of a child named Alia, the daughter of one of Kanzi's trainers. The two were studied at a similar stage of language development, at least in terms of the size of their vocabularies and the average length of their utterances.

Both Kanzi and Alia were quite skilled at responding appropriately to requests such as "put the ball on the pine needles," "put the ice water in the potty," "give the lighter to Rose," and "take the snake outdoors." Many of the actions requested (squeezing hot dogs, washing the TV, and the like) were entirely novel, so the subjects could not succeed simply by doing what one normally does with the object named.

The range of possibilities to which both Kanzi and Alia correctly responded was broad enough to show that each of them could form a conceptual representation of an action involving one, two, or more roles—that is, words could correspond to participants in action or locations of participants or actions. Both were then able to connect information in the utterance with those roles. Kanzi is the first nonhuman to show evidence for such an ability.

Kanzi can also make connections between word order and what the words express about the world. For example, he can distinguish between the sentences "make the doggie bite the snake" and "make the snake bite the doggie." His success, at a minimum, implies he must be sensitive to regularities in word order. Such an ability is unprecedented in studies of animal cognition. Still, it does not in itself prove that Kanzi represents sentences in terms of the kind of structure that characterize human understanding of language.

Remarkably, Kanzi can distinguish "make the doggie bite the snake" from "make the snake bite the doggie."

In contrast, when the understanding of a sentence depends on "grammatical" words, such as prepositions or conjunctions, Kanzi's performance is quite poor. He does not seem to distinguish between putting something *in, on,* or *next to* something else. Sentences in which the word *and* links two nouns (as in "give the peas and the sweet potatoes to Kelly,") or two sentences (as in "go to the refrigerator and get the banana") frequently lead to mistakes that suggest Kanzi cannot interpret such words.

It is also not clear that Kanzi can understand subordinating conjunctions, such as *that* or *which*. It is true that he can correctly respond to sentences such as: "Go get the carrot that's in the microwave." But appropriate behavior alone does not imply that he has understood the sentence as having a hierarchical structure with an embedded clause, specifying a particular carrot (the one in the microwave) rather than any other (such as one on the counter or on the floor). The content words alone ("go, "get," "carrot," "microwave") are enough to convey the command: "carrot" has to be the object of "go get," but "microwave" has no role to play in that action and can only be interpreted as a property of the carrot (its location). Kanzi needn't understand the grammar to get the right carrot.

Concrete verbs and nouns correspond to observable actions and things in the world, and they can constitute the meanings of symbols for Kanzi. Prepositions and conjunctions, however, are important because they govern how words and phrases relate to one another. Kanzi can associate lexigrams and some spoken words with parts of complex concepts in his mind, but words that are solely grammatical in content can only be ignored, because he has no grammar in which they might play a role.

What then does it mean to use a natural language? Here is a classic example: "The chickens are ready to eat." The sentence has two strikingly different interpretations, but the ambiguity has nothing to do with grammatical words, ambiguous words, or the multiple ways of organizing words into phrases. One interpretation is that someone has chickens that are ready for people to eat. The other interpretation is that some chickens are hungry.

The point is that the syntax of a language involves more than merely combining elements into sequences of words. Sentences incorporate that kind of structure, to be sure, but they also have much more structure, involving abstractions that are not readily apparent in the superficial form of the sentence—abstractions that allow the same group of words to communicate very different pieces of information in systematic ways.

As speakers of a natural language, we manage such abstractions without noticing them. But without them, language would not be the flexible instrument of expression and communication that it is. Perhaps that is the most important "take-home lesson" from the studies of animal communication. Nonhuman animals lack the kind of system that linguists are still hard at work trying to understand, and without such a capacity, animals can communicate only in much more restricted ways. The ability to use language is probably grounded in the biological nature that makes us the particular animal we are. □

Adapted from Stephen R. Anderson's forthcoming book, Doctor Dolittle's Delusion: Animals and the Uniqueness of Human Language, *which is being published this month by Yale University Press.*

THIS LAND

Peruvian Dry Life

Between the Andes and the Pacific, an arid landscape harbors abundant life.

By Robert S.R. Williams

Dry forest in northern Peru, a haven for wildlife

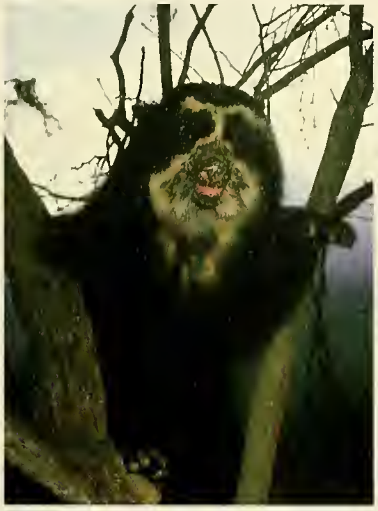
This November 21, PBS will air director Kevin Macdonald's film *Touching the Void,* shot on location in the Peruvian Andes. It recounts the famous mountaineering story of a climber who falls, shatters his leg, and barely escapes with his life. If the spectacular scenery in the movie inspires you to travel to Peru, be sure to allow time to visit what biologists call the Tumbesian region, encompassing the extreme southwestern corner of Ecuador and the northwestern corner of Peru.

At first, the Tumbesian region may sound uninviting: It is a parched, rural, thinly forested landscape sandwiched between the western slopes of the Andes and the Pacific Ocean. Its plains are overgrazed, and its forests are overlogged. Yet it is also a global hot spot of biodiversity, with scores of endemic species of amphibians, birds, mammals, plants, and reptiles. As a whole, the region supports nearly sixty endemic bird species and about ten endemic species of mammals. Some 20 percent of the plant species and a staggering 60 percent of the reptiles and amphibians occur nowhere else in the world. Endemic species are numerous here in part because of the surrounding climatic and topographical barriers. The Pacific lies to the west, the towering Andes to the east, the wet forests to the north, and the Atacama Desert—the most rainless place on Earth—to the south. The cold waters of the offshore Humboldt Current, as well as the proximity of the Andean peaks, play a role in the dryness and stability of the climate.

The region is also the locus of 1,500 years of dramatic and bloody human history. For a millennium before the arrival of Spanish conquistadors in the early sixteenth century, great cities flourished close to what is now the lively Peruvian coastal city of Chiclayo, as they did elsewhere in Peru. Huge pre-Inca pyramids and palaces, lavish burial sites, and extensive aqueducts have been uncovered near Chiclayo, at sites such as Batan Grande, Sicán, Sipán, and Túcume. The peoples who built those cities maintained transportation networks connecting inland farms with coastal fisheries.

In 1532 the Spanish adventurer Francisco Pizarro and his recruits entered the Tumbesian region, initiating an era of colonization, accelerated population expansion, shipbuilding, and the conversion of forests to cropland. By the twentieth century the dry forests were severely depleted and degraded. Yet conservation planning was impossible until 1998, when a half-century-long border dispute between Ecuador and Peru was finally resolved. Today a consortium called Bosques Sin Fronteras (Forests without Borders) is working, in collaboration with the region's inhabitants, to conserve and rehabilitate about 2,500 square miles of the surviving Tumbesian dry forest.

In one of the more remote pockets of that forest, about fifty miles inland from Chiclayo, is the first community-owned ecological reserve in Peru, the 133-square-mile Chaparri Private Conservation Area. The reserve was created four years ago through the joint efforts of a wildlife photographer, a bear biologist, a conservation ecologist, and the 500 families of Santa Catalina de Chongoyape, within whose communal lands the reserve is situated. The Chaparri reserve is one of the first tangible steps toward realizing the goals of Bosques Sin Fronteras. It has become a refuge for endangered species, a haven for individual damaged animals, a recovery site for plant life, and an employment opportunity for local residents. It is also a place where a traveler can spend an afternoon sitting beside a stream



White-winged guan (left) and spectacled bear (center), two endangered species being protected in the Chaparri Private Conservation Area

and watching hordes of hummingbirds from a dozen feet away.

