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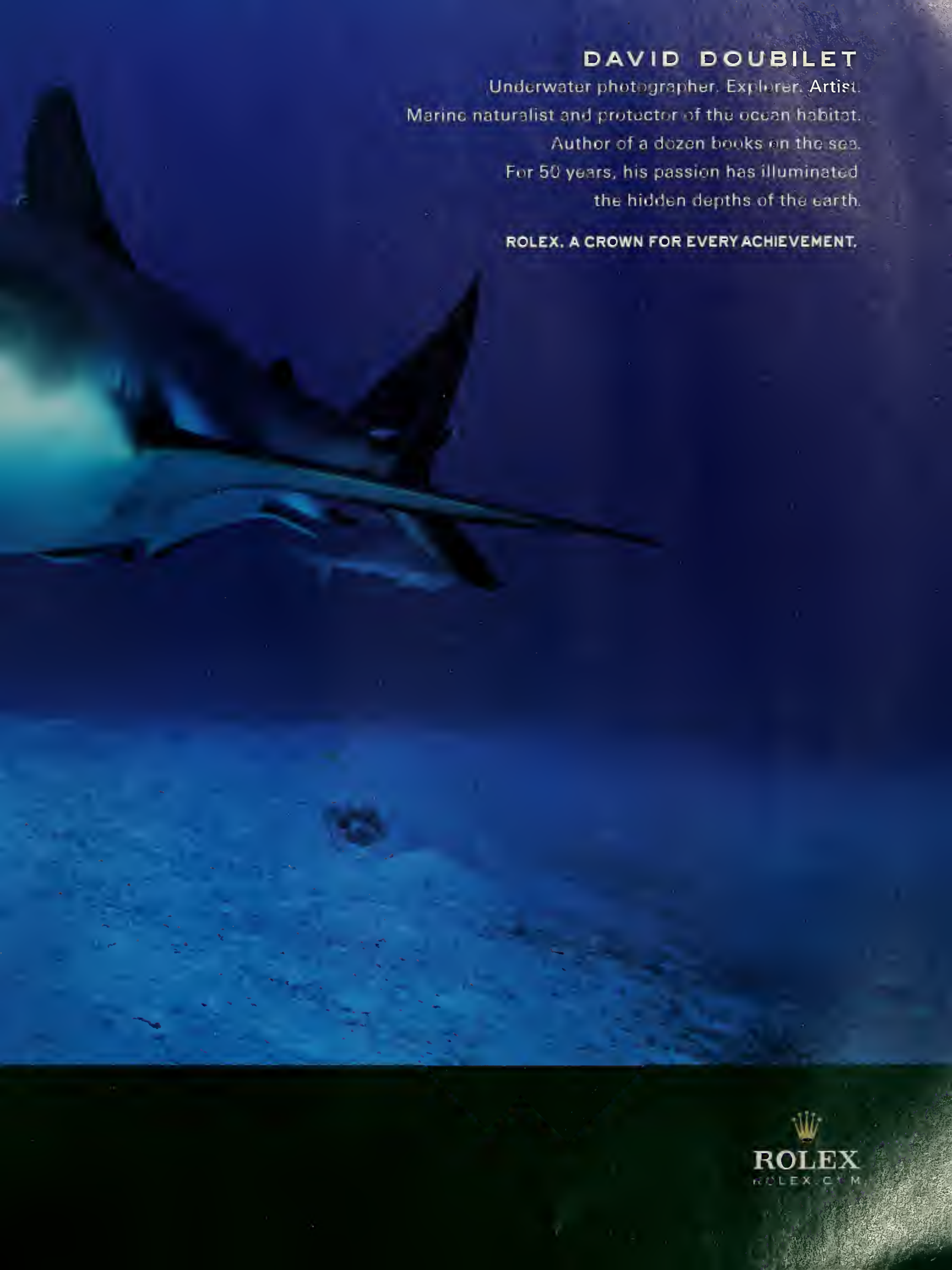
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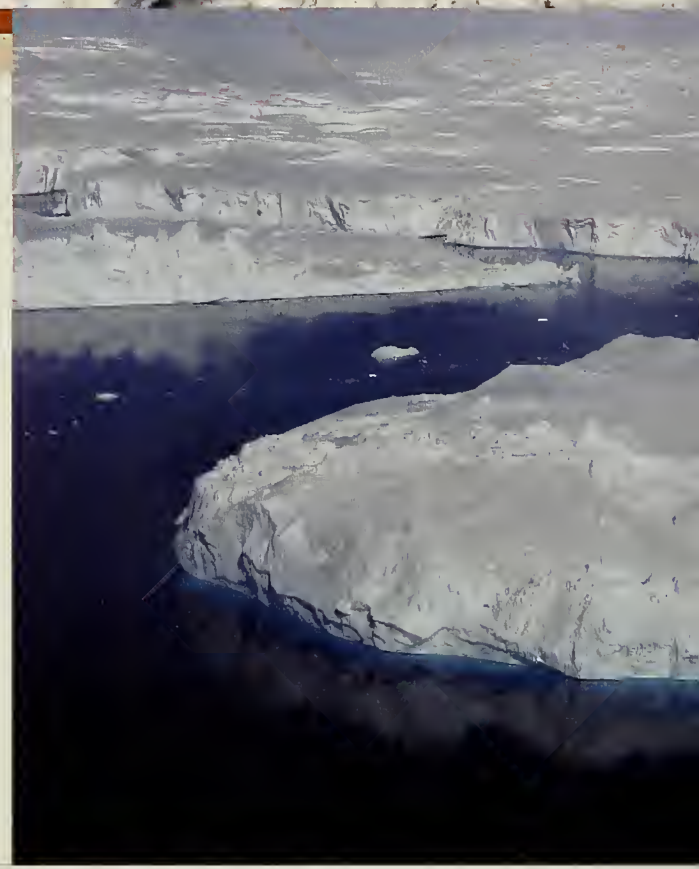
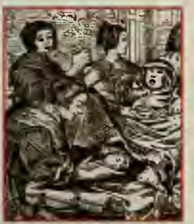


FEATURES

DEPARTMENTS



ON THE COVER: *Composite image of white-winged vampire bats (*Diaemus youngi*) in flight.*
PHOTOGRAPHS BY SCOTT ALTENBACH

THE NATURAL MOMENT

A STUDY IN SALMON

Photograph by [illegible]

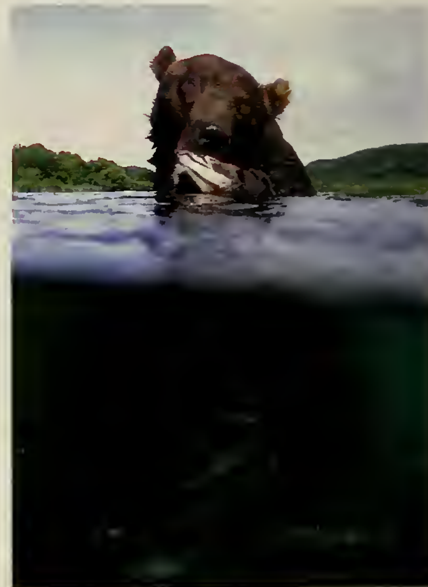
◄ *See preceding two pages*

THE NATURAL EXPLANATION BY ERIN ESPELIE

Every bear has its own way of fishing. So says photographer Sergey Gorshkov, who has spent hundreds of hours over the course of four years observing brown bears on the Kamchatka Peninsula, in eastern Russia. For instance, the solitary bear pictured at right fancied a fish's-eye-view to nab salmon. The mother bear pictured on the preceding two pages preferred pouncing from the rocks while her cub observed her technique from the shore.

The Kamchatka brown bear—one among many subspecies of *Ursus arctos*, including the grizzly and the Kodiak bear—depends upon salmon to fuel hibernation. Bears hunker down for the winter only when they've gorged enough to survive the six-month fast. And even though mating occurs in May or June, the start of pregnancy is delayed until October or November; the female's body gauges its fat stores before allowing her fertilized eggs to implant—the ultimate in planned parenthood.

A mother, along with two or three newborn cubs, will usually emerge in April, ravenous. For the first few months, the family is almost exclusively vegetarian. When the salmon start spawning in June, however, a fishing frenzy ensues. The cubs begin to learn by watching. They need two or three years of tutelage to become independent, since hunting takes a great deal of practice. (Unless, of course, by "hunting" you mean paying a guide to help you shoot a trophy bear—the fate last year of about 900 of Kamchatka's 12,000 bears.)



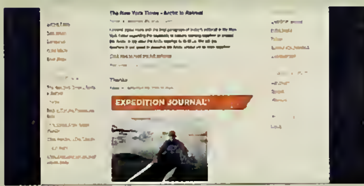
Half of all Kamchatka bear cubs die in their first year, usually of starvation. Even adults weighing as much as three-quarters of a ton struggle to find enough to eat. Yet Asia's biggest sockeye salmon spawning ground is Kuril Lake, in Kamchatka, and one-quarter of all wild Pacific salmon hatch in the Peninsula's waterways. Why should there be a shortage?

For starters, illegal fishing robs the bears of about 100,000 tons of salmon every year. That may begin to account for an incident that occurred late last July: a roving pack of thirty or so hungry bears killed and ate two miners in Kamchatka, prompting a shutdown of the mine for several days for fear of further attacks. With fewer salmon to stalk and an encroaching human population, a new kind of hunting lesson may be in store for the next generation of cubs.

Sergey Gorshkov used to hunt Kamchatka brown bears, but now only tracks them through the sight scope of a camera. "Photographing salmon-hunting bears is an inexpressibly more beautiful and difficult task than killing a beast," he says. One of Gorshkov's bear photos garnered him a Shell Wildlife Photographer of the Year award in 2007. Visit www.gorshkov-photo.com for more information.

nature.net by robert anderson

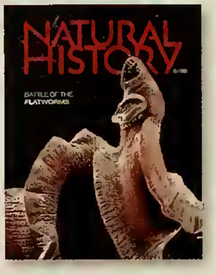
NORTHERN EXPOSURE



TALES OF ARCTIC EXPLORATION have always fascinated me, so I was intrigued when I heard British adventurer Lewis Pugh was attempting to kayak from Spitsbergen, Norway, to the North Pole. Until recently, the thought that such a journey might be possible—through open seas—would have been ridiculed. In a pre-expedition BBC video (news.bbc.co.uk/1/hi/sci/tech/7588377.stm), Pugh explained his hope was to bring attention to the rapidity with which the Arctic is warming. Although he made it farther north than any previous kayaker, he fell about 500 miles short of his goal, blocked by sea ice. For once, an adventurer was happy to be thwarted. (Search for *expedition journal* at polardefenseproject.org/blog/.) For my guide to Web sites on the shrinking Arctic ice pack and the consequent environmental effects, please visit the magazine online (www.naturalhistorymag.com).

ROBERT ANDERSON is a freelance science writer who lives in Los Angeles.

WORD EXCHANGE



All Due Credit

The credit line for the image of a schistosome that appeared on the cover of the June 2008 issue, shown above, should have credited preparation of the microscopic specimen to Ezequiel R. Rivera of the University of Massachusetts Lowell.

The Pompeiian wall painting in "I, Cleopatra" [10/08, page 46] is from Scala/Art Resource, NY.

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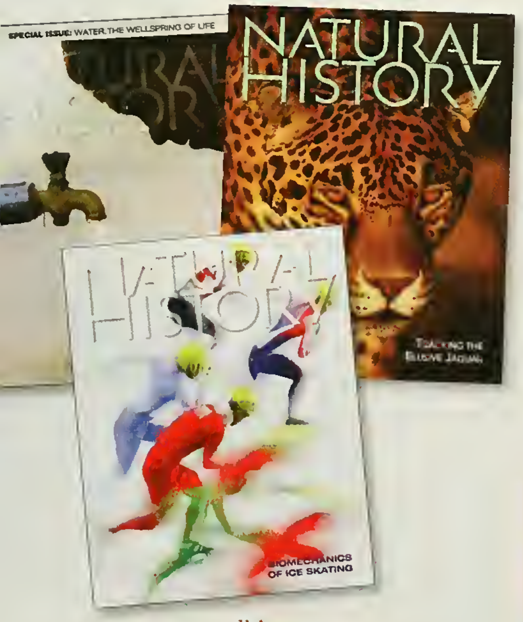
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Big Mamma, Little Papa

DARRYL GWYNNE

Female Cook Strait giant weta

When a female Cook Strait giant weta, a four-inch-long insect resembling an overstuffed cricket, pairs up with a male—usually half her size—they surely make an odd couple. Such disparity, or dimorphism, between sexes is common and fascinates biologists, who debate whether the cause is generally natural selection acting on females, males, or both. But how to tell? The trick is to find a dimorphic species that provides hints about how it got that way—and the giant weta is just the ticket.

Clint D. Kelly, now at Iowa State University in Ames, and two colleagues studied the mating habits of the Cook Strait giant weta, *Deinacrida rugosa*, on Maud Island, New Zealand, by radio tracking sixty insects for several days. A male often walks long distances to find a receptive female—up to 300 feet each night—and once he does, he follows her to her refuge. There, the pair copulates repeatedly throughout the day, conveniently leaving behind empty sperm capsules that researchers use to estimate the amount of sperm transferred.

Kelly's team found that small, long-legged males are more mobile than large ones and thus do better in the scramble for females. And along with mobility goes success at insemination. The discovery suggests that in this giant weta, and perhaps in other animals with big females, selection for smaller, more mobile males might have caused the size difference between the sexes. Whether evolutionary forces are simultaneously enlarging the females remains to be seen. (*The American Naturalist*) —*Graciela Flores*

The Ancients' Antiques

Inhaling bowl from Trinidad, slightly smaller than actual size, with spouts on the right

Inhaling bowls—shallow vessels with two adjacent spouts—are artifacts found on many Caribbean islands. Early Amerindians probably used them to snort hallucinogens, liquid or powdered, through the nose.

Now ponder this. Three inhaling bowls unearthed on the island of Carriacou, near Grenada in the Antilles, were made around 400 B.C., according to an analysis of radioactive isotopes conducted by Scott M. Fitzpatrick of North Carolina State University in Raleigh and several colleagues. Yet Carriacou was first settled 800 years later, around 400 A.D. Moreover, one of the bowls was found among archaeological deposits dating from about 1000 A.D. And the mineral content of the bowls indicates that they probably weren't manufactured on Carriacou.

So the bowls must have come from another island—one possibility is Puerto Rico, 465 miles away, where other bowls of similar antiquity have been discovered. And they must have been kept around for at least eight, if not fourteen centuries.

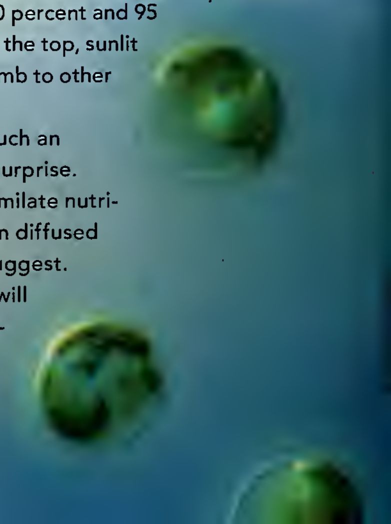
What could account for such endurance? The bowls were not buried in the manner of ritual offerings. Fitzpatrick thinks they were probably passed on from generation to generation as useful or treasured heirlooms. (*Journal of Archaeological Science*) —*Stéphan Reebs*

Bacterial Banquet

Photosynthesis is the hallmark of the do-it-yourself crowd. Organisms that rely on it need only light, carbon dioxide, and some inorganic nutrients to grow. There are exceptions, of course, such as carnivorous plants that live in low-nutrient habitats. And here's a new one: microscopic algae that eat free-floating bacteria in the open ocean.

The smallest of the marine phytoplankton are unicellular algae less than one-tenth the width of a hair. They grow almost exclusively by photosynthesis, or so most scientists thought. But working aboard a research vessel in the North Atlantic, and using isotopes to track the fate of nutrients in samples of seawater, Mikhail V. Zubkov of the National Oceanography Centre in Southampton and Glen A. Tarran of the Plymouth Marine Laboratory, both in England, have determined that the tiny algae obtain about a quarter of their biomass from bacteria. So abundant are the little algae that they alone devour between 40 percent and 95 percent of all the bacteria eaten in the top, sunlit layer of the ocean—the rest succumb to other kinds of unicellular beings.

That algae should depend to such an extent on bacterivory came as a surprise. Perhaps it's more efficient to assimilate nutrients concentrated in bacteria than diffused in seawater, Zubkov and Tarran suggest. Whatever the reason, ecologists will have to revise their models of marine food chains to account for algal appetites. (*Nature*) —*S.R.*



Phaeocystis globosa, *marine algae, magnified 3,800×*

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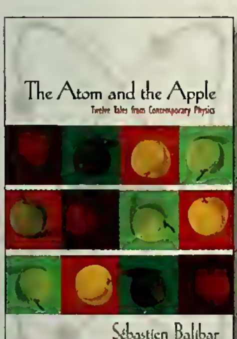

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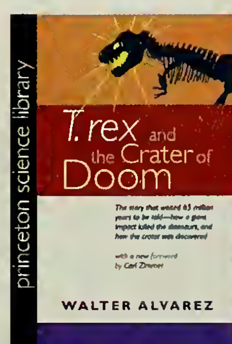

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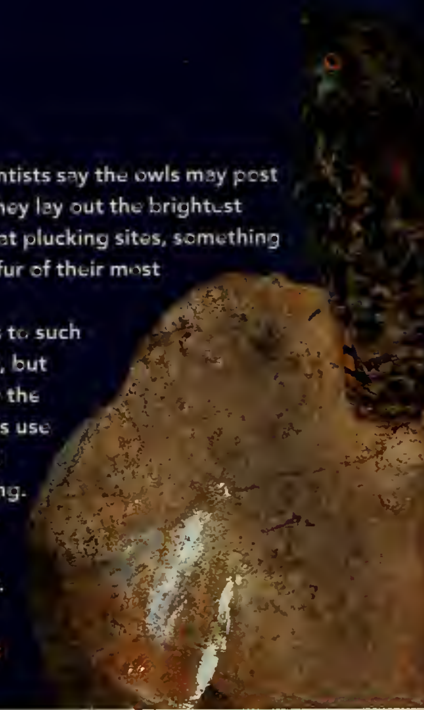
Whose Poo?

With a four-foot wingspan, the Eurasian eagle owl is a big bird with a big appetite—and a fecal output to match. Yet the owl's body waste does not always go to waste. New research suggests that breeding eagle owls defecate strategically, using their excrement to erect "No Trespassing" signs within their territories.

Vincenzo Penteriani and Maria del Mar Delgado of the Doñana Biological Station in Seville, Spain, report that when breeding eagle owls answer the call of nature, they squirt their white feces onto the vertical faces of dark rocks in exposed locations, rather than onto more abundant—but less contrasting—pale rocks. When not breeding, the owls let go indifferently onto the ground. After the two scientists erased feces on both exposed, dark rocks and more inconspicuous spots by spray-painting over them, they noted that the owls only re-marked the exposed, dark rocks, usually within a day.

Among eagle owls, fights between territory owners and intruders are nasty and often fatal, so it pays to advertise ownership clearly. In fact, the scientists say the owls may post a second form of signage: they lay out the brightest feathers of their avian prey at plucking sites, something they never do with the dull fur of their most frequent victims, rabbits.

The reaction of intruders to such marks remains to be tested, but Penteriani and Delgado say the evidence suggests that owls use feces and feathers as visual supplements to their hooting. Most birds use their voices alone to stake territorial claims. (*PloS ONE*) —*S.R.*



Eurasian eagle owl perches atop a rock marked, perhaps territorially, with feces.

Fear Factor

One whiff of an alarm pheromone sends figurative shivers down a mouse's little spine. Animals in distress release such pheromones, which serve as warnings to others of their kind. But just how mice—or other mammals—detect the chemicals has been unknown. Now, researchers have found that the mouse's danger detector is a mysterious wad of sensory cells at the tip of the nose called the Grueneberg ganglion. The structure was first described thirty-five years ago, but has been largely ignored ever since.

In 2005, five research teams independently discovered that the Grueneberg ganglion connects directly to the olfactory system, and the race was on to determine its function. Some scientists thought it enabled mouse pups to recognize their mothers, perhaps from chemical cues in milk. Then Julien Brechbühl, his graduate adviser Marie-Christine Broillet at the University of Lausanne in Switzerland, and a colleague noticed that the structure's tiny sensory hairs were sheathed in protective layers of collagen and keratin, permeable only to water-soluble and highly volatile molecules, such as certain components of milk—or alarm pheromones.

The researchers soon discovered that slices of Grueneberg tissue respond to alarm pheromones, but not to mouse milk or mammary secretions. As a final test, they released the alarm pheromone in cages with normal mice and watched as the mice huddled against the back wall. But after they severed the Grueneberg ganglion's connection to the olfactory system, mice failed to detect the chemical. Still, the researchers say, the mice had no problem finding cookies . . . or their mommies. (*Science*) —*Brendan Borrell*

Mouse Grueneberg ganglion cell in false color, magnified 5,000×

MICROGRAPH: MARIE-CHRISTINE BROILLET; MOUSE: JOE SHARKEY

Early Life Lessons

Some say it's never too late to learn new things, but can it be too early? Apparently not, if the behavior of wood frogs is any indication. Those amphibians can learn to identify predators while still in the egg, according to new research by Alicia Mathis of Missouri State University in Springfield and several colleagues.

After hatching, many amphibians and fish learn to recognize a predator by associating its odor with an alarm pheromone released by injured conspecifics. Mathis' team wondered whether frogs might have that cognitive capacity even earlier, as embryos.

For three hours a day, on six consecutive days, the team exposed wood-frog eggs to water from a bucket containing crushed tadpoles mixed with water from a bucket housing fire-belly newts. (The newts, native to Asia, are unfamiliar to wood frogs, but eat tadpoles of other species.) A control group received newt water alone. Two weeks after hatching, only the tadpoles that had experienced the combo of crushed-tadpole and newt water reacted when newt water was presented by itself: they stopped moving, a typical anti-predator response.

The study complements previous research showing that frog embryos can learn to distinguish between food flavors even before they hatch. Classes start early in a frog's life, it seems. (*Proceedings of the Royal Society B*) —*S.R.*

Wood-frog tadpoles hatch.

Big Bird Brains

Having a big brain can open all kinds of doors, even evolutionary ones, it seems.

First formulated in the 1980s, the "behavioral drive" hypothesis posits that intelligence can influence the course of evolution. The idea is that intelligent animals can find ways to exploit new foods and new habitats, thus exposing themselves to new selection pressures. So, if the species in a given taxonomic family have large brains relative to their body size, they should also have widely divergent body sizes, among other traits, as a result of varied selection pressures.

Daniel Sol of the Autonomous University of Barcelona and Trevor D. Price of the University of Chicago tested that prediction on birds. They extracted data on 7,209 bird species from the scientific literature, and found many examples of bird families that are both brainy and quite diversified in body size, such as the crows, the woodpeckers, the hornbills, and the parrots.

Comparing all avian families, Sol and Price showed statistically that brain size explains 12 percent of the variation in body size. The percentage may be small, but it confirms the theory that in evolution, behavior is more than just the result of selective pressures; it can also alter those pressures. (*The American Naturalist*) —*S.R.*

Southern ground hornbill

© MARTIN HARVEY / ALAMY

THE WARMING EARTH

Cooking Up Males?

Many reptiles have no sex chromosomes. Instead, their gender is determined by temperature. In crocodiles, for example, males are hot: eggs incubated in sand above a certain "pivotal temperature" almost always hatch males. That could spell trouble, because Earth is warming so fast that natural selection may not have time to adjust pivotal temperatures. Female crocodiles may become scarce.

Some experts think fish are in the same hot water because temperature-dependent sex determination, or TSD, occurs in many species. But a critical analysis of the fish literature by Natalia Ospina-Álvarez and Francesc Piferrer, both of the Marine Science Institute in Barcelona, Spain, casts doubt on that assertion. The pair point out that fourteen of the twenty diverse fish genera previously reported as having TSD in fact have sex chromosomes, and that it takes unnatural temperatures found only in the laboratory to masculinize their genetic females.

But the six genera that do show true TSD, including the *Menidia* silversides and the *Apistogramma* cichlids, could see their sex ratios skewed by global warming. And Ospina-Álvarez and Piferrer found that males were hot in all six. The researchers calculated that in such temperature-sensitive fishes—and there might well be many more than just six genera—a rise of 7 Fahrenheit degrees predicted by some models for the end of the century would yield three males for every female, a ratio unfavorable for maintaining populations. (*PloS ONE*) —*S.R.*

Atlantic silversides, a species in which temperature determines gender

Warmer and Weedier

Crabgrass will get a strong assist from global warming in its campaign to take over your lawn.

That's the unexpected finding of a study investigating a very different aspect of lawn biology: Neeta S. Bijoor, her graduate advisor Diane E. Pataki of the University of California, Irvine, and two colleagues set out to determine how warming affects lawns' emission of nitrous oxide (N_2O), a greenhouse gas 300 times more powerful than carbon dioxide. Lawns are the United States' largest irrigated crop, covering about 2 percent of the nation's surface area, and their effect on climate concerns scientists.

The team established a series of adjacent plots of fescue grass and, to mimic global warming, heated half of them by 6 Fahrenheit degrees. They applied high doses of commercial fertilizer to half of each plot; the other half got low doses.

To the researchers' surprise, crabgrass sprouted in the plots after only one year, and it was 30 percent more prevalent in the heated plots than in the unheated ones. (Fertilizer had no effect on it.) In contrast to fescue and most other crop plants, crabgrass and many other weeds photosynthesize with greater efficiency the warmer it gets, so they have been predicted to proliferate as temperatures rise. Still, such swift confirmation in the field was unexpected.

The study also showed that warming, as well as intensive fertilizing and irrigating, causes increased N_2O emissions. That, in turn, could contribute to more warming—which would reinforce the march of crabgrass across your lawn. (*Global Change Biology*) —*Harvey Leifert*

Death Beds

MARY EVANS PICTURE LIBRARY

The eighteenth century was a time when a mother, not her baby, needed to be delivered.

By Druin Burch

Have you ever had that stubborn feeling that the natural world reflects your mood and your mind? The sun shines when you are happy and disappears when you are glum. Your own vitality—or lack of it—seems reflected in nature. That form of thinking is often called the "sympathetic fallacy."

"It appears to me impossible that I should cease to exist, or that this active, restless spirit, equally alive to joy and sorrow, should only be organised dust."

So wrote the English feminist Mary Wollstonecraft as the eighteenth century drew to its politically explosive end. Defying danger and convention, she was traveling with her illegitimate child around Scandinavia. Rowing herself along the Norwegian coastline, she wrote of looking into the sea at the strange jellyfish. "They look like thickened water. . . . Touching them, the cloudy substance would turn or close, first on one side, then on the other, very gracefully; but when I took one of them up in the ladle, with which I heaved the water out of the boat, it appeared only a colourless jelly."

During the same period William Godwin, the radical philosopher and novelist, was clouded with gloom in the aftermath of the French Revolution. Not only did Britain seem to him a corrupt society—undemocratic, unfair, and unequal—but he believed that he himself, for all his wit and worldly success, was a fundamentally cold and unlovable man. Yet when Godwin read Wollstone-

Micrograph of Streptococcus pyogenes, *magnified 800×. Opposite page: Seventeenth-century engraving of a wealthy woman in labor.*

craft's dryly titled *Letters Written During a Short Residence in Sweden, Norway and Denmark*, he was ravished: "If ever there was a book calculated to make a man in love with its author, this appears to me to be the book."