Communities nearby, having observed Chaparri's successes, are seeking to establish a network of such reserves. The goal is that within five years a biological corridor—provisionally known as Gran Chaparri—will be in place. Not only would it protect a huge swath of the southern Tumbesian region, but it would also allow local residents to pursue their traditional practices, including grazing herds of goats and cattle.

Unfortunately, the very uniqueness and isolation of the region now threatens many of its flora and fauna: only about 5 percent of the once-thriving forests remain in a healthy state of conservation, and many species of birds and mammals have been hunted to extinction. The wild population of the white-winged guan, for instance—a critically endangered Tumbesian bird thought to be extinct until it was rediscovered in 1977—still numbers fewer than 250 birds. Nevertheless, even a habitat subjected to enormous stress can still hold surprises: at Chaparri, several seemingly new species have been discovered, including a porcupine and a cat.

Conservation initiatives already under way at Chaparri include a five-year moratorium on hunting white-tailed deer; a wetland restoration project; and the levying of an annual grazing fee of roughly three dollars per animal, which every herder must pay. Reforestation, too, has begun: more than four tons of native mesquite seed have been sown at the reserve's lower elevations. In addition, some 1,500 nursery-grown native fruit trees, mostly guava, have been planted, and a drip-irrigation system has been installed to ensure their longevity.

Last year, the reintroduction of the white-winged guan commenced; twenty-six released birds now survive within the boundaries of the reserve, including four wild-hatched young. Spectacled bears are being protected, and a rescue facility has been established for confiscated bears illegally held by circuses or private owners. In the works are projects to help protect the Andean condor and to reintroduce the guanaco—a South American member of the camel family—to Tumbesian Peru. Santa Catalina's communal lands will long remain parched, but soon be more bountiful.

ROBERT S.R. WILLIAMS, a conservation ecologist, is the scientific director of the Peruvian environmental group Asociación Naymlap.

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Pimentel, Peru
011-51-74-9685626
chaparri@terra.com.pe
www.chaparri.org

Wildlife Sampling

Birds Andean condor, aplomado falcon, Baird's flycatcher, cinereous finch, collared antshrike, comb duck, elegant crescent-chest, grey-and-white tyrannulet, Guayaquil woodpecker, henna-hooded foliage-gleaner, king vulture, little woodstar, necklaced spinetail, ochre-bellied dove, Pacific hornero, Peruvian black-faced ibis, Peruvian plantcutter, Peruvian sheartail, Peruvian thick-knee, purple-collared woodstar, red-masked parakeet, rufous flycatcher, scrub nightjar, solitary eagle, Tumbes hummingbird, Tumbes sparrow, Tumbes tyrant, white-edged oriole, white-tailed jay, white-winged guan.

Mammals Collared peccary, fraternal fruit-eating bat, long-tailed weasel, northern tamandua, pampas cat, puma, Sechuran fox, spectacled bear, tayra, white-tailed deer.

Reptiles Barnett's lancehead, green iguana, Peruvian boa constrictor, Tumbesian tegu (false monitor).

American Spirits

The Neopagan and New Age movements have now been put under the microscope of anthropology.

By Michael F. Brown

Neopagans with lighted candles at a "spirit gathering" held last summer in southeastern Ohio

Witching Culture: Folklore and Neo-Paganism in America
by Sabina Magliocco
University of Pennsylvania Press, 2004; $55.00 cloth, $19.95 paper

New Age and Neopagan Religions in America
by Sarah M. Pike
Columbia University Press, 2004; $35.00

Alexis de Tocqueville, the nineteenth-century French thinker whose observations on daily life in early America remain as fresh today as they were when they were published in 1835, was fascinated by the nation's religious enthusiasms. "Scattered throughout American society," he wrote,

> one finds souls filled with an impassioned, almost wild spiritualism that one seldom encounters in Europe. From time to time there arise bizarre sects that attempt to open up extraordinary pathways to eternal happiness.

For Tocqueville, such religious zeal was an inevitable reaction to the materialism of the young republic. "I would be surprised," he predicted, "if, in a nation preoccupied solely with its well-being, mysticism did not make some progress before long."

Mysticism and religion in general continue to prosper in America. Global opinion surveys consistently show that many more Americans identify religion as an important force in their lives than do their counterparts elsewhere in the developed world. Cross the border into Canada and the self-reported significance of religion drops in half. One recent poll indicated that Dutch respondents were eight times more likely than Americans to report that they do not believe in God. The steady decline of religious belief in Western Europe has led some commentators, ranging from academics to the religious right, to label the region "post-Christian."

Why has the United States remained distinctive in the intensity of its religious commitments? Following Tocqueville, some experts hold that the single-minded pursuit of material wealth in the U.S. creates an emotional emptiness that draws people to religious faith. Others note that the U.S. never had an official state religion so embedded in everyday experience that citizens felt free to ignore it, as has been the case in much of Western Europe. A few scholars have suggested that America remains a hothouse for spirituality because constitutional protections make religion the single most unregulated zone of our otherwise bureaucratized, legalistic society. The vitality of contemporary American religion can also be traced to high levels of immigration from countries where faith still matters.

The energy of American religion is inseparable from its diversity. As a nation that welcomed religious dissenters, the U.S. has long been known for the variety of sects that flourished here, a circumstance that famously prompted another Frenchman, the late-eighteenth-century diplomat Charles Maurice de Talleyrand-Périgord, to complain that America had thirty-two religions but only one kind of sauce. Of course, Americans have more choices of food than in Talleyrand's time, but the choices of religion have certainly multiplied as well.

Among the most controversial expressions of contemporary American spirituality are the New Age and Neopagan movements, the subject of new books by Sabina Magliocco and Sarah M. Pike. Magliocco, a cultural anthropologist at California State University in Northridge, offers a detailed look at efforts to revive pre-Christian forms of spirituality, which its practitioners adopt as an antidote to what they see as Christianity's moral rigidity and disregard for the natural environment. Although Magliocco provides background information on the history of pagan revivals in Europe and America, her account is primarily an ethnographic study of Neopaganism in the San Francisco Bay area.

Pike, a professor of religious studies at California State University in Chico, approaches Neopaganism and the related New Age movement more comparatively. Hers, in contrast with Magliocco's, is a view from the mountain, a search for broad patterns and common themes. Yet she, too, offers enough portraits of individuals to give her account a human face.

Groups that flee conventional understandings and institutions are predictably touchy about labels. Many Neopagans, for instance, resent the tag "neo" because they see themselves as reviving a religion that has always been part of human experience. They prefer to call themselves "pagans." They also voice a bewildering array of more specific identities—as druids, Wiccans, witches, practitioners of "the Craft," or worshipers of "the Goddess." Some are organized into recognizable denominations—the New Reformed Orthodox Order of the Golden Dawn is a prominent example. The majority take a more fluid approach, aligning themselves with one coven, or group, while regularly sampling the ritual activities of others. They draw on an equally diverse set of cultural traditions: Anglo-Saxon, Celtic, Greco-Roman, Nordic, and occasionally African or Native American.

Talleyrand once complained that America had thirty-two religions but only one sauce.

The New Age movement is even trickier to define and label. I studied New Agers in the mid-1990s, and at that time they tended to refer to their spiritual interests as "metaphysical," mentioning the term "New Age" only for ironic effect. But the label has stuck, and it is better than most of the alternatives. Pike identifies the movement's common denominator as a commitment to the "transformation of both self and society." New Age practices include astrology, channeling (direct communication with spirits), work with one's "inner child," shamanism, vision questing, and a laundry list of unconventional healing techniques. Some scholars have labeled the New Age an "audience cult," rather than a kind of religion in the conventional sense, because of its diffuse, networklike quality.