And love was what followed. Theirs was a successful marriage of contraries, the fiery and intemperate feminist and the icy philosopher. Suddenly there was fertile happiness for both. At the end of August 1797, Godwin wrote, Mary "was taken in labour." Attended at home by a midwife from a nearby hospital, she gave birth eighteen hours later to a girl. The baby, also called Mary, would grow up to marry the poet Shelley and write the novel *Frankenstein*.

Four days after the birth, however, Wollstonecraft became feverish. A part of her placenta needed to be pulled out by a doctor's hand. She developed puerperal sepsis, an infection of the genital tract, which very painfully, and over the period of about a week, killed her.

Today we grow concerned about birth not being natural enough, having become too medical. Historically it was thoroughly natural, wholly unmedical, and gravely dangerous. Only from the early eighteenth century did doctors begin getting seriously involved, with obstetrics becoming a medically respectable specialty and a rash of new hospitals being built. Unfortunately, the impact of both was bad. Puerperal, or childbed, fever was a mystery, but both doctors and hospitals made it worse. Wherever the medical men went the disease grew more common, and in their hospitals it was commonest of all.

Childbed fever killed at the cruelest moments. It was described as a "desecration," an aspect of the natural world that felt almost deliberately evil. What caused it? Some thought "a failure of uterine discharge"; others, a little later, called it "milk metastasis," noting that the internal organs of the women who died seemed covered in milk. Eventually it was accepted that the fluid was not milk at all. It was pus.

Compound microscopes had been developed in the seventeenth century, opening up the world of miniature "animalcules." Inexplicably, an initial flurry of medical interest quickly died away. Even though the technology was now in place to help demonstrate it, germ theory took another two hundred years to arrive. In the meantime doctors were puzzled, blaming puerperal fever on a host of different causes: mists, sewage, poor ventilation, cold, or vague "putrid tendencies."

In 1791, the year Wollstonecraft and Godwin first met, an epidemic of puerperal fever was ripping through Scotland. Alexander Gordon was Aberdeen's leading obstetrician, and when puerperal fever came along he studied it and wrote down his conclusions. They amounted to what he felt were three great truths: the disease was spread by doctors and midwives; it was somehow related to skin infections; and the only treatment was bleeding—by the bucketload. A pint and a half was a good initial measure.

Bleeding was quickly and incorrectly accepted as a cure, but it took almost a century for the contagious nature of puerperal fever to be widely recognized. Many cases were isolated and sporadic, undermining those who argued the disease was infectious. At other times its epidemic nature was clear. William Campbell, another Scot, was a close contemporary of Gordon's. He first denied the contagiousness of puerperal fever, but personal experience changed his mind. He dissected the corpse of a woman killed by the disease, putting her uterus in his coat pocket so that he could show it to his students. He felt neither gloves nor hand washing was needed.

"The same evening," he wrote, "without changing my clothes, I attended the delivery of a poor woman in the Canongate; she died. Next morning I went with the same clothes to assist some of my pupils who were engaged with a woman in Bridewell, whom I delivered with forceps; she died."

Campbell's language, as well his report, is a reminder that no one then spoke of delivering a baby. Obstetricians and midwives talked of delivering *women*—delivering them from the peril of childbirth.

In the first half of the nineteenth century about five European women in a thousand died from childbirth. Death rates in maternity hospitals were often ten times that; the hospitals stayed open because doctors had an incurable faith in good intentions, and patients a poor grasp of mortality statistics. The physician and poet Oliver Wendell Holmes led the American campaign to stop the spread of the disease by getting doctors to wash their hands. Obstetricians felt slighted. "Doctors are gentlemen," said Charles Meigs of the Jefferson Medical College in Philadelphia, arguing that no such care was needed, "and gentlemen's hands are clean." How could the pure of heart possibly be spreading disease? For Meigs and many others, noble intentions mentally equated to good outcomes. It would be hard to find another example of the sympathetic fallacy with such far-reaching and tragic consequences. Yet hand washing slowly grew commoner. Aided by Louis Pasteur's advocacy of germ theory, hygiene improved. Giving birth began to get safer.

A few different organisms turned out to be capable of causing puerperal fever, but the vast majority of cases were due to just one: *Streptococcus pyogenes*. The etymology is revealing. *Pyogenes* means creator of pus. The bacterium lives only on humans, and consists of roughly 1,800 genes, a third of which "have no identifiable function," according to a 2001 paper reporting one complete genome sequence of the bug. Of the genes we partially understand, around forty seem directly connected with the virulence of the organism. *S. pyogenes* causes a range of other diseases, including strep throat, scarlet fever, rheumatic fever, and skin infections such as mild impetigo and catastrophic necrotizing fasciitis (now commonly called the "flesh-eating disease"). Epidemics of puerperal fever historically matched those of skin infections, and a person who contracted one was able to pass along the other.

Why should it be in a germ's interests to make us ill at all? In most cases, the illness is simply a consequence of the germ hijacking and disturbing our metabolism in order to reproduce. Other times our misery is an essential part of the way our invader spreads, as when a virus causes us to sneeze out millions of aerosolised copies of itself.

Streptococcus pyogenes is harder to understand. It might be named for causing pus, but that is misrepresentative. As far as this bacterium is concerned, Eden is the inside of our noses. Anywhere between 5 and 20 percent of us are harmlessly inhabited by the bug at any time. The nineteenth-century head of Paris's main maternity hospital thought Pasteur must be wrong in attributing puerperal fever to a bug so common: "It exists everywhere," he objected, "you can very easily extract it from the common water supply, and in consequence there is not a woman in childbirth who, daily using this water for drinking, douching, and washing, would escape invasion by the infectious organism."

We know that Pasteur and the germ theorists were right, but the mysteries that slowed their intellectual victories still exist. Why should such a generally harmless bug sometimes become troublesome? Today we might phrase the question differently: why should it be in the evolutionary interests of a bacterium to leap from docility into rampaging ferocity? What's in it for the bug? Sporadic cases might be chance, but trends suggest an evolutionary imperative.

Joseph J. Ferretti, a University of Oklahoma specialist in streptococci, notes that *S. pyogenes* has some remarkable qualities, containing "more virulence-factor genes than any other bacterial species." Moreover, he says some strains possess genetic switches for hypermutation, which increase mutation rates over a hundred-fold. We are a long way from fully understanding how all these virulence mechanisms work. And that makes it even more difficult to explore the deeper questions about how evolution is driving them.

Puerperal fever has never entirely gone away. Sporadic cases still appear—rare, potentially lethal, but now easily treatable with antibiotics if caught in time. Epidemics, however, have mysteriously vanished. The last was in Boston, in 1965, an enigmatic outbreak after an anesthesiologist scratched his hand on a rosebush. (*S. pyogenes* does not live on roses.) Hygiene, asepsis, and antibiotics seem only partly to thank. Some argue that something in the bacterium itself has shifted, that it has evolved to become more benign. It could be that a less damaging form spreads more successfully by virtue of not killing its hosts, or that it becomes more efficient by not needing to manufacture virulence factors.

At any given time, between 5 and 20 percent of us are carrying the childbed-fever bacterium.

Today the standards of asepsis in normal births have slipped. Most normal deliveries are clean but not sterile: a step away from the strict standards that would be required of an operating theater. My first child was born during the writing of this essay, and that was exactly the case. Mother and baby did brilliantly.

Certain types of *S. pyogenes* infections are currently on the rise, but puerperal fever is not. Unable to fully understand the way it has behaved till now, we are stumped when it comes to facing it in the years to come. Has its virulence really declined? Why might that be? And why should it be so for puerperal fever but not for other streptococcal infections? Without firm answers, we cannot understand how the disease might evolve, or what dangers it might hold for our future.

Tackling those questions requires us to stop viewing the world from our own perspective and see it from that of the bacterium. It is a point of view we are still remarkably ignorant about. We are like Mary Wollstonecraft leaning over her boat, looking into the water—able to describe what we see, but more with puzzled wonder than with comprehension.

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RETURN OF THE KNIGHT

AMNH/RODERICK MICKENS

Story by Joyce Cloughly and Ian Tattersall

FORTY MILLENNIA AGO, in what is now southwestern France, Neanderthals fashioned stone tools in a rockshelter overlooking the River Vézère. Their technique was to carefully shape a stone "core" on both sides until a single blow would detach a sharp flake of desired size and shape. In the nineteenth century their tools were uncovered, and the name of the site, Le Moustier, became attached to similar artifacts wherever they subsequently turned up (in archaeological lingo, they all belong to "the Mousterian tool tradition"). Between 1911 and 1913 the French anatomist Marcellin Boule published the first description of a reasonably complete Neanderthal skeleton. Those discoveries provided the inspiration and scientific basis for *The Neanderthal Flint Workers of the River Vézère*, shown here, one of the masterworks of Charles R. Knight, America's leading portrayer of extinct animals during the first half of the twentieth century.

The painting was completed in 1920 for the American Museum of Natural History's Hall of the Age of Man. Prepared under the guidance of the museum's director, the vertebrate paleontologist Henry Fairfield Osborn, it reflected the view of Neanderthals current at the time. They were, in Knight's words, "short, stocky, and uncouth in appearance . . . a very lowly form of the human animal." Current reconstructions represent them as altogether less crouched and brutish. Despite the biases of his time, however, Knight managed to convey the Neanderthals' dignity as a "distinct species . . . very intelligent and well fitted to their time and place."

The painting remained on display until 1966, when the old Hall of the Age of Man was dismantled and a more up-to-date exhibition was created elsewhere in the museum. That hall was itself recently replaced by an even newer one. Meanwhile, though, Knight's painting remained out of public view. Now, nearly a half century later, it has been unearthed from storage,

repaired and restored by conservator Felicity Campbell, and installed in a new location in the museum.

Visitors to the American Museum, in New York City, might notice something oddly familiar about the painting. Although Osborn had spent some weeks in the Vézère Valley in 1912, the landscape Knight represented looks nothing like the rugged, eroded limestone that borders the French river. Knight did not visit the region until 1927, and so seems to have painted the Hudson River Valley, with which he was familiar.

Joyce Cloughly is a senior principal preparator in the Exhibition Department and **Ian Tattersall** is a curator in the Division of Anthropology at the American Museum of Natural History.

LEFT: AMNH/DENIS FINNIN; ABOVE: AMNH/RODERICK MICKENS

THE CURIOUS, BLOODY LIVES OF VAMPIRE BATS

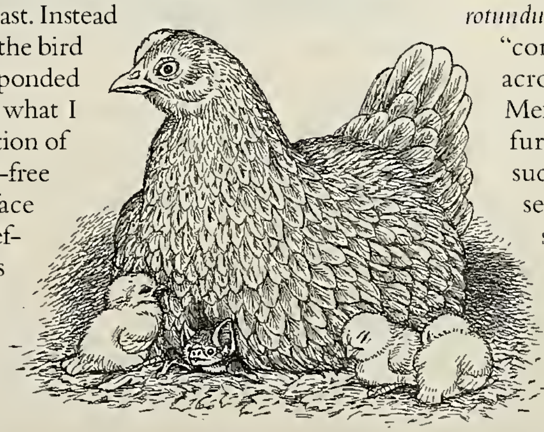
Among the most highly specialized mammals on the planet, vampire bats display a host of fascinating adaptations to their blood diet.

BY BILL SCHUTT

ILLUSTRATIONS BY PATRICIA WYNNE

EVERY DAY, I and my undergraduate assistant Kim Brockmann fed a Snapple bottle full of cow's blood to our captive vampire bats. Our colony consisted of twenty-two animals—eleven common vampire bats (*Desmodus rotundus*) and eleven white-winged vampires (*Diaemus youngi*)—and we maintained them for two years while I was doing my graduate work at Cornell University. One of the keys to our success was giving them the opportunity to feed on a live hen once a week.

It was on one of the first of those special feeding days that I noticed two of the white-winged vampires doing something incredible. They crawled across the floor of their feeding enclosure like a pair of spiders, and then one of the bats made a bold approach to a rather large hen. The bird cocked her head to one side, eyeing the bats. Her beak could have severely injured or even killed them, so I got ready to intervene. Sharing my concern, perhaps, one of the vampires stopped a couple of inches beyond pecking distance. The other bat, however, crept even closer, and then, amazingly, it nuzzled against the hen's feathery breast. Instead of becoming alarmed or aggressive, the bird seemed to relax. The vampire responded by pushing itself even deeper into what I would later learn was a sensitive section of skin called the brood patch: a feather-free region, densely packed with surface blood vessels, where body heat is efficiently transferred to the hen's eggs or to her chicks. As I watched, the hen reacted to the bat by fluffing her feathers, hunkering down—and closing her eyes.



*White-winged vampire bat (*Diaemus youngi*) snuggles up to a hen's brood patch, a region rich in surface blood vessels that functions to warm eggs or chicks. By mimicking chick behavior, the bat lulls the bird into a relaxed state, then feeds on the hen's blood. Opposite page:* Desmodus rotundus.

My God, I thought, these bats have learned to mimic chicks!

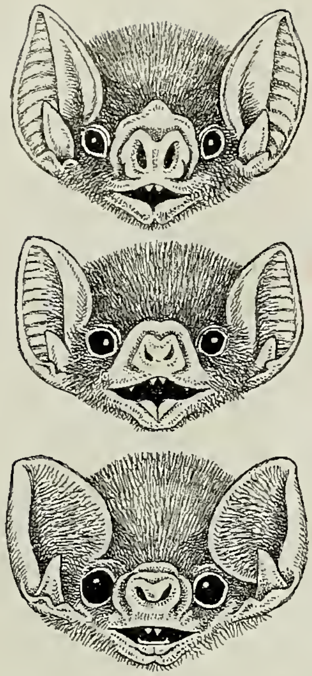
What was most remarkable to me was that in all likelihood chick mimicry wasn't innate behavior written into the *D. youngi* DNA over millions of years. It had probably developed in less than a thousand years—since humans brought domesticated fowl to South America. Were vampire-bat mothers teaching this cuddle-up trick to their young?

So enthralled was I at this wonderfully diabolical maneuver and its implications that I didn't notice that the second vampire had disappeared under the hoodwinked hen's tail feathers—not until several minutes later, that is, when a thin trickle of blood appeared on the floor behind the bird. Through the gloom of the darkened enclosure I could see a small puddle forming, glistening like red tinsel.

VAMPIRE BATS FEED SOLELY on blood, and their adaptations to the peculiar challenges of that diet make them among the most highly specialized of all living mammals. Only three bat species out of the 1,100 in the order *Chiroptera* qualify as vampires. As I began to take an interest in these creatures, I noticed that vampire-bat researchers (with a few notable Mexican and South American exceptions) hadn't done much with the two rarer vampire bat species—*Diaemus youngi*, described above, and the hairy-legged vampire, *Diphylla ecaudata*. Instead, most of their research and nearly everything that had been written about vampire bats dealt solely with the common vampire bat, *Desmodus rotundus*. I wondered why. The bat experts I consulted told me confidently that all vampire bats would act similarly, but how could that could be so? With overlapping ranges and a coveted resource (blood), wouldn't the species be competing with one another, and wouldn't it be likely that differences in behavior and anatomy had evolved to reduce that competition?

Perhaps the reason for the near-exclusive focus on *D. rotundus* can be found simply in the name "common." This species is numerous across a widespread range that includes Mexico and Central and South America; furthermore, it has been maintained successfully in captivity for more than seventy years, with some individuals surviving for as long as twenty years. The hairy-legged and white-winged vampire bats, by contrast, are far more difficult to locate and capture within their more limited ranges, and they long had a reputation for being difficult to maintain in captivity. As a result, even though local scientists in places like Trinidad and Brazil, where the less common vampires live, had been aware of differences among the vampire species for years, it wasn't until the very end of the twentieth century that the mainstream scientific community began looking at each of the three vampire bats as separate and distinct. Hence, the door was wide open for the comparative work I'd proposed to undertake, and for new discoveries like the one described above concerning chick mimicry.

Ultimately, my colleagues and I found that not only did significant differences exist between the three vampire bat species, but that most of the variation—including unusual feeding methods and social interactions between



Faces of the three species of vampire bats: Desmodus rotundus *(top),* Diaemus youngi *(middle), and* Diphylla ecaudata *(bottom)*

roost-mates—relates to the bats' preference for either mammalian or avian blood.

ASIDE FROM THE RELATIVE ease of studying the common vampire bat, its slew of fascinating behavioral, anatomical, and physiological features helped to sustain the exclusive interest in the species. And some of those "common" features do indeed seem likely to apply to all vampire bats. Take, for instance, one of the most fascinating of all vampire bat adaptations, which I observed only once in the three years I kept a colony of *Diaemus* at Cornell: blood-meal sharing between bats.

In 1984, zoologist Gerald S. Wilkinson, then of the University of California San Diego in La Jolla, first reported that vampire bats in the wild commonly share food by regurgitating blood. Wilkinson, who made his initial observations on *Desmodus*, determined that about 70 percent of blood-sharing incidents occurred between a mother and her dependent offspring (until around the age of one). Blood sharing between mothers and newborn pups presumably transfers not only nutrients, but also bacteria necessary to an infant's digestive tract.

Blood sharing between both related and unrelated vampire bats also occurs on a reciprocal basis; that is, bats that Wilkinson had experimentally starved for one night and that then received blood from another individual were more likely to donate blood to that individual when it, in turn, was starved. That reciprocity almost certainly evolved in response to two basic realities: a bat that cannot find a blood meal will starve to death in less than three days, and yet on any given night, as Wilkinson found, about one in fourteen adult bats and fully a third of young vampires-in-training will fail to feed. And so there will be numerous occasions over a vampire bat's lifetime both to receive and to share food.

Therefore, it's remarkable but not surprising that *Desmodus* can remember past donors as well as recognize cheaters—those individuals who try to beat the system by not sharing blood. There's another way in which bats discriminate among recipients: adult males will share blood with females and young bats, but rarely with other adult males. That makes perfect sense. Why share food with someone who may be your rival for a mate?

There is anecdotal evidence that the white-winged and hairy-legged vampires also share blood, but in contrast to Wilkinson's in-depth study of *Desmodus*, this behavior in *Diaemus* and *Diphylla* has yet to be studied in detail.

In other ways, *Desmodus* exhibits unique traits among the trio of vampire bat species. One of the reasons for the common vampire's success is its ability to feed from the ground—and thanks to humans, they have developed a partiality to cows' blood. This they often obtain while on the ground, from the region behind the cows' hooves, an area with relatively thin skin and an ample blood supply flowing close to the surface. Feeding also takes place with the bat riding its prey's back, where it's easy for the vampire to reach sensitive areas like the ears.

To feed on the ground, *Desmodus* has evolved the ability not only to walk and even run on all fours, but to make spectacular, acrobatic jumps in any direction. A flight-initiating jump off the ground is powered by strong pectoral muscles and fine-tuned by elongated thumbs, which are the last things to leave the ground. The thumbs impart precise direction to jumps that can reach three feet in height. That enables the common vampire to escape predators, avoid being crushed by its relatively enormous prey, and initiate flight after a blood meal. This ability to feed efficiently and safely on large mammals, combined with the increasing supply of domesticated livestock, is the primary reason why *Desmodus* has been so successful in numbers and range.

WILD BATS SHARE
REGURG

WHILE WORKING WITH white-winged vampire bats, I discovered that they move differently from the common vampire, and not only because they have shorter thumbs. Perhaps *Diaemus* bats once initiated flight similarly to their aggressive, spring-loaded cousins, but now their movements are more deliberately paced and show little sense of urgency. When placed on a force platform—which measures the forces generated by an animal as it moves across the surface—white-winged vampires would give a little hop or two, then scuttle off to find a dark corner to hide in.

Watching *Diaemus* feed in trees, rather than terrestrially like *Desmodus*, I learned why the former doesn't need to catapult into the air. Approaching a roosting bird from below its perch on a branch, a white-winged vampire will move slowly and stealthily, always keeping the branch between itself and the underside of its intended avian prey.

Once situated beneath the feathered lunch wagon, *Diaemus* picks a potential bite site, usually on the bird's backward-pointing big toe, the hallux. Feeding from that particular digit keeps the bat better hidden from above than if it were to feed on one of the forward-facing toes. After licking the

FOOD BY EATING BLOOD

Common vampire-bat mothers share food with their young by regurgitating blood.

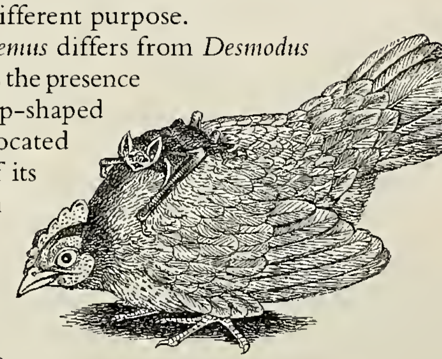
chosen site for several minutes, the bat inflicts a painless bite with razor-sharp teeth, which characterize all three vampire bat species. The bite is never violent and very often occurs as the bird shifts position slightly. Anticoagulants in the bat's saliva will keep blood flowing from the tiny wound well after the bat has drunk its fill.

Still hanging below its completely oblivious prey, *Diaemus* begins feeding, and within five minutes it begins peeing. To meet its energy needs, the vampire must drink close to half its body weight in blood at each meal, and blood is about 80 percent water. So the bat's digestive and excretory systems have evolved to unload the excess quickly: the stomach lining is rich in blood vessels that absorb water and shunt it straight to the kidneys. *Diaemus* deftly avoids soiling itself while it eats by extending one hind limb sideways and downward. After feeding for fifteen to twenty minutes, the bat releases its thumbs from the branch, hangs briefly by its hind limbs, then drops into flight. Initiating flight in this manner means that there is no need for *Diaemus* to jump in the manner of its terrestrially feeding cousin, *Desmodus*.

On numerous occasions, my colleagues and I have observed *Diaemus* feeding on birds from the ground. Supporting its body in a low crouch, as compared with the extreme upright stance of *Desmodus* feeding on a cow, the white-winged vampire is adept at hopping around, rather comically, in pursuit of a feathered blood meal. Although ground locomotion has not been reported in the wild, we proposed on the basis of this behavior (and the possession of robust hindlimb bones) that white-winged vampires have made a relatively recent return to the trees, thus avoiding competition with their ground-feeding cousins.

During the terrestrial feeding bouts of our white-winged vampires, we also recorded a parasite–host interaction that rivaled chick mimicry on the "weird-o-meter." When a bat leaped or climbed onto a chicken's back to get a meal, a male chicken would quickly grow agitated and dislodge the bat with a shake and a peck. A hen mounted in this fashion, however, would immediately assume a crouching posture, giving the bat the opportunity to scuttle forward and bite the back of the bird's head or its fleshy comb. The hen would maintain this crouch until after the vampire bat had finished feeding and hopped off. With a little research into poultry behavior, we learned that this was the exact posture taken by a hen while being mounted by a male bird—for a completely different purpose.

Another way that *Diaemus* differs from *Desmodus* and *Diphylla* is the presence of a pair of cup-shaped oral glands located at the rear of its mouth. When *Diaemus* gets upset or engages in battles for dominance, these glands are projected forward and can be seen quite easily when the bat opens its mouth. *Diaemus* simultaneously emits a strange hissing vocalization and a fine spray of musky-smelling liquid from the oral glands. Although a detailed study remains to be performed, the oral glands of *Diaemus* appear to be employed in self-defense, as well as in communicating infor-



White-winged vampire bat (Diaemus), above, climbs onto the back of a hen, which crouches as if mounted by a rooster. The bat will then feed, typically from the rear portion of the bird's fleshy comb. Below: The common vampire bat can run along the ground like a spider and make spectacular jumps, to initiate flight and to avoid being crushed by its mammal prey, such as cows.

Diaemus possesses a unique feature among the three vampire bats, a pair of cup-shaped oral glands that project forward when the bat is agitated or during displays of dominance. The glands emit a fine spray of musky-smelling liquid.

mation such as status, mood, and territorial boundaries to others of its kind.

A CLOSER LOOK at the third genus, *Diphylla*, the hairy-legged vampire bat, so named for the frill of hair that borders the back margin of its hind legs, also revealed unexpected morphological and behavioral adaptations related to feeding. *Diphylla* is thought to exhibit the most primitive anatomical characteristics of its group. In other words, scientists believe that *Diphylla* has undergone the least evolutionary change from ancestral vampire bats—whatever they were.

The hairy-legged vampire possesses an anatomical characteristic not seen in its blood-feeding cousins—or in any other animal. It is a unique variation in a structure found in many bats called the *calcar,* a bony or cartilaginous extension of the heel bone (the calcaneus).

Since bat hind limbs are rotated up to 180 degrees from the typical mammalian position—picture your knees facing backward—the calcar generally points toward the midline of the body. Its function is to strengthen and straighten the trailing edge of the tail membrane, or *uropatagium,* that spans the space between a bat's hind limbs. Basically, the calcar increases aerodynamic efficiency by preventing that extra lift surface from flapping around during flight.

As one would expect, the calcar varies in size and shape among the 1,100 bat species. It's also no surprise that the calcar is absent in bats that do not have a tail membrane. At least, that's what I thought until I started examining preserved specimens of *Diphylla* at the American Museum of Natural History, where I was working as a postdoctoral research fellow.

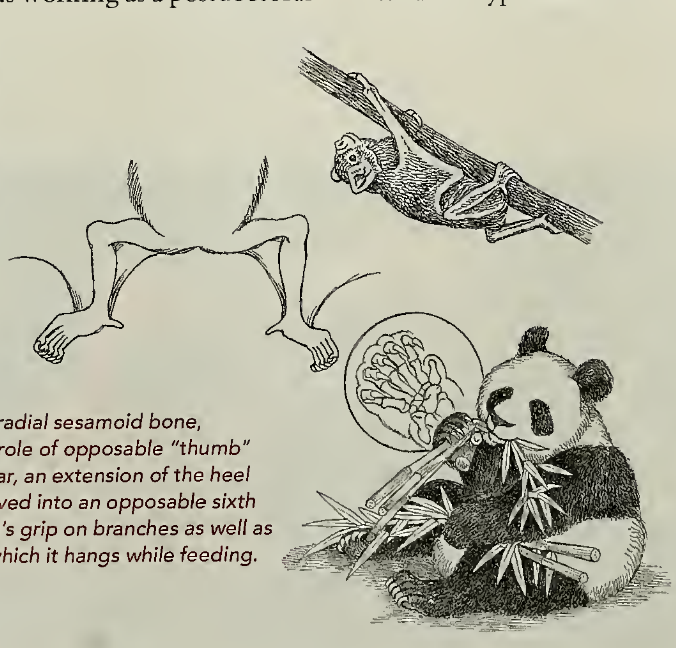
Having determined that differences in behavior existed between *Desmodus* and *Diaemus,* such as jumping versus non-jumping, I started looking to see if those differences might be reflected in their anatomy. Comparing vampire-bat hindlimbs, I noticed that the calcar was absent in *Diaemus* and reduced to a flaplike tab in *Desmodus.*

No big deal, when you consider that all three vampires lack a functional tail membrane.

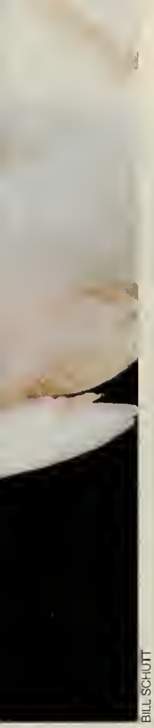
The calcar of *Diphylla* was a completely different story. Not only was it present in the specimen I examined, but it protruded like a tiny finger. I immediately pulled out several additional specimens to make sure I wasn't simply looking at one extremely odd individual. But in each instance, I saw the same finger-shaped structure. Next, I hit the literature, looking for any mention of *Diphylla's* calcar. "Small but well developed," ran the typical description, but nothing more.