Unlike Neopagans, who look for spiritual meaning in ancient traditions, New Agers tend to focus more intently on the future. They are also more individualistic and less inclined to accept the personal compromises needed to maintain a stable group. That tendency has led to accusations that the New Age movement attracts self-indulgent consumerists whose primary focus is on themselves. New Age excesses have provided fertile ground for satire, the most memorable of which may be the cartoonist Gary Trudeau's send-ups of channeling, which enlivened *Doonesbury* in the late 1980s.

In fact, Neopagans must be counted among the fiercest critics of the New Age. Neopagan Web sites frequently include jokes that lampoon the financial motives of New Age gurus and therapists: Q. What is the difference between a New Age event and a pagan event? *A.* About $500. Yet on the evidence put forward by both Magliocco and Pike, the two movements, in their theological flexibility, organizational looseness, and resistance to authority, have much in common.

Studying Neopagans and New Agers is not as easy as you might expect. Many Neopagans, for instance, are secretive about esoteric ritual knowledge. Fieldworkers documenting Neopagan beliefs and practices must devote years to building strong personal relations with their research subjects. They may also have to accept restrictions on what they can record and publish. That is part of the dilemma posed by Magliocco's account. Pursuing her anthropological study required, to some degree, that she "go native": in her case, undergo ritual initiation in the Coven Trismegiston, a group based in Berkeley, California, and take an oath of silence about the ritual's content. She participated in a range of group events thereafter for several years and, indeed, found a spiritual home in Neopagan worship. Thus it is important to note that there

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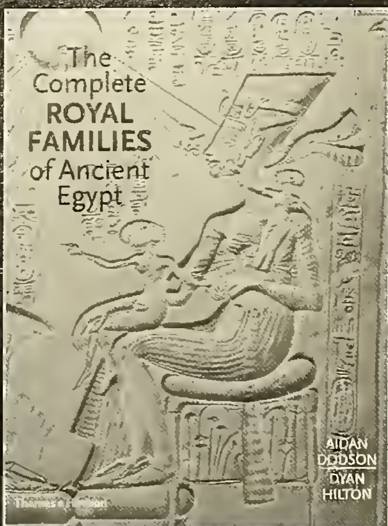

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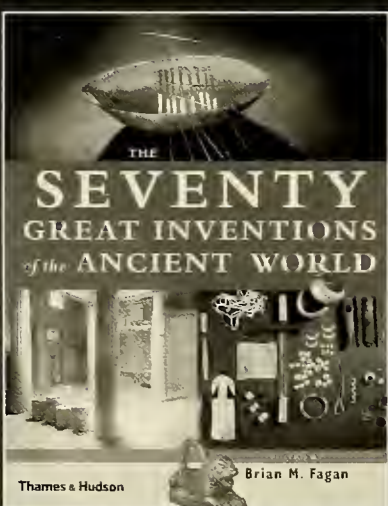

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are legitimate questions about her objectivity. To her credit, however, she is open about her attachments and willing to comment dispassionately on aspects of Neopaganism that perplex or amuse her.

The challenge of research into New Age practices and beliefs is more or less the opposite: the movement's antipathy to organizations complicates efforts to develop a coherent picture of its devotees' views or even to figure out who its devotees are. Pike does an admirable job of weaving together multiple strands of New Age practice into a single pattern, but the coherence she thus establishes inevitably frays a bit at the edges.

Both movements have deep roots in American culture and history. For much of the nineteenth century, the nation was awash in religious experiments, many influenced by European occultism. Spiritualists regularly communicated with the dead in middle-class drawing rooms. Educated nonconformists reinvented religious and family life in utopian communities such as Amana, Brook Farm, Koreshan, and Oneida. Charismatic visionaries proclaimed new theologies loosely based on biblical revelation—one of which, the Church of Jesus Christ of Latter-Day Saints, today ranks among the world's fastest-growing religions. And, inseparable from spiritual innovation, was the rise of novel therapies: chiropractic, faith cures, homeopathy, magnetism, vegetarianism, and New Thought, the latter emphasizing the power of positive thinking.

As Pike observes, some of this ferment was linked to progressive politics. Abolitionists, freethinkers, and suffragettes found spiritual innovation compatible with their quest for social reform. Even less overtly political forays into spirituality and healing were based on an underlying conviction that people should meet their own needs rather than surrender control to clergymen or doctors. Women were especially prominent in these experiments, apparently because they were able to assume leadership roles denied them in mainline churches. The lure of self-empowerment lives on in the contemporary movements documented by Magliocco and Pike.

Unlike Heaven's Gate, most New Age groups show little lasting interest in charismatic gurus.

So what do followers of New Age and Neopagan religions actually do? How do they worship or express their spirituality? According to Pike, New Agers are likely to gather in homes or conference centers to meditate, listen to someone "channel" a wise spirit, share ideas about approaches to healing, or try out techniques to get in touch with their spiritual core or "true self." The prevailing atmosphere may be solemn or playful, but it always has an improvisational quality. Participants are often strangers to one another, and their expectations of what should take place may vary considerably. Skillful facilitators learn to balance their own goals and those of audience members by encouraging give-and-take. Because New Agers resist dogma, almost any statement of belief requires the disclaimer, "This is my personal reality, but it may not be yours."

The New Age movement has given rise to a handful of groups whose followers respond to every twitch and whim of a charismatic guru. Heaven's Gate, a cult with New Age antecedents, self-destructed in 1997 in a tragic mass suicide. But the centrifugal tendency of the movement is so pronounced that the shelf life of charismatic leaders tends to be brief. New Agers see themselves as individuals embarked on a spiritual journey, and they are disinclined to stop for long at any one place along the way.

Neopagan spirituality, as Magliocco

explains, "involves training the imagination to perceive the links connecting the elements in the universe." The connections follow natural laws that fold space, time, natural phenomena, human beings, and spirits into a unitary system. The laws of mutual causality are put to work in elaborate group rituals, many held outdoors, that summon the energy of gods, goddesses, fairies, and the Earth itself.

Neopagan rituals mark the transitions from season to season throughout the year, as well as milestones in the lives of individuals—birth, maturation, marriage, death. They may also focus healing energies on group members facing personal crises. In Magliocco's own case, her coven held an improvised ritual that, according to her fellow participants, helped secure her a university teaching post. Whether the spirits invoked are Celtic, Roman, or simply the Goddess, the rituals promote group catharsis and even ecstasy. In field notes reproduced in Magliocco's book, the author describes her own visionary trances, which made her feel "alive, aflame, part of the dance."

Such a focus on the group rather than the individual in Neopaganism is inextricably bound up in what Magliocco calls an "oppositional identity." Neopagans see themselves as actively resisting the excesses of a monotheistic, patriarchal, nature-hating culture that has launched humanity on a path to self-destruction. The radical wing of Neopaganism is represented by a group that calls itself Reclaiming, an ecofeminist collective dedicated to social activism and opposed to nuclear power, logging in the Pacific Northwest, and the expansion of global capitalism.

Magliocco suggests that her research subjects, most of whom come from European-American backgrounds, have embraced Neopaganism as a new subcultural identity, preferable, in their view, to their own traditional ethnic backgrounds, which have lost vitality. Along with that shift in self-perception comes a

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self-dramatizing concern with the powerful forces allegedly arrayed against pagan practices today—an identification, no doubt, with the violent witch hunts that punctuated the history of Europe and colonial America, the so-called "Burning Times." Yet even though Neopagans are occasionally—and mistakenly—confused with Satanists in the popular imagination, neither Magliocco nor Pike presents compelling evidence that Neopagans are more likely to suffer discrimination than are members of other minority religions.