I immediately put together a proposal to examine the function of *Diphylla's* calcar, and I set my sights on a visit to central Brazil, where I would be working with Brazilian zoologist Wilson Uieda—a scientist who had been studying the hairy-legged vampire for years with his colleague Ivan Sazima.

What I'd hypothesized was similar to the story of the panda's thumb, popularized in an essay by Stephen J. Gould in *Natural History* ["This View of Life," November 1978]. The giant panda feeds on bamboo leaves that it strips off branches, seemingly with the aid of its opposable thumb. But anatomists who examined the panda's forelimb found that things weren't quite as they seemed. The panda's thumb was actually a wrist bone—the radial sesamoid—that had become greatly enlarged, allowing the structure to take on a new function: grasping bamboo



Evolution has co-opted the panda's radial sesamoid bone, originally a part of its wrist, into the role of opposable "thumb" (inset right). Similarly, Diphylla's *calcar, an extension of the heel bone (above and top right), has evolved into an opposable sixth digit that is used to facilitate the bat's grip on branches as well as on the body of its avian prey, from which it hangs while feeding.*



BILL SCHUTT

Diaemus feeds from a wound it has inflicted on a chicken's backward-facing big toe, called the hallux. Feeding this way keeps the bat hidden from its sharp-beaked prey.

stalks. Gould cited the panda's "thumb" as a beautiful example of how evolution tinkers with what's already there, modifying structures for a new function rather than creating new structures from scratch. Would the same principle apply to the vampire bat's calcar?

At a ranch outside the capital city of Brasília, Uieda and I set up my infrared video camera at sunset. We aimed the camera upward, into the branches of a fig tree, for it was there that the resident guinea fowl went to roost at dusk.

Several hours after nightfall, as I stared bleary-eyed through the camera's viewfinder, a pair of dark shapes flew past the sleeping birds.

"Wilson, check this out," I whispered.

My friend, who had been dozing on the chair next to mine, was instantly alert.

Less than a minute later, we performed the aerial reconnaissance a second time.

Uieda whispered a single word: "*Diphylla*."

After that we saw nothing for several minutes—until a tiny pair of glowing spots appeared beneath one of the roosting birds. I hit the zoom on the camera, focusing in on the twin points of reflected light. They were eyes!

Uieda traced a dark silhouette on the screen, and I could just make out *Diphylla's* upside-down head peeking out from the guinea fowl's feathery breast.

"Dinnertime," he said.

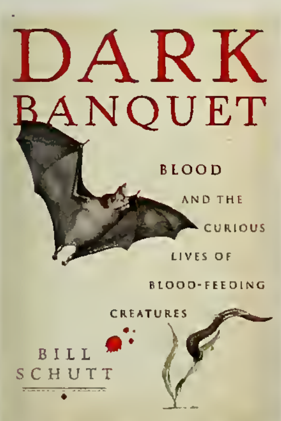
"This is different from *Diaemus*," I responded.

Rather than feeding from below the branch, *Diphylla* was actually hanging from the bird! Even more interesting, photographs taken by Wilson Uieda and his colleagues at another site clearly showed that *Diphylla* was using its opposable calcar to get a grip on the body of its avian prey. Unlike the white-winged vampire, which generally hangs from a branch and feeds from the toes of perching birds, *Diphylla* made many of its bites around the cloaca—the common opening for the digestive, urinary, and genital tracts found in many non-mammalian vertebrates, such as birds.

Several days later, we visited a cave that was home to a small colony of *Diphylla*. Using the infrared camera again, we recorded three hairy-legged vampires as they moved across the stony ceiling. Not only were the bats walking upside down, they were moving backward (not really strange, since bat knees face backward). What was unique was the way they led with their hind limbs, carefully seeking a secure purchase before taking a step—and using their "sixth digits" much as a rock climber would use his thumbs.

After scrambling around the cave ceiling for a few minutes, the vampire bats disappeared into a narrow crevice. I left the cave elated that we'd been able to support my hypothesis with observations in the field. What had begun as a surprising observation back in New York City ended with the discovery that, just like the panda's radial sesamoid bone, the hairy-legged vampire bat's calcar had been co-opted for a new role as an opposable digit.

VAMPIRE BATS HAVE LONG been prime candidates for superstition and folklore-based fear. Only relatively recently have they gone from barely glimpsed creatures of the night to subjects of thoroughgoing scientific research and increasing open-mindedness. Rather than presuming that the three vampire bat genera are similar, researchers are currently studying these mammals with an eye toward variation. As a result, we are discovering intriguing adaptations and behaviors related to blood feeding. But we've also come to understand that two of the three vampire species (*Diaemus* and *Diphylla*) urgently need our help if they are to avoid extinction over the next few decades. The welcome shift in the vampire bat's public image may be coming just in the nick of time.



This article was adapted from *Dark Banquet: Blood and the Curious Lives of Blood Feeding Creatures*, by Bill Schutt, © 2008. Reprinted with permission from Harmony Books, a division of Random House, Inc. All rights reserved. On sale in bookstores in October.

Bill Schutt earned his Ph.D. in zoology at Cornell University and worked on a postdoctoral research fellowship at the American Museum of Natural History with bat expert Nancy B. Simmons. He is currently an associate professor of biology at the C.W. Post Campus of Long Island University and a research associate in Mammalogy at the American Museum.

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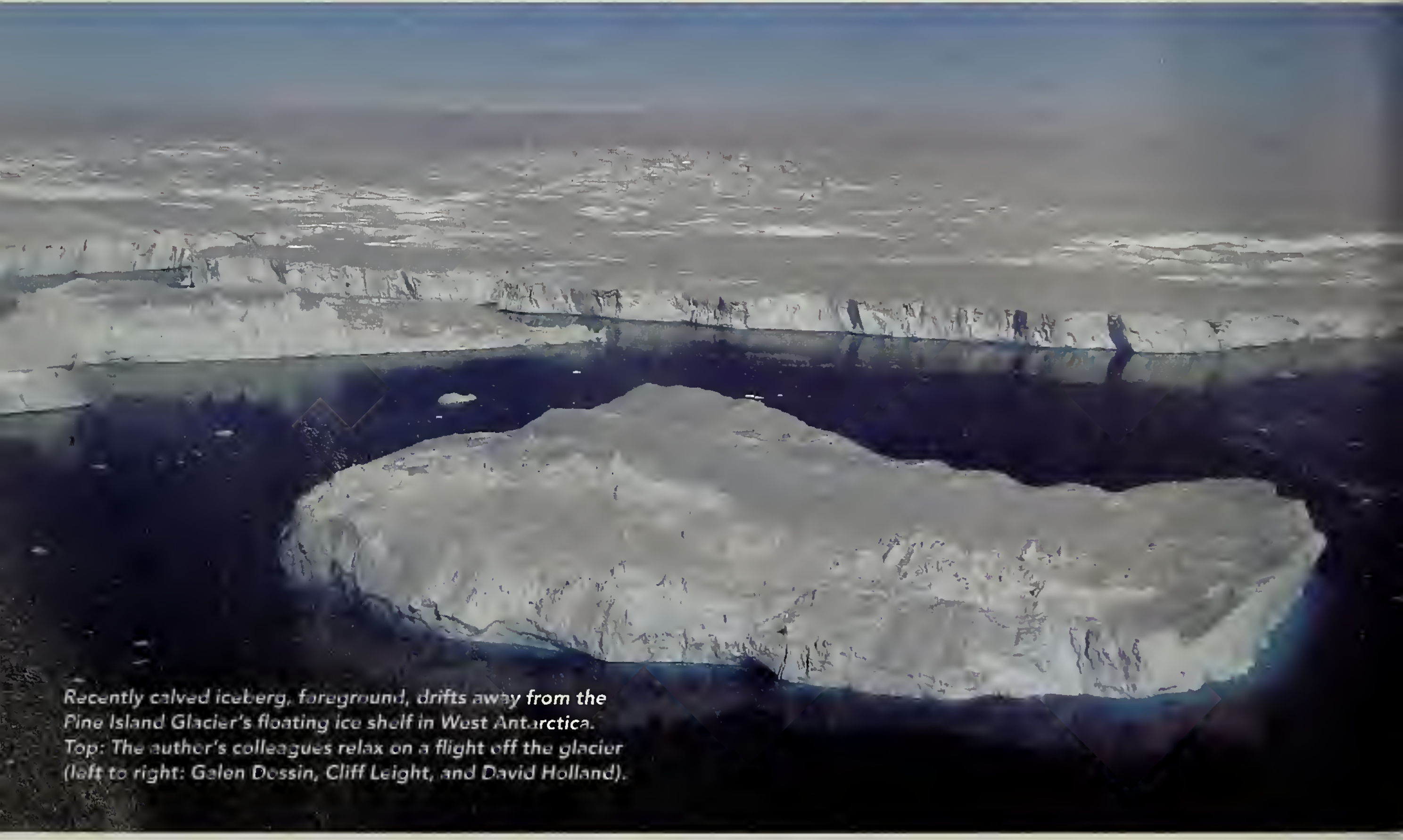
ROBERT BINDSCHADLER

Ice on the

What's happening beneath West Antarctica's ice shelves? The warmth and flux of water there may determine how far sea level rises.

The ice shelf, a thick lip of floating ice extending beyond the ice-bound continent beneath us, came into view through my window on the Twin Otter plane. Undulating and deeply crevassed, the shelf was a welcome sight; months poring over flat satellite imagery had made me impatient to see it in vivid, three-dimensional reality, and here it was at last. Deep-blue water just beyond the ice caught me off guard: funny, but after nearly three weeks in Antarctica, I was surprised to see a color other than white. Offshore, an iceberg drifted majestically into the blue. It didn't look anywhere near as large as 150 square miles, its actual size according to the satellite images. Scale will always fool you in Antarctica.

The ice shelf—the plane's destination—had never before been visited. The nearest trace of civilization, a lonely research outpost, lies 350 miles away. The shelf buttresses West Antarctica's immense Pine Island Glacier, and it has been melting alarmingly in recent years. A breakup of the shelf would hasten the glacier's gradual slide to the sea; if



Recently calved iceberg, foreground, drifts away from the Pine Island Glacier's floating ice shelf in West Antarctica. Top: The author's colleagues relax on a flight off the glacier (left to right: Galen Dessin, Cliff Leight, and David Holland).

Edge

BY ROBERT BINDSCHADLER

other local ice shelves follow suit, as they threaten to do, the glaciers they unleash will contribute substantially to rising global sea level. The trip, made last January, was the first stage of a project to discover the cause of the ice shelf's worrisome melting. Our mission: to scout a safe landing site, return later that day to set up a field camp on the shelf, and spend a week reconnoitering and installing some basic scientific instruments that would allow us to monitor the site from afar.

As the Twin Otter approached the shelf, I pondered my long journey there. Nearly three years to develop the research project and plan the trip, for starters. The actual trip began with a full day of commercial flights from the United States to Christchurch, New Zealand. Five hours after lifting off from summery Christchurch I'd arrived on the frozen continent, along with my collaborator, David M. Holland, a polar oceanographer from New York University. Our first stop was McMurdo Station, the main American-run base for Antarctic research [*see map above*], where we spent a week testing and packing camp equipment. Once prepared, however, we had to sit tight for ten days as flight after flight was cancelled due to high winds or poor visibility. Eventually, good weather at McMurdo and at an intermediate stopover—the tiny research outpost, called the West Antarctic Ice Sheet Divide camp—let us take a 1,000-mile jump toward the ice shelf.

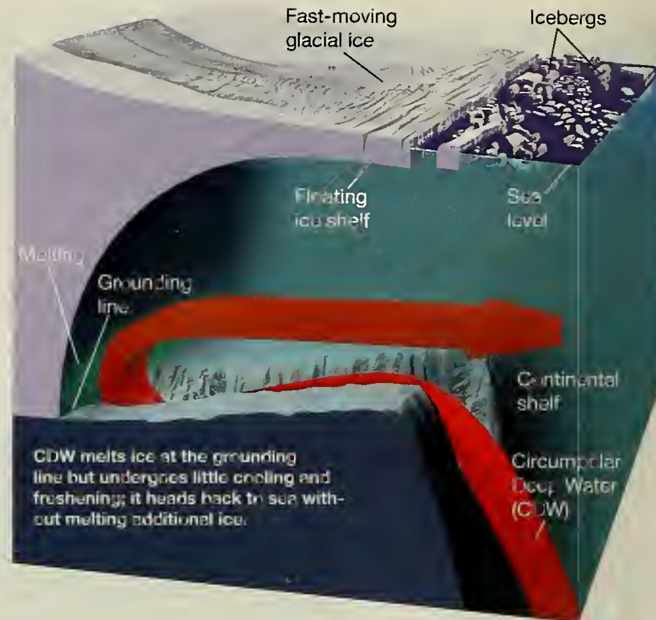
After another two-day weather delay at the stopover, I embarked without Holland on the reconnaissance flight to the ice shelf, the journey's final 350-mile leg. Two mountaineering experts joined me; their experience with crevasses helped the two pilots and me assess the safety of the surface for a landing. Recent satellite images directed us to a narrow, five-mile-long strip of smooth ice. Through the windows we could see monstrous crevasses bounding the strip—but were there smaller ones we couldn't see? To find out, the pilot nosed in for a "ski drag": he ran the plane's skis over the icy surface, attempting to crush any ice bridges that might hide crevasses, while maintaining flying speed to prevent us from falling into one. A-OK. The plane soared up, circled again, and in short order we landed bumpily and skied to a safe stop. Finally, the moment I'd thought about so often in my office and on the long trip!

I whooped, thrust my fist in the air, and clapped my hands for the pilots to see. Then, leaping out the plane's door, I became the first person ever to stand on that desolate ice shelf. My companions quickly joined me. Sunny and windless—ideal conditions. The surface was as hard as a concrete sidewalk. That would turn out to be a big problem for the rest of our plans, but for the moment I felt only joy. Fifteen hundred feet beneath our boots, warm water was rapidly melting the underbelly of the ice shelf. The shelf, carrying us, was racing toward the sea at one foot per hour.

Like grumpy Rip van Winkles, the world's three landmass-covering ice sheets—two on Antarctica, the East Antarctic and West Antarctic ice sheets, and one on Greenland—seem to be waking from a long sleep and becoming active, especially around their edges. Rising global temperature, boosted by humankind's increasing combustion of fossil fuel, is the ringing alarm clock. The ice sheets are shedding some of their frozen selves, as they've done each time the world has warmed in bygone eras.

Experts are astonished at how fast the Antarctic ice sheets, which hold 90 percent of Earth's grounded ice, and the Greenland ice sheet, with 9 percent, are changing. (Comparatively puny mountain glaciers and snowcaps around the world hold the remaining 1 percent.) Even

Diagrams show three hypothetical ways in which the warmest water of the Southern Ocean, called the Circumpolar Deep Water (CDW), may be melting the ice shelves of West Antarctica. In each case the CDW flows from the deep ocean onto the continental shelf, whose valleys steer it toward the glacier's grounding line—where the grounded ice sheet comes afloat to form the floating ice shelf. The CDW melts ice at the grounding line, and the meltwater not only cools but freshens—and therefore lightens—the CDW, so it rises before flowing back out to sea. How much cooling and freshening takes place affects the stability of the ice shelf. The author seeks to determine which of these three scenarios is occurring, because the ice shelf helps keep land-bound glaciers from slipping into the sea and raising sea level worldwide.



the best models of ice-sheet dynamics failed to predict the dramatic developments, so clearly important processes have been missing from our calculations. Yet the revelation of inadequate understanding comes just when the need to predict ice-sheet behavior is most pressing: shrinking ice sheets raise sea level, and elevated sea level will have enormous consequences for coastal populations and ecosystems and for nations' economies. Most ice experts expect at least a three-foot rise in sea level by 2100, and a recent estimate put the global price tag of that eventuality at just under a trillion dollars.

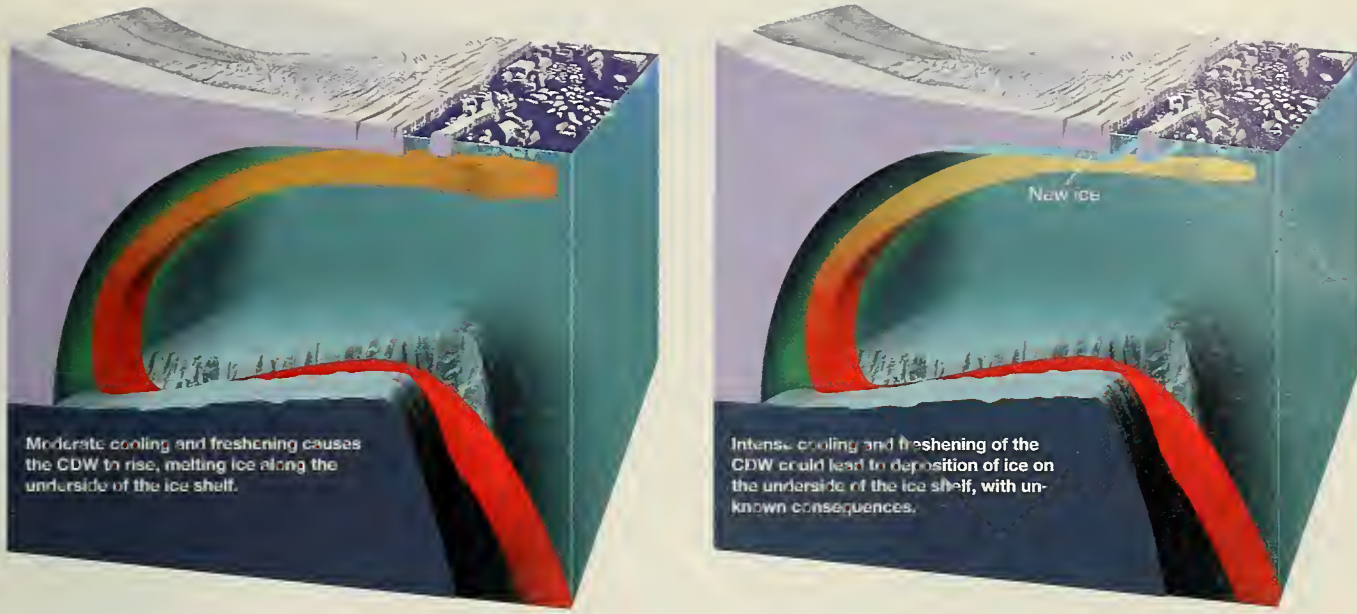
Of Antarctica's three major geographic units—East Antarctica, West Antarctica, and the Antarctic Peninsula—the last is changing most dramatically. After at least 10,000 years of relative frozen stability throughout most of the region, ten of the thirty or so ice shelves on the peninsula have receded in recent decades, half of them either vanishing entirely or diminishing to less than a quarter of their original area. Increasingly warm summers melt snow on the surface of those immense floating plates; the meltwater fills cracks in the ice and, because water is denser and heavier than ice, it can drive the cracks all the way down through the 300-foot-thick shelves. Reduced to a series of icy towers teetering in an undulating ocean, the shelf's remnants tip over and launch a vast armada of icebergs that drift away from a suddenly ice-free bay.

Melting and disintegration of floating ice shelves do not, by themselves, change sea level, because the volume of seawater displaced remains the same. But with no ice shelf to block their progress, the flowing glaciers that fed the former shelf speed up—by a factor of four or five. And glacial ice entering the ocean from land raises sea level instantaneously. The ice shelves of the Antarctic Peninsula buttress enough grounded glacial ice—roughly equal to all the world's mountain glaciers and ice caps—to raise global sea level ten inches. If temperatures over the peninsula continue rising as predicted, much of that ice will flow into the ocean in the next century or two.

Fortunately, East Antarctica is at present the coldest of the continent's three regions, and its ice sheet, which holds roughly 90 percent of Antarctica's ice, appears to be mostly stable. West Antarctica, however, is a different story. That region is changing rapidly in areas like the Pine Island Glacier, and much vaster expanses of ice are affected than those on the adjacent Antarctic Peninsula.

The West Antarctic ice sheet, resting on a rocky bed mostly below sea level, averages nearly a mile in thickness. A network of glaciers (called ice streams if they're bounded by slower-moving ice on both sides) funnels large volumes of ice from the inland center of the sheet to the relatively fast-flowing perimeter, where the ice comes afloat in immense ice shelves. West Antarctica has three subregions of nearly equal size. One feeds the Ross ice shelf, which calves icebergs into the Ross Sea; another feeds the Ronne ice shelf, whose icebergs drift away in the Weddell Sea; and a third feeds several smaller ice shelves that calve into the Amundsen and Bellingshausen seas. Satellite observations show that the third subregion, with enough ice to raise sea level five feet, is changing most dramatically. Two glaciers—both monstrously large—dominate the discharge, the Pine Island Glacier and the Thwaites Glacier. Hundreds of miles long by tens of miles wide and nearly a mile thick, they move at a rate of more than a mile per year.

When satellite data began to accumulate in the early 1990s showing that those two immense glaciers were acting up, scientists became deeply concerned. Pine Island Glacier showed the greatest changes. It was thinning and accelerating everywhere, and its "grounding line," where ice loses contact with land and comes afloat to form the ice shelf, was retreating upstream. Calculations of the rate of



FRANK IPPOLITO

flow indicted that the bottom of the Pine Island Glacier's floating ice shelf was melting at a rate of more than 150 feet per year. Those calculations rocked the glaciological community: at the time, basal melt rates of just thirty feet per year were considered extreme. Also notable was that the rate of thinning and the acceleration of flow were much greater near the coast than inland, suggesting that the cause lay at the grounding line or offshore on the floating ice shelf—not on the grounded glacier. Then, about five years ago, new measurements made with sensors carried by airplane showed that the rate of thinning had increased throughout most of the ice feeding into and floating on the Amundsen Sea. Pine Island Glacier again exhibited the greatest changes. Thinning ice shelves are vulnerable to collapse, of course. Even short of wholesale disintegration, however, thinning almost certainly results in acceleration of glacial flow, and therefore in sea-level rise.

But what's causing the changes in West Antarctica? Whereas the ice shelves of the Antarctic Peninsula are under attack from the top down, those of West Antarctica are melting from the bottom up. The region hasn't warmed nearly as much as the Antarctic Peninsula, so surface snowmelt isn't the trigger—something else is. Identifying and understanding the trigger is critical to the urgent task of predicting the ice shelf's, and thus the ice sheet's, future. In 2005 it became clear that despite agreement on that point by virtually every scientist working in West Antarctica, nobody had research plans to address the question on the ground. I decided to fill the void and, working with a team of colleagues from several specialized disciplines, developed a research program to understand the West Antarctic changes.

As we crafted our program, other investigators were considering hypotheses to explain the melting. Here's how the favored explanation works [*see diagrams above*]: The warmest water in the Southern Ocean, called Circumpolar Deep Water (CDW), occurs at depths of between 1,600 and 3,000 feet and flows eastward, clockwise around Antarctica. Surface waters, formed from sea ice melting each Antarctic summer, are less dense, and therefore lighter, than the CDW because they're fresher—less salty. Bottom waters, below the CDW, are denser because they're very cold. The CDW usually stays well offshore, in the deep ocean, because its upper boundary lies deeper than the seafloor of Antarctica's continental shelf.

To get to the ice, the warm CDW must first get up onto the continental shelf. Increased surface wind probably starts the process by dragging surface water more rapidly around Antarctica. The Coriolis force, an effect of Earth's rotation, nudges that surface water away from the coast. The CDW rises to replace the displaced surface water. The stronger wind, for its part, could stem from an increase detected in the temperature difference between the air over the continent and the air over the surrounding ocean. (Most of Antarctica is warming more slowly than the rest of the planet.) Bigger temperature differences cause stronger pressure gradients, which cause stronger winds.

Back to the main theory. Once up on the continental shelf, the salty CDW stays below the comparatively fresh resident surface water, hugging the continental shelf's seafloor. But the continental shelf isn't flat; it slopes down toward the continent, and it has numerous valleys carved by glaciers during past ice ages. The CDW sinks into the valleys, which steer it downslope to the present-day grounding lines of the glaciers that carved them so long ago.

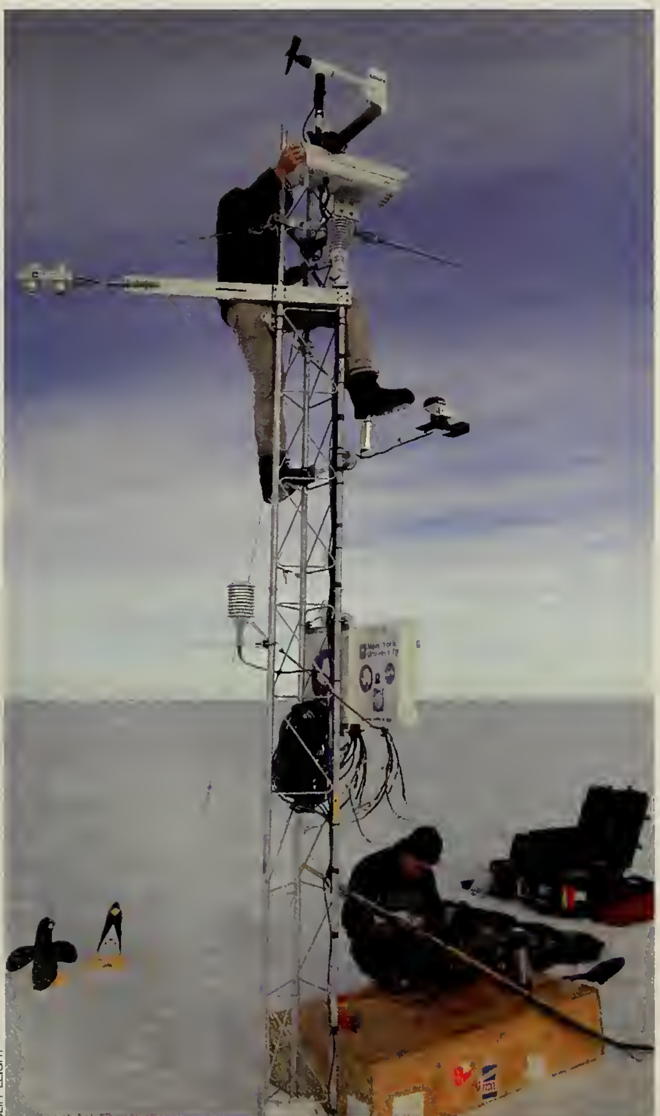
Arriving at the glaciers' bases, the relatively warm CDW melts the ice it contacts. How much melting occurs depends on the temperature difference between ice and water. The CDW may be as warm as 5 Fahrenheit degrees above freezing. In that case, though, the temperature difference would be even larger than 5 degrees, because the freezing point of ice decreases with increasing pressure. Pine Island Glacier's grounding line lies nearly 4,000 feet below sea level—deep enough to lower the freezing point nearly another 3 degrees. Thus, the total temperature difference near Pine Island would be about 8 degrees. That might not sound like much, but it's enough to cause the huge observed melt rates.

The meltwater chills the CDW, making it slightly heavier, but also dilutes it, making it fresher and so lighter. Freshening wins out, and the CDW rises while flowing back out to sea under the ice. Just how much freshening and chilling occurs is an important question, and one my team seeks to answer. A moderate amount would cause the CDW to rise from the grounding line along the underside of the shelf, continuing to melt and thin the ice there, before heading offshore. Less freshening and chilling, and the CDW would head out to sea at some intermediate depth below the ice; losing contact with the ice would prevent further melting. A third possibility is that the CDW becomes extremely fresh and cool. It would melt ice as it rises, but would actually freeze onto the shallow, seaward underside of the ice shelf because the meltwater infusion puts its temperature somewhere between the freezing points of the ice at depth and the shallow part of the floating ice shelf. The consequences of transferring masses of ice from near the coast to the offshore shelf are unknown.