Stone circles assembled by New Agers at the base of sandstone cliffs in the desert

Neopagans regularly mine published works of folklore and anthropology for inspiration as they try to recover pre-Christian ritual knowledge. Early twentieth-century efforts to reconstruct pagan practices mostly drew on a patchwork of folkloric accounts, many detailing magical beliefs and practices that had survived for centuries in Europe's isolated peasant communities. Today Neopagans range more widely, blending ideas from theoretical disciplines—including psychology and religious studies—with oddments of folklore, some of such dubious accuracy that they are dismissed as "fakelore" by skeptics.

Many of Magliocco's Bay Area research subjects are highly educated professionals whose conversations about religion remind one of graduate-school seminars. When I studied anthropology in the 1970s, experienced fieldworkers groused that their native informants were rarely able to explain beliefs and practices with anything more satisfying than the throwaway line, "We do it because it's customary." Today's Neopagan "natives," in contrast, are likely to cite Carl Jung or Jacques Lacan, and interpret one of their ceremonies as "symbolic praxis mediating the binary opposition of male and female." Nothing is more discomfiting to social scientists than having their own writings thrown back at them by research subjects, which may be a reason why sustained ethnographic fieldwork among Neopagans and New Agers is still relatively rare.

The inclination to borrow liberally from many traditions has sparked complaints that New Agers and Neopagans are hijacking the religions of the world's indigenous peoples, particularly those of the American Indians. Critics within both movements have tried to underscore the hurtful impact of imitating another community's most sacred rituals. New Agers who perform faux sweat-lodge or medicine-wheel ceremonies in their backyards increasingly face criticism from their politically sensitive peers. The desire to avoid disapproval may account for the New Agers' inclination, apparently growing, to leave Native American traditions alone and instead to comb the early religions of Europe for inspiration.

Magliocco and Pike are well aware that Neopagans and New Agers still constitute a religious minority in contemporary America. Accurate information on the size of either movement is scarce. Magliocco estimates that about 700,000 North Americans practice Neopaganism, a number that appears to be growing steadily. New Agers are harder to count, given the transitory nature of their loyalties. Pike cites journalistic estimates of roughly 12 million practitioners, a figure that should be regarded with caution.

Whatever the correct number, one has to acknowledge the movements' cumulative impact on American values. Thirty years ago, who would have thought that yoga would be taught at Girl Scout camps, or that highly educated professionals would become regular consumers of herbal medicines and fringe healing techniques? Who imagined that one First Lady, Nancy Reagan, would routinely consult an astrologer, and another, Hilary Rodham Clinton, would seek the counsel of Jean Houston, a psychologist with impeccable New Age credentials? Whether one welcomes or deplores the spread of unorthodox spiritual practices, there is little question that New Age and Neopaganism practices have subtly reshaped public life in the U.S.

For anyone who wants to take the measure of alternative spirituality in America, these books are excellent places to start. Pike's is the more concise and readable of the two, Magliocco's the more fine-grained and theoretically ambitious. Both balance sympathetic portraits of individual practitioners with frank reflections on the movements' inconsistencies, internal squabbles, and areas of moral blindness. One comes away from both books with renewed appreciation for the restless creativity of Americans, who today, as in Tocqueville's time, seem unable to settle for middling piety or garden-variety contentment.

MICHAEL F. BROWN is a professor of anthropology at Williams College and the author of The Channeling Zone: American Spirituality in an Anxious Age *(Harvard University Press, 1997) and, more recently,* Who Owns Native Culture? *(Harvard University Press, 2003).*

By Laurence A. Marschall

Defining the Wind: The Beaufort Scale, and How a Nineteenth-Century Admiral Turned Science into Poetry
by Scott Huler
Crown Publishers, 2004; $23.00

The remarkable life of Sir Francis Beaufort (1774–1857), one of the generation of polymaths who ushered in a golden age of natural history in Victorian England, seems the perfect subject for a modern biographer. Beaufort began his adventures at sea at age fourteen, captained a Royal Navy ship by age twenty-two, and for more than twenty years seldom seemed to step onto dry land. In 1817 he wrote a best-selling travel book—illustrated with his own meticulous drawings—about the little-known southern coast of Turkey, where a grievous wound sustained during a brawl with the locals ended his seafaring career. In the succeeding three decades he served as chief of the admiralty's Hydrographic Office, consolidating Britain's rule of the seas by fostering the scientific observation of the oceans and the exploration of remote shores. Beaufort was on friendly terms with Captain William Bligh, of *Bounty* fame, and with Captain Robert Fitzroy of the *Beagle*, as he was with most of the scientific luminaries of the age. It was Beaufort, in fact, who suggested to the young Charles Darwin that he sail with the *Beagle* as its onboard naturalist.

Claire Forgeot, Force-five wind (from the book The Rising of the Wind: Adventures along the Beaufort Scale, *by Jacques Yvart, Green Tiger Press, 1984)*

Yet Scott Huler's book is not exactly a biography of Beaufort, who has already been well served by historians and biographers. Rather, it is more of an extended essay on what Huler, a journalist by trade, learned while tracking down the story of the admiral's most lasting accomplishment: a twelve-step numbering system for gauging the strength of winds. The Beaufort scale, of course, has become a part of the standard operating lingo for meteorologists and sailors. Huler, who first noticed it twenty years ago in a dictionary, was immediately smitten by its economy, its matter-of-fact utility, and its almost poetic imagery and cadence: "0: calm smoke rises vertically"; "6: strong breeze; large branches in motion; telegraph wires whistle; umbrellas used with difficulty"; "9: strong gale; slight structural damage occurs; chimney pots and slates removed." Like Beaufort, who filled dozens of pocket notebooks with daily observations of anything that struck his fancy, Huler began to fill notebooks with odd facts and observations about the wind and about the origins and evolution of the Beaufort scale.

Much of his research, as one might expect, was done in library stacks and government archives, where Huler found, unsurprisingly, that Beaufort's wind scale was not the first of its kind. Daniel Defoe, in a 1704 book called *The Storm*, had organized winds into categories, as had Robert Hooke in the 1600s and Tycho Brahe in the late 1500s. In 1759 John Smeaton, a British engineer, defined a hierarchy of winds on the basis of how fast they turned a windmill. In about 1790 Alexander Dalrymple, one of Beaufort's predecessors in the Hydrographic Office, devised a table combining Smeaton's scale for windmills with the descriptions used in ships' journals to record the force of the wind.

Although it's doubtful that Beaufort ever saw that table (it appeared in a text, *Practical Navigation*, that was never published), Dalrymple's work anticipated Beaufort's first scale, with its descriptive phrases based on the number of sails a standard three-masted vessel could keep aloft in a particular wind. That scale was widely adopted and bears Beaufort's name, largely because of his preeminence at a time when Britain ruled the waves.

What makes Huler's book exceptional, however, is his absorbing account of how he tried to empathize with Beaufort, to find out what kind of person would devise and use such a scale. Huler took a boat to Montevideo, Uruguay, toting the young oceanographer's 1806 sketches and charts of the harbor, to relive some of Beaufort's experiences. He sailed on board a three-masted bark, the *Europa*, to feel the wind the way it must have felt to a nineteenth-century seaman. He interviewed historians, weathercasters, even poets and musicians who had been inspired by Beaufort's scheme.

What did he learn from it all? That the numbers are not what give the Beaufort scale its lasting value. After all, modern anemometers can read off wind speeds to as many decimal places as there are numbers on an LCD display. The true value is the message implicit in its lucid prose, inspiring us to observe nature with the wide-eyed empathy of a curious naturalist. Look beyond the numbers, Huler tells us; look to the meaning, not just the ranking, of the wind.

¡Tequila!
A Natural and Cultural History
by Ana G. Valenzuela-Zapata
and Gary Paul Nabhan
University of Arizona Press, 2004;
$29.95 cloth, $14.95 paper

Agave, a genus of hardy succulent plants that dot the landscape from the Grand Canyon to Guatemala, derives its scientific name from the Greek word *agauē* ("illustrious" or "noble"). Yet centuries before Europeans first encountered the plant, during the conquest of Mexico, the indigenous hunter-gatherers of the region had already come to admire its virtues. Trimming its forbidding fright wig of spiny leaves, they discovered a sweet, nutritious bulb of plant material, called a *bola*, at the base of the stem. The native Mexicans roasted the ball, which resembles a giant pineapple, for several days among slow-burning coals. The roasted bola could also be left to ferment, yielding a mildly alcoholic drink known as *mescal crudo*.

The most familiar modern descendant of the drink is tequila, a colorless liquor distilled from roasted, fermented blue agaves, often given a little extra kick by adding sugar to the mash. For more than a century the plant has been cultivated principally in the Mexican state of Jalisco, with production centered around a town a few dozen miles northwest of Guadalajara. Tequila—for that is the name of the town—has become synonymous with the purest, strongest form of the drink.

Many millions of agave plants grow today in Jalisco's volcanic soil, and much of the tequila produced there each year is exported to the United States and Europe, where it frequently winds up in such festive drinks as the margarita.

The worldwide popularity of tequila is a quite recent phenomenon. For many years the crystal fluid, sometimes distilled to more than 100 proof, was reckoned as nothing but a cheap high for boozing cowboys. But in the past few decades, as globalization has brought Tex-Mex and other spicy foods to palates accustomed to more timid fare, tequila has gained legitimacy and even sophistication. To slake the growing thirst for the stuff, traditional agricultural practices have become industrialized, turning family farms into giant conglomerates.

As tequila flowed to the masses, a market for specialty formulas of the liquor took form. Market-savvy growers lavished care on the best agave plants, carefully controlling distillation, using only natural agave sugars in the fermentation, and aging the product under tightly controlled conditions. "Artisan" batches of the best tequila began to be sold in designer bottles, appealing to a coterie of tequila connoisseurs who savor the drink undiluted, in small shots. A true tequila aficionado (dubbed a "tequilleur" by the authors) can argue the merits of agaves from the Los Altos region versus those from the *zona centro* with the intensity of a scotch drinker defending the superiority of a particular brand of single malt. Buoyed by the market for mavens, boutique bottles of the finest tequila can run as high as a couple of thousand dollars. Some restaurants specialize in the stuff—I visited one in San Diego several years ago that offers literally hundreds of brands of fine tequila.

Agave bolas at the Herradura Tequila Distillery, Jalisco State, Mexico

Ana G. Valenzuela-Zapata and Gary Paul Nabhan, two respected experts on agave agriculture, have produced a scholarly yet entertaining guide to the history and husbandry of this phenomenal beverage. They devote an entire chapter to analyzing the problems associated with Jalisco's single-crop agriculture, which have led to devastating agave blights. They provide a lengthy bibliography and an illustrated guide to the various agave cultivars, along with copious reference notes in the text. But they also give lucid accounts of traditional methods of cultivation, along with stories from the modern-day *jimadores*, harvesters who traditionally wield a *jaivica*, or axelike tool for trimming and uprooting agave bolas. For most readers, tequila may be better sipped than studied. But since a little tequila goes a long way, this book can provide an alternate, albeit less intoxicating, form of pleasure. (See also www.ianchadwick.com/tequila/links.html for more lore and links about tequila.)

The Geese of Beaver Bog
by Bernd Heinrich
Ecco, 2004; $24.95

Just before dawn on September 2, 2002, a dozen Canada geese *(Branta canadensis)* landed on a beaver bog not far from the home of Bernd Heinrich, a biologist at the University of Vermont. To many suburbanites, such a landing would be no cause for joy: Canada geese have become so common on lawns and golf courses in the Northeast that people regard them not as elegant avatars of wildness, but as noisy, messy squatters. Heinrich, however, welcomed the birds, for among them was an old friend named Peep—a female that Heinrich adopted when she was just a few days old, and who had spent the summer of 1998 living with his family. Now on her own, Peep was stopping by on her way south, seemingly to pay her respects, and perhaps to show off the kids—a brood of goslings trailing in her wake—to the new grandparents.

Some members of Bernd Heinrich's extended family

Serving as a surrogate father to Peep, much less writing about the secret lives of geese, was probably the last thing on Heinrich's mind when he first noticed the geese near his property. Highly regarded for his research on animal adaptation, Heinrich has written a number of lucid popular books on the subject. But studies of geese, as anyone who has the slightest acquaintance with animal behavior knows, are dominated by the formidable figure of Konrad Lorenz, who devoted half a century to the greylag goose *(Anser anser)*, and whose book *King Solomon's Ring* is one of the past century's most influential ethological texts.

Lorenz popularized the concept of imprinting, the learning process whereby animals, in a critical period during development, may form a parent bond with the first nurturing creature they encounter. (As it happened, famously, Lorenz himself sometimes became that parental figure.) Lorenz's spiritual "descendants" thus include not only legions of his students, but also a flock of greylag geese at the Konrad Lorenz Research Station in Grünau, Austria.

Yet if Heinrich had no intention of following such a well-trampled research path in 1998, his two-year-old son Eliot persuaded him otherwise. An orphaned gosling, Heinrich soon realized, afforded a unique opportunity to observe family relations among wild birds. Peep flew south at the end of that summer but returned two years later with a mate (the Heinrichs named him Pop) to nest in the pond once more. In the next few years, because of his imprinted relationship with the goose, Heinrich was able to observe Peep at close range whenever she reappeared. When Peep moved on to other ganders and no longer frequented Beaver Bog (contrary to popular belief, geese do not mate for life), Heinrich was able to establish close relations with the female that became Pop's new love interest. The new goose, Jane, allowed the scientist to stroke her back, lift her off her nest, and even inspect her eggs during incubation.

Most of all, the geese just let him be there, pen in hand, and *The Geese of Beaver Bog* is the result. The book is really a selected diary of observations, unencumbered by references to Lorenz's work, which Heinrich claims he didn't read closely until his project was completed. Instead of explaining goose behavior (which he does only briefly, in an appendix), Heinrich aims to recreate the rhythms of bog life: frost sparkling on sedges in the morning light; red-winged blackbirds flitting in and out of the bushes and reeds; beavers surfacing in the pond; coyotes appearing furtively on shore. The intent, as in Heinrich's earlier books, is to apprehend an animal from the "inside," and so learn implicitly how it knows what it knows, why it does what it does. If geese were literate, they'd no doubt offer encouragement after reading Heinrich's account. "Yes," Peep might honk, "that's how it was."

LAURENCE A. MARSCHALL, author of The Supernova Story, *is the W.K.T. Sahm professor of physics at Gettysburg College in Pennsylvania, and director of Project CLEA, which produces widely used simulation software for education in astronomy.*

Full Spectrum

By Robert Anderson

The English astronomer William Herschel is best remembered for his hand-built telescopes and his discovery of Uranus in 1781. But to my mind the simple experiments he performed with glass prisms and thermometers in 1800, with which he detected what is now known as infrared light, were far more momentous. They gave science its first evidence that an entire world lay hidden beyond the limits of our visual perceptions.

If you'd like to duplicate Herschel's experiment, go to the site devoted to the infrared universe, "Cool Cosmos" (coolcosmos.ipac.caltech.edu). An animated turning gear previews the menu items as soon as the home page opens. When the gear turns to "Cosmic Classroom," click on "Infrared Light Lessons" and then on "The Herschel Experiment." You can also visit the "Infrared Zoo" (in the "Cosmic Kids" section), where animals are viewed through a thermal infrared camera, and the difference between warm- and cold-blooded animals takes on a whole other dimension.

For a thorough guide to the electromagnetic spectrum, go to "Imagine the Universe" (imagine.gsfc.nasa.gov). Scroll down to the blue menu bar and click on "Imagine Science." Thus informed about the potential of each wavelength for contributing to astronomy, you'll be ready for the Web sites that focus on the telescopes that gather information from narrow slices of the spectrum in increasingly precise forms.