To test whether the CDW is indeed responsible for the observed melting, we need to simultaneously monitor the water beneath the ice shelf and the flow of the overlying ice. Nobody has ever explored beneath such an active ice shelf. Our instruments will have to fit down a 1,500-foot-deep hole only five inches in diameter—that's the widest hole my teammate Martin Truffer, a glaciologist at University of Alaska Fairbanks, can create with a system he developed that heats melted snow and pumps it through a nozzle to melt the ice. Once we hit seawater, we'll have a look around with a video camera. Whether the underside of the shelf is rough or smooth affects the exchange of heat between water and ice. We don't expect to see any marine life, but who knows?

We'll also measure the temperature, salinity, and current strength of the water flowing in and out under the shelf. Because the inflow and the outflow move at different and possibly changing depths, Timothy Stanton, an oceanographic engineer at the Naval Postgraduate School in Monterey, California, is designing sensors that will rise up and down along a taut steel cable to profile the water column. The sensors will transmit their data through the cable to a receiving station on the surface, which will send the data back to Stanton in California. The ice will seal the sensors permanently within days of deployment, but onboard batteries should keep them running for at least three years. A different team, led by Stanley S. Jacobs, an oceanographer at Columbia University's Lamont-Doherty Earth Observatory, plans to measure water properties at several points seaward of the ice shelf. Their moored instruments should observe the same water approaching and exiting the ice shelf that we detect beneath the shelf.

It was while our teammates were developing the instruments for the project that Holland and I embarked on our journey to see the Pine Island Glacier ice shelf—so far only observed by satellites and from airplanes—up close.



CLIFF LEIGHT

Author's colleagues erect a weather station on the Pine Island Glacier.

Montage of video stills taken in March 2008 shows the disintegration of a portion of the Wilkins ice shelf on the Antarctic Peninsula. So far this year, Wilkins has lost a total of 740 square miles, twice the area of New York City. Such losses along the peninsula are attributed to warming air temperatures. By contrast, the thinning of the ice shelves of West Antarctica seems to result from the impact of warm seawater.

"Bob, I have some bad news." The words came through my headset shortly after lifting off from the Pine Island Glacier ice shelf. I was in a state of elation at the success of the reconnaissance mission: we'd landed safely and scouted a workable site for the field camp. We were planning to return later, with Holland, to set up camp for a week of reconnoitering and to install two GPS receivers and an automatic weather station—all in preparation for a return the following year to set up our main instruments.

"We aren't going to be able to put in your field camp," the pilot continued. He and the pilot of an accompanying plane, which carried some of our camp equipment, had determined that the surface was too hard and rough to permit repeated takeoffs without damaging the landing gear when the time came to fly us and our gear off the ice shelf.

Naturally, I was massively disappointed. But the decision didn't diminish what we'd already accomplished. Deciding to make the best of it, we spent the next few days at relatively accommodating sites on a slow-moving area of the ice shelf and on the Pine Island Glacier, where we set up our gear. The GPS receivers would still tell us whether glaciers feeding the ice shelf change speed over time. And the weather station would fill a huge gap in global weather data. Once the last instrument was installed, our parkas came off, jokes flew, and cameras snapped.

The equipment we left behind is now transmitting a steady stream of data that should continue until our return—by helicopter instead of plane—in December 2009. (Hey, who said we were giving up?) I'm more excited about the project than about any other in my twenty-five years of Antarctic fieldwork. It's a thrill to study ice misbehaving in ways that five years ago were considered impossible. But it's the pressing need to anticipate future sea level, a matter critical to the well-being of people around the world, that gives the project such urgency. What more could a scientist want?

Robert Bindschadler is Chief Scientist of the Hydrospheric and Biospheric Sciences Laboratory at NASA Goddard Space Flight Center in Greenbelt, Maryland. He is also a fellow of the American Geophysical Union and a past president of the International Glaciological Society. He has led fifteen Antarctic field expeditions, and has worked in Greenland and on various glaciers around the world. He has published more than 150 scientific papers and numerous review articles. A glacier and an ice stream in Antarctica are named after him.

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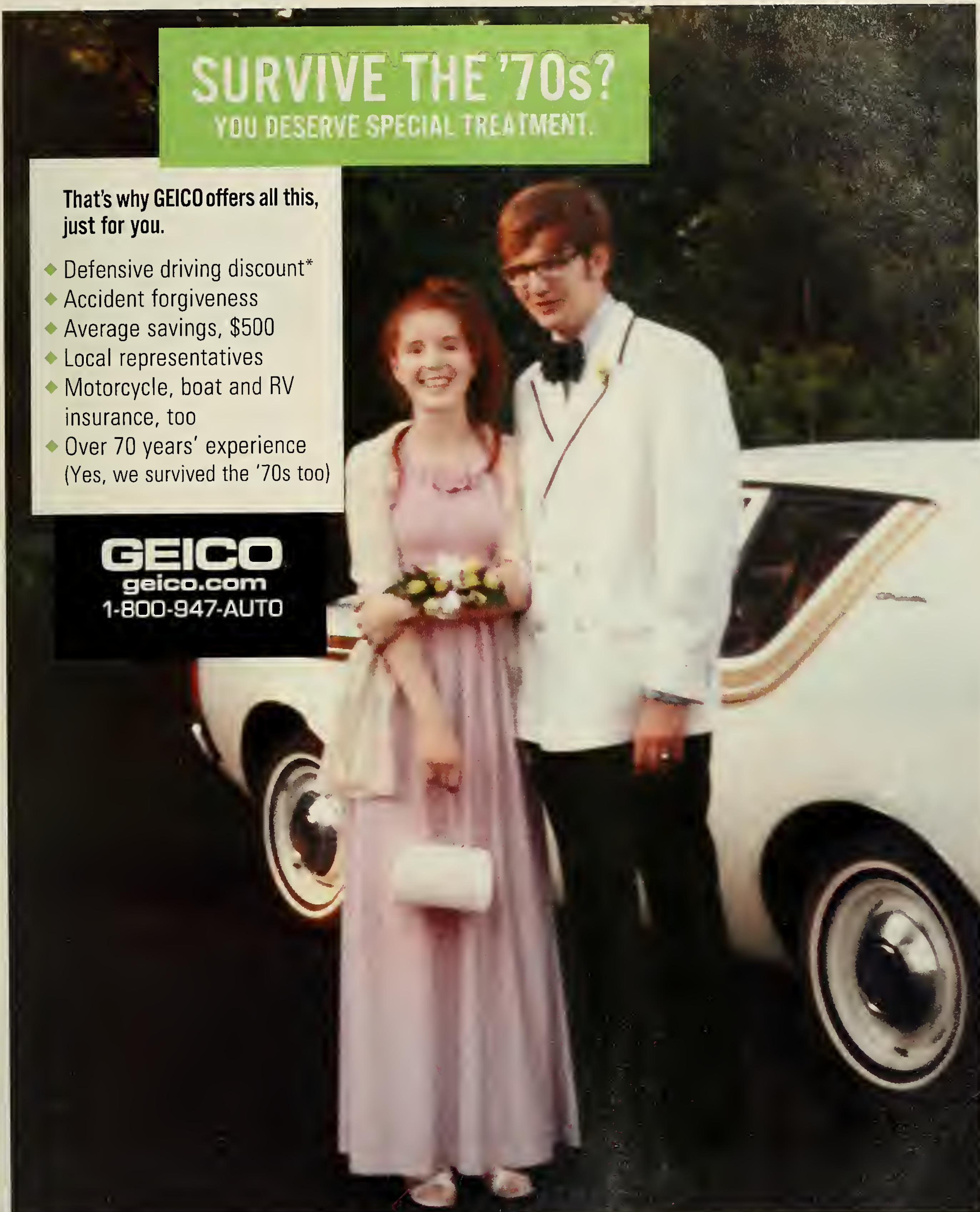
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View east over Mohonk Preserve from a pinnacle in Mohonk Mountain House Resort

Top of the Gunks

Rocky ridges in the Empire State draw climbers, falcons, and highland rushes.

by Howard R. Feldman and John Thompson

New York State's Shawangunk Mountains—locally pronounced SHONG-gum, and often called "the Gunks"—are the northeastern extension of an Appalachian ridge that, under other names, runs south through New Jersey, Pennsylvania, Maryland, West Virginia, and Virginia. A rugged topography lures more than fifty thousand rock climbers a year, eager to practice their craft. Other visitors to the Shawangunks are attracted by the opportunities for hiking, biking, cross-country skiing, snowshoeing, hang gliding, birding, hunting, and horseback riding. The public can access the region principally at Minnewaska State Park Preserve, Mohonk Preserve (whose visitors can also roam the outdoor property of the Mohonk Mountain House resort), and Sam's Point Preserve.

Responsible for much of the Gunks' appeal is their characteristic bedrock, laid down during the Silurian period, approximately 444 million to 416 million years ago, by shallow, braided rivers and streams. Although rapid-flowing, those waters shed large quantities of their sediments—mud, sand, gravel, and stream-worn quartz pebbles. Uniform consistency is not in the Gunks' nature, however, as attentive hikers and climbers will discover. Depending on what sediments the streams carried at different times, and how they were sorted according to the flow of water, the largest granules and pebbles were often concentrated in certain layers and locations. In time, they were bonded together by a silica-rich natural cement to form a type of sedimentary rock known as a conglomerate.

Elevated by subsequent mountain building, the Gunks' bedrock—a geological unit called the Shawangunk Formation—now peaks 2,289 feet above sea level. In New York the formation ranges in thickness from about 1,400 feet near the border with New Jersey to only 10 feet at Binnewater, in the northeast. Beyond there it finally "pinches out" and disappears, though Silurian deposits extend north to the Albany region. Resistant to erosion because of its quartz content, the Shawangunk rock is nevertheless heavily faulted and jointed, probably from the tectonic and gravitational stresses endured as a result of mountain building. Small cracks further widen as trees push down their roots, and as water freezes and expands (a process called frost wedging, which is also responsible for New York City's notorious potholes).

Through such mechanical processes, huge blocks of rock are gradually split apart, and deep fissures and narrow canyons are formed. Some crevices, often with overhanging rock, are known as ice caves because they accumulate snow and ice in the winter that persists through the summer. They are a notable feature in Sam's Point Preserve. Elsewhere, cliffs have been carved out as softer rock surrounding the conglomerate has weathered away. They jut out of the landscape like white scars.

Other scars mark the face of the

ARGO IMAGES GMBH / ALAMY

Witch hazel blossoms

Gunks. Beginning about 100,000 years ago, a glacier plowed through the entire Hudson Valley. The ice retreated from the Shawangunk Mountains about 18,000 years ago, but one can find polished outcroppings of bedrock with scratches and grooves left by boulders that traveled beneath the huge mass of ice. The direction of the striations changes according to how the glacier moved. For example, on the north side of Mohonk Lake, the striations run from northeast to southwest at an angle of about 10 degrees, but on the south side of the lake, at the top of a crevice known as the Lemon Squeeze, the striations angle 20 degrees to the southeast. That is because the glacier swung around a high cliff now known as Sky Top.

In some places, closely-spaced, curved scars called chattermarks are evident. The pressure from rock fragments dragged along beneath the glacier flaked off bits of brittle bedrock, creating those small, crescent-shaped indentations. Each chattermark lies roughly at a right angle to the direction of ice movement, the ends of its crescent commonly pointing in the direction the glacier moved.

From a distance, the landscape of the Shawangunks appears to comprise a fairly uniform hardwood forest interrupted by bare cliffs and rock outcroppings. In fact, as a result of inconsistent weathering and variations in topography, the mountains embrace numerous habitats and microenvironments. Among them are the cliff tops and faces and the rocky areas beneath the cliffs, called talus slopes, which have built up from fallen rock fragments. Historically, those linked zones have suffered the least from human disturbance, owing to their relative inaccessibility. Some of the oldest trees in New York State—more than 300 years old—survive on the talus slopes.

The cliffs, as well as talus areas with little tree cover, discourage the growth of many common plant species but harbor others well adapted to those zones. Quite a few of those species are designated by the New York State Department of Environmental Conservation as endangered or threatened. One is broom crowberry, which grows on Shawangunk cliff tops but nowhere else in the state, and whose normal habitat is in sandy coastal soils.

The cliffs are also home to peregrine falcons, still classified as endangered in New York State, although their recent population growth is encouraging. The species often nests on buildings and bridges. Two natural cliff sites that the birds have taken to are Millbrook Mountain, where one pair has nested each year since 1998, and the Trapps, in Mohonk Preserve, where another pair has lived since 2005. On average each pair fledges only one chick each year, which is a poor success rate, less than half the rate statewide. Predators, such as great horned owls, have likely been preying on the young. Such discouraging outcomes may explain why these two pairs usually choose new ledges every year, whereas a peregrine pair normally nests in the exact same place.