For example, the longest wavelengths in the universe are radio waves. At the Web site of the National Radio Astronomy Observatory (www.nrao.edu), click on "General Public," on the menu bar at the left, for an informational video. It tells you about radio telescopes around the globe. And if you've never heard the likes of sferics, tweeks, or whistlers, or listened to radio from Jupiter, tune in to a page on the site "Exploring the Electromagnetic Spectrum" (www.altair.org). Click on "Natural Radio" in the site map.

Also check out NASA's "Chandra X-ray Observatory" (chandra.harvard.edu). To learn about supernovas, black holes, and other exotic X ray-generating objects, click on "Field Guide" under the "Public Information and Education" menu at the left. Kids can learn about X rays and their uses at a site developed by the University Hospitals of Cleveland (www.uhrad.com/kids.htm).

A hundred years after Herschel's discovery of infrared light, the physicists Paul Villard and Ernest Rutherford completed the electromagnetic spectrum with the discovery of gamma rays—wavelengths so short that they can readily pass through metal or several feet of concrete. At the site "Milagro Gamma-Ray Observatory" (www.lanl.gov/milagro/everyone.shtml), visitors can view an instrument that "sees" what the universe brings to Earth in the form of radiation with about a trillion times the energy of visible light.

One band of wavelengths, the ultraviolet, or UV light, is particularly helpful at revealing earthly as well as cosmic mysteries. Although invisible to us, UV is readily seen by birds and insects such as bees and butterflies. Many blossoms display distinct floral patterns in UV light that can attract pollinators [*see "How Plants 'See,'" by Marcelo J. Yanovsky and Jorge J. Casal, September 2004*]. Bjorn Rorslett, a Norwegian aquatic ecologist and nature photographer, has created a wonderful Web site that lets you "see" flowers the way insects and birds might see them (www.naturfotograf.com/UV_flowers_list.html).

Robert Anderson is a freelance science writer living in Los Angeles.

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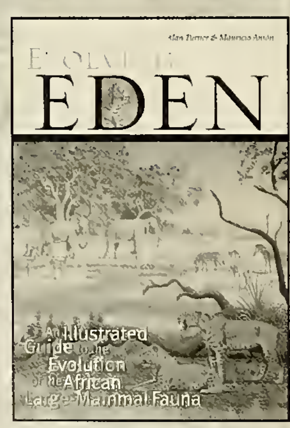

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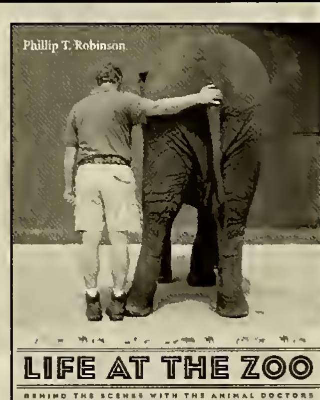

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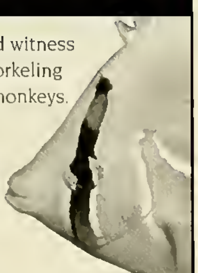

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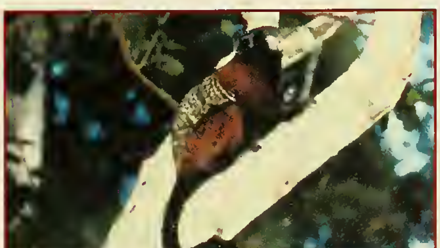

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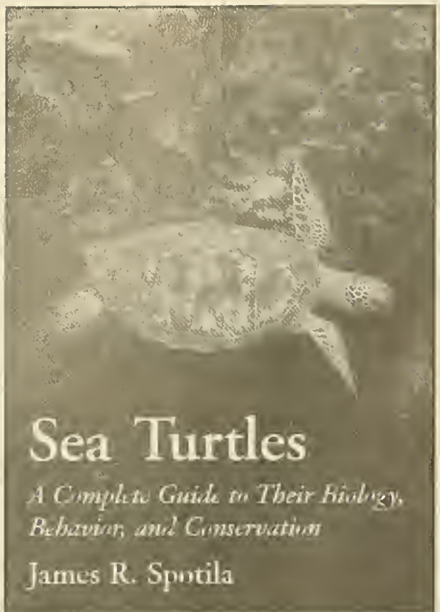

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THE SKY IN NOVEMBER

By Joe Rao

Mercury sets in the southwest soon after the Sun does throughout the month, which gives it a poor evening apparition—though you can view it easily enough with binoculars. The farther south you are, the easier time you'll have seeing the planet. On the 20th Mercury reaches its greatest eastern elongation, or apparent distance from the Sun, twenty-two degrees east of our star. On that evening it sets seventy-five minutes after sunset. Thereafter Mercury sets earlier with each passing night.

Venus, queen of the predawn hours, is brilliant, as always. The planet rises an hour or so before dawn twilight; by fifty minutes before sunrise it is at least twenty degrees above the east-southeastern horizon. Early in the month Venus joins with Jupiter—the latter shining brightly, but with only about one-eighth the brilliance of Venus—in the constellation Virgo, the virgin. The two planets are closest on the 4th and 5th. On the 9th the duo is joined by the Moon; Mars and the first-magnitude star Spica are not far below. Imagine the astrological significance the ancients might have ascribed to such a celestial encounter! Venus is on its way around the far side of the Sun, so through a telescope it appears gibbous and small. The planet passes Spica at midmonth, moving four degrees north of the star on the 16th.

Mars rises out of the east-southeast just after 5 A.M. on the 1st and only about fifteen minutes earlier by the end of the month. At magnitude 1.7, Mars is still a relatively inconspicuous object. The planet moves from Virgo into the constellation Libra, the scales, by the 22nd.

Jupiter, in Virgo, rises in the east at roughly a quarter to four in the morning at the beginning of November, and about ninety minutes earlier by month's end. At dawn Jupiter is well up in the southeast. As I noted earlier, Jupiter joins Venus and the Moon on the 9th, which will make for a striking predawn sight. After sunrise that day the Moon occults, or hides, Jupiter above much of central and eastern Canada, as well as parts of the Great Lakes region and the northeastern United States. A more spectacular occultation of Jupiter is in store next month—stay tuned.

Saturn is in the constellation Gemini, the twins, and is easy to see all month. The ringed planet rises just before 10 P.M. on the 1st, and about two hours earlier by month's end. It appears as a very bright yellowish-white "star" shining at magnitude 0.1 at midmonth. On the evening of the 3rd, Saturn appears well to the west (to the right) of a waning gibbous Moon. On the 30th the Moon again pays a visit to Saturn, passing about five degrees to the north of the planet late that evening. Its great ring system is tilted nearly twenty-two degrees to our line of sight, making Saturn breathtakingly beautiful even when viewed through a small telescope.

The Moon wanes to last quarter on the 5th at 12:53 A.M. and becomes new on the 12th at 9:27 A.M. It waxes to first quarter on the 19th at 12:50 A.M. and becomes full on the 26th at 3:07 P.M.

All precise times are given in eastern standard time.

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Giant Squid Lived Fast, Died Young

It's hard to study an animal that no one has seen alive. But that's what Neil Landman, Curator in the Museum's Division of Invertebrate Zoology, and his colleagues did with the giant squid.

Their latest findings show that giant squids, the largest invertebrates on Earth, live about 14 years or less and tend to live at depths of 125 to 250 meters (400 to 800 feet). Previously, scientists thought giant squids lived in deeper waters and estimated that they lived for several decades. These new results were published in a recent issue of the journal *Marine Biology*.

Previous expeditions in submersible vehicles to find these elusive creatures may have failed because the scientists were looking at the wrong depths.

AMNH

A giant squid specimen at the Museum

The new habitat and age estimates for giant squid are based on analyses of carbon and oxygen isotopes (different forms of an element) in the ear-like equilibrium organs of three female specimens captured off Tasmania between January and March 1996. The team used the ratio of oxygen isotopes in the organs, called statoliths, to determine the temperature at which they formed (and thus ocean depth).

The organs from all three squid contained radiocarbon (carbon-14) introduced into the oceans from the atmosphere as a result of nuclear bomb testing prior to the Nuclear Test Ban Treaty. The team used observations of how the bomb radiocarbon was mixed downward in the oceans with time, together with a model for the growth of the statolith, to determine the age of each giant squid.

D. FINNIN/AMNH

This NASA Mars Exploration Rover is on display in the Museum's Cullman Hall of the Universe; it is a full-scale replica of the ones currently on Mars. Here, Neil deGrasse Tyson, Frederick P. Rose Director of the Hayden Planetarium, describes to a group of rapt schoolchildren how the rover sends images back to Earth.

R. MICKENS/AMNH

On August 4, 2004, New York City Council member José M. Serrano of the Bronx joined a group of kids from Blondell Joyner Day Care as they became junior anthropologists for a day when the *Structures & Culture* Moveable Museum from the American Museum of Natural History rolled up to the front door of the Woodstock branch of the New York Public Library.

The Moveable Museum program was established with the support of the City Council of New York. *Structures & Culture* is made possible through the generous support of Citigroup. Additional support for the Moveable Museum program is provided by The Coca-Cola Foundation.

C. CHESEK/AMNH

Kids' favorite cartoon characters such as Liz from the Magic School Bus™, Spot, and Clifford the Big Red Dog® help celebrate at the Museum's annual Halloween party. Kids can trick-or-treat throughout the Museum's halls, create eerie origami, and make spooky crafts. Those who need a rest can watch a master pumpkin carver at work or see a special unearthly Space Show in the Hayden Planetarium's Space Theater.

The Museum's annual Origami Tree has welcomed the holiday season for over 30 years. Located in the first-floor Theodore Roosevelt Memorial Hall, each year the tree is lavishly decorated with several thousand intricately hand-folded natural history–themed paper ornaments. This year's lighting ceremony will take place on Tuesday, November 23, at 11:00 a.m.

Summer Interns Study Environmental Biology at the Museum

In just one of the many intensive educational programs at the American Museum of Natural History, college students this summer studied such creatures as Alabama coral snakes and Brazilian sea turtles.

Candice Fraser, for example, who attends St. Francis College in Brooklyn, New York, tracked the genealogy of Indian mongooses found in Jamaica. Working alongside Rob DeSalle, Curator in the Museum's Division of Invertebrate Zoology, and Chanda Bennett, a graduate student at Columbia University doing her doctoral research at the Museum, Candice used the Museum's DNA sequencing machines and other laboratory equipment to conduct population genetics work on more than 100 Indian mongoose tissue samples. Eventually, the data could help distinguish local populations of mongooses and help with efforts to control this invasive species that harms the Jamaican economy.

Candice was just one of 20 interns who participated this summer in the Undergraduate Mentoring in Evolutionary Biology (UMEB) program. This new opportunity for minority college students, funded by the National Science Foundation, provides students with mentoring as they study environmental biology, ecology, and systematic biology. Most of the recent group of UMEB interns are immigrants to the United States, born in countries such as Jamaica and Trinidad.

The two-year-old UMEB program, which involves students at St. Francis as well as Medgar Evers College in Brooklyn, teams up motivated minority undergraduates with the Museum's top-notch biologists and extraordinary laboratories, helping them work toward their goal of becoming scientists.

Museum Events

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PHOTOS BY KIYOSHI TOGASHI

Left: *Woman in the Moon* pendant. Jim Hart (Haida). 2003. Private collection. Right: *Universe within the Bear* pendant. Jesse Monongya (Navajo). 1991. Private collection.

EXHIBITIONS

Totems to Turquoise: Native North American Jewelry Arts of the Northwest and Southwest
Through July 10, 2005
This groundbreaking exhibition celebrates the beauty, power, and symbolism of the magnificent tradition of Native American arts, examining techniques, materials, and styles that have evolved over the past century as Native American jewelers have adapted to technical, social, and commercial changes, transforming their traditional craft into vital forms of cultural and artistic expression.

The Butterfly Conservatory: Tropical Butterflies Alive in Winter
Through May 30, 2005
A return engagement of this popular exhibition includes more than 500 live, free-flying tropical butterflies in an enclosed habitat that approximates their natural environment.

The Butterfly Conservatory is made possible through the generous support of Bernard and Anne Spitzer.

Frogs: A Chorus of Colors
Through January 9, 2005
This delightful exhibition introduces visitors to the colorful and richly diverse world of frogs, with over 200 live specimens thriving in re-created habitats.

Frogs: A Chorus of Colors is presented with appreciation to Clyde Peeling's Reptiland.

Smokey jungle frog — DAVE NORTHCOTT, CLYDE PEELING'S REPTILAND

Vital Variety: A Visual Celebration of Invertebrate Biodiversity
Through Spring 2005
Invertebrates, which play a critical role in the survival of humankind, are the subject of these extraordinarily beautiful close-up photographs.

Art in Nature: The Photographs of John Daido Loori
Through January 9, 2005
These striking abstract photographs reveal hidden treasures and explore notions of scale in the dramatic land- and seascape of Point Lobos State Reserve in California. The photographer is the abbot and founder of Zen Mountain Monastery, in Mt. Tremper, New York.

This exhibition is made possible by the generosity of the Arthur Ross Foundation.

Fall Colors across North America
Through March 13, 2005
The fiery colors of autumn come to life in these images by Anthony E. Cook, taken as he journeyed across the deciduous color belt that runs from deep southern bayous to northern tundras.

MARGARET MEAD FILM & VIDEO FESTIVAL

Thursday–Sunday, November 11–14, and Saturday and Sunday, November 20 and 21
Themes for the 28th annual Mead Festival include Native cinema from the Northwest Coast and the Southwest and a tribute to Jean Rouch (1901–2004), the creator of cinema verité. Visit www.amnh.org or call 212-769-5200 for a complete schedule.

LECTURES

Totems to Turquoise: Traditional and Contemporary Jewelry
Tuesday, 11/9, 6:30 p.m.
A tour of this compelling and beautiful exhibition is followed by a slide-illustrated discussion with the co-curators and advising artists.

RICK EDWARDS

No Turning Back
Tuesday, 11/16 7:00–8:30 p.m.
Richard Ellis's latest book presents answers to many questions on animal extinction. He describes creatures that were driven to extinction in recent times, some that were brought back from the precipice, and even some that have been recently rediscovered.

The Land of Naked People
Tuesday, 11/30, 7:00–8:30 p.m.
Madhusree Mukerjee's extraordinary relationship with previously isolated Andaman Islanders off the coast of India allows her to offer insights into the processes and effects of modernization and colonization.

FAMILY AND CHILDREN'S PROGRAMS

Dr. Nebula's Laboratory: Wind and Water
Saturday, 11/6, 2:00–3:00 p.m.
Dr. Nebula's apprentice Scooter dodges tornadoes and other forces of nature in this whirlwind science adventure.

Navajo Weaving Workshop
Saturday, 11/6, 11:00 a.m.–12:00 noon (Ages 4–6, each child with one adult) or 1:00–2:00 p.m. (Ages 7–9)
Learn about the importance of weaving in Navajo culture and hear stories about Spider Woman and other characters while weaving a sampler to take home.

Haida Blanket Workshop
Sunday, 11/7, 11:00 a.m.–12:00 noon (Ages 4–6, each child with one adult) or 1:00–2:00 p.m. (Ages 7–9)
Learn about button blankets and the potlatch tradition of the Haida of the Northwest Coast.

Astrofavorites for 4- to 6-Year-Olds: Earth and Space
Three Wednesdays, 11/3–17, 4:00–5:30 p.m. (Ages 4–6, each child with one adult)
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ESO

Galaxy NGC 613

Space Explorers: Stars and Galaxies
Tuesday, 11/9, 4:30–5:45 p.m.
(Ages 10 and up)
On the second Tuesday of each month, kids (and their parents) can learn under the stars of the Hayden Planetarium.

HAYDEN PLANETARIUM PROGRAMS

TUESDAYS IN THE DOME

Virtual Universe
Multiwavelength Milky Way
Tuesday, 11/2, 6:30–7:30 p.m.

This Just In...
November's Hot Topics
Tuesday, 11/16, 6:30–7:30 p.m.

Celestial Highlights
The Celestial Sea
Tuesday, 11/30, 6:30–7:30 p.m.

LECTURES

Origins
Monday, 11/15, 7:30 p.m.
With Neil deGrasse Tyson, Frederick P. Rose Director of the Hayden Planetarium

The Search for Habitable Worlds
Monday, 11/22, 7:30 p.m.
With Margaret Turnbull of the University of Arizona's Steward Observatory


D. FINNIN/AMNH

PLANETARIUM SHOWS

SonicVision
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Lewis & Clark: Great Journey West
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Sacagawea, Lewis and Clark's best-known Native American guide

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ENDPAPER

Sultans of Rot

By Gary Noel Ross

Death Kiss: Malachite imbibes from the fermenting lip of a discarded pumpkin.

A few years ago, I was walking the streets of Mission, Texas, after attending the city's annual Texas Butterfly Festival. I passed several jack-o'-lanterns discarded at the base of a dumpster. It was two days after Halloween, and they were in an obvious state of decay. But I am a lepidopterist—not an authority in pumpkinity—and so what caught my attention was the attendant population of butterflies, flitting about and settling on the pumpkins.

Butterflies typically feed on floral nectars, but some groups enjoy fluids from rotting fruits as well. The wafting aromas of fermentation are pungent enough to any human who has overkept a pumpkin, and they can attract butterflies several hundred yards away. Bingeing butterflies get so drunk and docile on the fruity alcohols that they can't even fly. I had no problem moving in to take close-ups—though I had to hold my breath while focusing, to keep from disturbing their wings.

Conspicuous among the butterflies were malachites *(Siproeta stelenes)*, members of the Nymphalidae, or brushfoots, the largest family of butterfly. At least half the brushfoots feed on fruit, and the ones that do have more muscular bodies and fly much more rapidly than the ones that don't. I suspect that rotting organic matter offers more concentrated energy than flower nectars do. Conceivably, too, certain by-products of fermentation are useful in the butterflies' metabolism: even if butterflies—like us—are prone to alcohol addiction, that doesn't mean the libation lacks nutritive value.

Second malachite (ventral view) goes over the edge.

People around the world have taken inspiration from the metamorphosis of the earthbound caterpillar into the ethereal butterfly, seeing in it the promise that the body will be transformed into spirit after death, and enter an afterlife. In most traditional Mexican cultures, butterflies are still regarded as embodiments of human souls. As I watched my woozy butterflies, I couldn't help reflecting that in Mexico, *los días de los muertos* ("the days of the dead") take place on October 31 (All Hallows' Eve), November 1 (All Saints' Day), and November 2 (All Souls' Day). Those holidays are a time of remembering and rejoicing, when, as many people believe, the dead return in spirit form—often as butterflies—to their earthly homes. To prepare, villagers clean gravesites, adorning them with breads, candy, flowers, and samples of the favorite foods and drinks of the departed.

Standing by the dumpster, with death and rebirth so closely joined, I felt that the real spirit of Halloween had become a treat for me—as it was, perhaps, for my ancestors as well.

GARY NOEL ROSS is a lepidopterist and writer living in Baton Rouge, Louisiana. He is the director of butterfly festivals for the North American Butterfly Association.

We found our best watch in a history book

In 1922, a small watchmaker in Switzerland designed the first automatic watch to display the day, month and date. Only 7 of these magnificent timepieces were ever made and this watch was almost lost to history. Today, they are so rare that our watch historians are willing to bid $300,000 for an original in mint condition.

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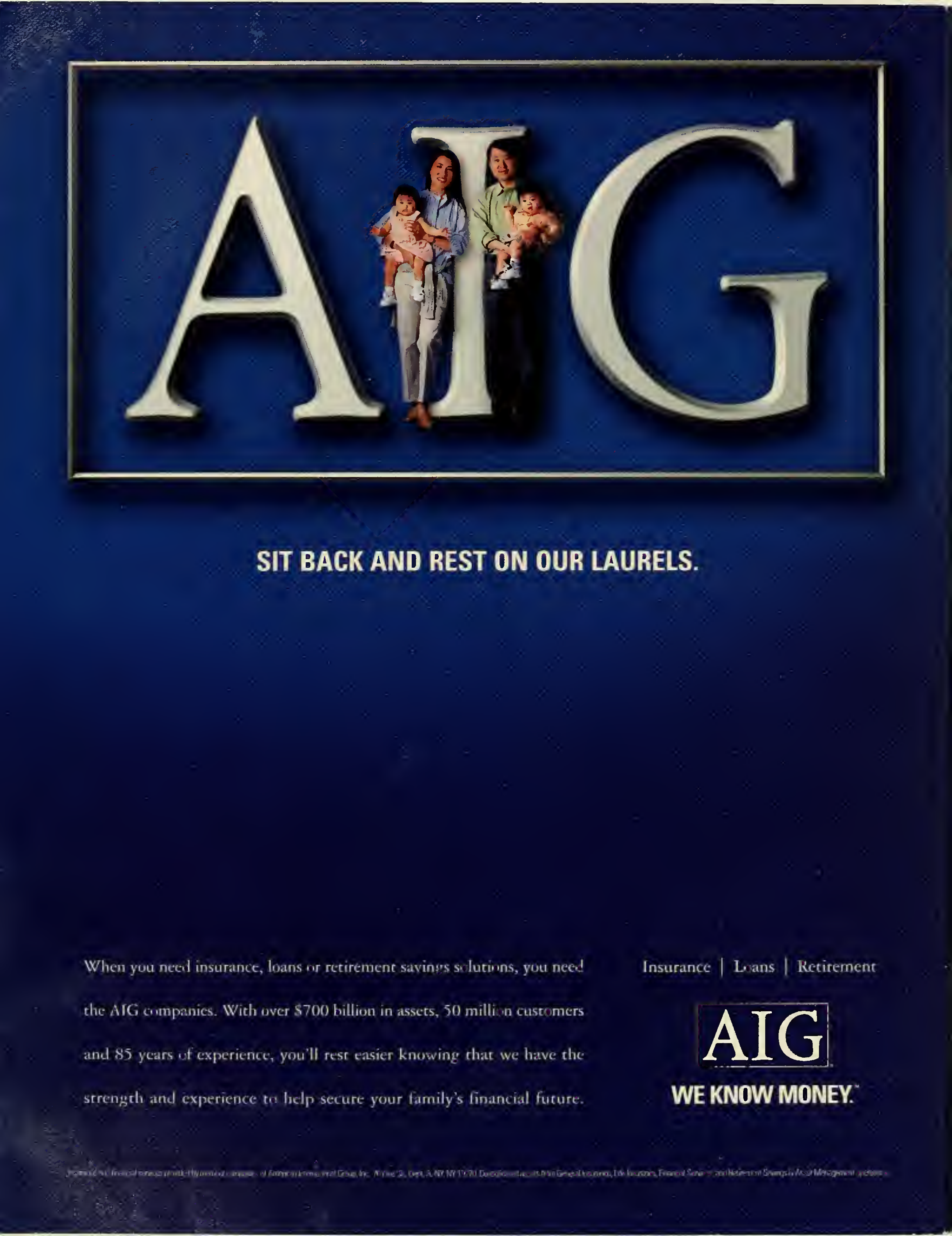
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