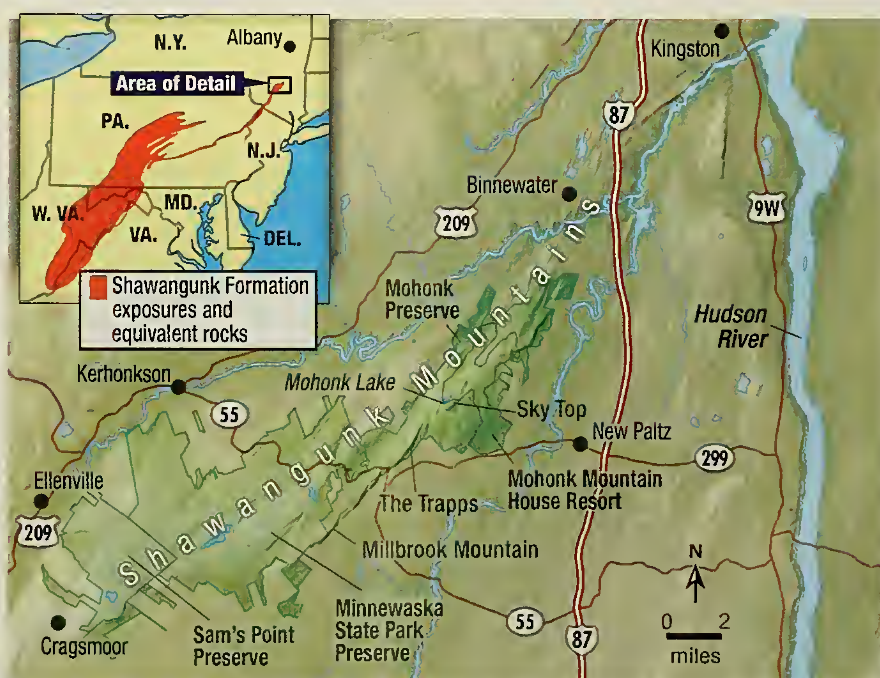
Another hindrance to cliff dwell-

VISITOR INFORMATION

Minnewaska State Park Preserve
5281 Route 44-55
Kerhonkson, NY 12446
845-256-0579
nysparks.state.ny.us/parks/info.asp?parkID=78

Mohonk Preserve
P.O. Box 715
New Paltz, NY 12561
845-255-0919
www.mohonkpreserve.org

Sam's Point Preserve
The Nature Conservancy
P.O. Box 86
Cragsmoor, NY 12420
845-647-7989
www.nature.org/wherewework/northamerica/states/newyork/preserves/art12207.html



JOE LEMONNIER

ers—both plants and animals—may be rock climbers and those who hike along cliff-edge trails. Treading along a cliff edge tramples plants, compacts soil, and causes erosion. Less obviously, it may disturb the animals even some distance below. Startled while brooding, a bird may accidentally kick an egg off the ledge when it flies out to defend its territory; a nestling may jump off a ledge before it can fly. At the Mohonk Preserve, rock climbs or trails near a breeding area are temporarily closed to help protect the falcons.

HARDIE TRUESDALE

Climber scales the Trapps, a cliff in Mohonk Preserve.

Cliff flora and fauna are also subject to global climate change. The Smiley family, the owners of Mohonk Mountain House, began making daily weather records at Mohonk Lake on January 1, 1896. The tradition was maintained from 1937 to 1988 by Daniel Smiley, who devoted his life to the collection of scientific data on Shawangunk weather, landscape change, and species. Since 1989, Paul C. Huth, Mohonk Preserve Director of Research, has continued to supply the data to the National Weather Service.

Records show that at Mohonk Lake the average daily temperature has risen 2.7 Fahrenheit degrees since 1896. Plants and animals are responding accordingly. Some cliff plants, such as common serviceberry, mountain laurel, red-berried elder, and small bluets are blooming earlier. The eastern phoebe arrives earlier in the spring, the turkey vulture is now a year-round resident instead of migrating south for the winter, and the black vulture has expanded its range to the north—with its first New York State nesting site situated in the Mohonk Preserve in 1997.

HOWARD R. FELDMAN is a professor of biology at Touro College in New York City and a research associate in the Department of Invertebrates, Division of Paleontology, at the American Museum of Natural History. JOHN THOMPSON is a natural resources specialist at the Mohonk Preserve.

Female peregrine falcon guards her three nestlings on a ledge of the Trapps.

JOSEPH T. BRIDGES

HABITATS

Chestnut oak forest Chestnut oak and northern red oak dominate the canopy, but a combination of drought and defoliation by gypsy moths has killed mature oaks in some areas. The gaps are being filled by red maple and such associated species as black gum and sassafras. The most common shrubs are lowbush blueberry, mountain laurel, and witch hazel. Wildflowers include Indian cucumber-root, northern starflower, trailing arbutus, white snakeroot, and wintergreen.

Hemlock–northern hardwood forest Eastern hemlock, an evergreen, and such hardwoods as red maple, sugar maple, and yellow birch predominate in ravines. Typically the canopy is dense, creating deep shade that limits the growth of understory vegetation. During the winter deer often congregate in this habitat.

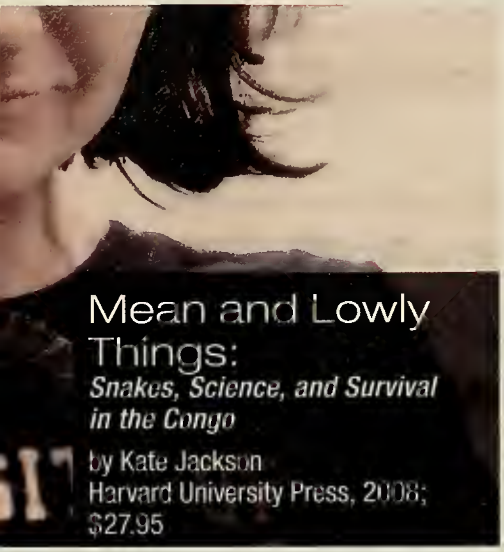
Dwarf pine ridge Flat-topped summits of the Shawangunk Mountains host a rare type of shrubland dominated by dwarf-size pitch pine trees and black huckleberry. Other woody species include black chokeberry, gray birch, lowbush blueberry, sheep laurel, and withe-rod (also known as possumhaw). Among the wildflowers are bunchberry, Canada mayflower, cow-wheat, pink lady's slipper, and wintergreen.

Cliff top, cliff face, and talus slope Black birch is common in talus-slope woodland. Rarities for New York State that are found on cliff tops and cliff faces include broom crowberry, highland rush, and mountain spleenwort. Others are common serviceberry (also known as shadbush), mountain laurel, red-berried elder, and small bluets (also known as Quaker ladies).

Hemlock–hardwood swamp Dominant trees include hemlock, red maple, red spruce, and yellow birch, while a characteristic shrub is highbush blueberry. Such ferns as cinnamon fern and sensitive fern abound. This swamp supports plant species normally found farther north, such as goldthread, hobblebush, and painted trillium.

Ice cave The cold microclimate favors northern species such as black spruce, mountain ash, and creeping snowberry, along with goldthread, spoon-leaved sundew, and starflower. Numerous mosses, lichens, and liverworts occur here.

BOOKSHELF BY LAURENCE A. MARSCHALL



As a travel book, Kate Jackson's account of snake collecting in the tropics is both humorous and dramatic . . . but it is *not* likely to attract tourists to the Republic of Congo. On expeditions to that nation's Lac Télé Wildlife Reserve, Jackson slept on damp mats at night, picked termites from her bed and ants from her larder and her underwear, and, several weeks into one jungle sojourn, forcibly evicted fly larvae encamped under her skin. Her accommodations featured shared bath facilities (the surrounding flooded forest) and distinctive local cuisine (fish-skeleton soup with manioc). Dinner often smelled bad, and sometimes came sprinkled with maggots. After five weeks on bush cooking, she had lost ten pounds.

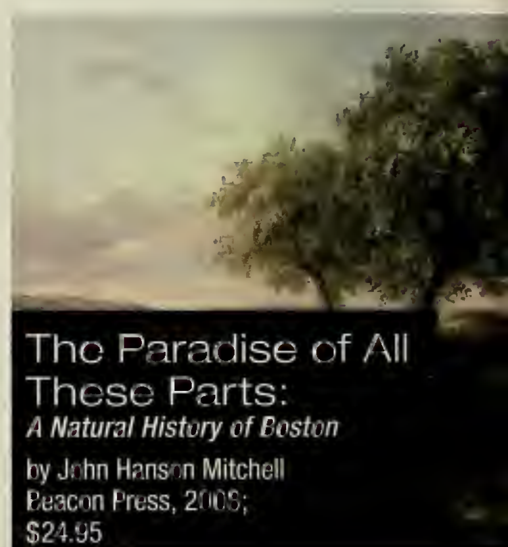
As an account of biological fieldwork under trying conditions, however, Jackson's book is both elegant and appealing. She's a born herpetologist, one of those rare people who have been attracted to slithery and scaly things since childhood, and her enthusiasm for her subject is infectious. She is also a natural storyteller, whether rhapsodizing over the biodiversity of equatorial jungles or explaining the intricacies of preserving specimens in a primitive camp. Even the negotiation of permits with third-world bureaucrats, as Jackson spins it, sounds like an adventure.

And what an adventure it all was! Scarcely out of graduate school, Jackson single-handedly mounted two scientific expeditions to one of the world's most underdeveloped nations, handling a variety of difficulties with admirable aplomb. The obstacles she faced, not surprisingly, were human as well as natural. Because she had limited funding, and also because she wanted to avoid appearing to be a foreign exploiter, she hired local people to help as guides, cooks, and apprentice naturalists. Although she spoke French, the colonial tongue, she struggled to learn the native language, Lingala, in order to negotiate the subtleties of village life.

In spite of her best intentions, cultures clashed: local villagers viewed her as a wealthy foreigner; pestered her to give away knives, flashlights, and other necessities of her work; and frequently balked at working conditions or pay. Graduate school had trained her in taxonomy, anatomy, and physiology, but practical field research tested her skills in diplomacy and crisis management.

Jackson's resourcefulness served her well on numerous occasions. In one of the book's most chilling passages, she pulls what she thinks is a harmless snake from a pile of bricks, only to find she is holding a forest cobra. As she fumbles for a more secure grip, the cobra strikes, whereupon, not quite sure whether it has actually injected her with venom, Jackson calmly walks back to camp, mentally counting off the time and anticipating the onset of symptoms. What follows is a hastily improvised emergency-room procedure—Jackson acting as both presiding physician and patient—that culminates in an action sequence with the cinematic impact of Quentin Tarentino's *Pulp Fiction*. The writing here, as in most of the book, is self-effacing and understated, but the chapter left me breathless.

There are probably only a few specialists who can fully appreciate the professional journal articles on the biodiversity of the Congo forest that resulted from Jackson's expeditions. And only a few adventurous readers may share her "irrational longing to return" to the Lac Télé forest, which, judging from her online blog, she did in the summer of 2008. But we can all hope that she will continue writing, and that we won't have to wait too long for the next installment of *Kate Jackson's Excellent Adventures,* wherever they may lead.



To stroll down the streets of any of the great cities of the world is to journey back through human history, well commemorated by plaques on walls and monuments in squares, and in detailed guidebooks that tell us who built what and who lived where. But a city walk, as John Hanson Mitchell reminds us in this amiable book of essays, is also a journey through natural history. The urban walker passes over bedrock laid down by ancient seas, along waterfronts and banksides which bear the marks of time as well as design, and past all sorts of vegetation and wildlife, some indigenous, some exotic. Yet, though a city owes as much to the character of its place as it does to the people who built it, governments seldom erect monuments to their rivers, trees, and birds. Mitchell, therefore, has provided an uncommon and exemplary book, a guide of sorts to the natural history of one great city, Boston, Massachusetts.

Don't look to Mitchell for a street-by-street breakdown of Beantown's parks and wildlife. This is, rather, a series of six rambles, each taking a different route in a different month (September, October, December, January, March, and June), with the author acting as a knowledgeable and opinionated guide, pointing out special sights that tie the urban scene to its natural environment. Where most of us might notice only the blaring of auto horns and the bustle of office-bound commuters, Mitchell hears the screams of red-tailed hawks, sees spiders spinning webs in overhanging trees, and contemplates the transient populations of migrating songbirds.

Not just a raconteur, Mitchell wants us to understand how geography affects urban destiny, even in a day when rapid development threatens to turn every cityscape into a set of cookie-cutter districts filled with Starbucks, Borders, and Staples storefronts. On blocks where all that can be seen is artifice and architecture, the author waves away the brick and pavement and imagines the land on which this all was built, the land as it was in the past, contemplating what it was that made this place so special and what still colors its growth and its culture.

The geography of Boston, an elongated peninsula marked by three hills, has long attracted human settlement. The first English colonists, of course, were drawn by the excellent harbor, but even before that, Native Americans, who called the place Shawmut, were drawn by the ample freshwater springs, the abundance of game and berries, and the vast numbers of fish that came into its rivers to spawn. In the early 1900s, construction workers uncovered over 65,000 stakes driven into the ground in what is now downtown Boston, evidence of an extensive network of fish weirs dating back five thousand years. Even then, it seems, it would have been hard to walk around the area without seeing signs of human development.

Still, it is difficult to see the Boston of 3000 B.C., and even the Boston of 1620, in the geography of the town today. River mouths have been dammed, shorelines extended, and the original landmark hills trimmed down to provide fill on which an expanding population could stake a claim. Forests and fields have been transformed into housing developments and highways, and green spaces have been recreated in deliberately landscaped parks. But throughout, local geography—the rolling, sandy land, the salt marshes, the ocean winds, the New England climate—have made it a distinctively Bostonian place.

You don't have to know Boston to appreciate the stories Mitchell is relating, for despite his local slant, his approach has global implications. It is easy to view London, or Shanghai, or Dubai as remarkable (or damnable) human constructions, but if you understood them as Mitchell understands Boston, you would see them also as works of nature.

The Lightness of Being
Mass, Ether, and the Unification of Forces
by Frank Wilczek
Basic Books, 2008; $26.95

Nobel Prize–winning theoretical physicist Frank Wilczek's latest contribution to the literature of popular science deals, not surprisingly, with the "deep structure of reality," the mathematical regularity that underlies the complex and changeable face of the universe. Surprisingly, however, its point of departure is a simple question: why do things have mass? If you remember even a shred of high-school science, the answer seems obvious: things have mass because everything, from atoms to galaxies, is made of matter, and mass is a fundamental property of matter. To question any further would be as futile as asking why a circle is round or why a square has four sides. You just can't separate the property from the object itself.

Or can you? As physicists in recent decades have probed the atomic nucleus, a regime that Wilczek calls the "micronanocosm," they have found that matter can pick up mass as easily as a wool sweater picks up lint (unlike a circle, which can't somehow pick up roundness). When two particles are smashed together in a giant accelerator, for instance, they often disintegrate, but not into smaller component parts. Instead, they produce showers of particles far heavier than the total mass of the particles that produced them. "It's as if," writes Wilczek, "you smashed together two Granny Smith apples, and got three Granny Smiths, a Red Delicious, a cantaloupe, a dozen cherries, and a pair of zucchini!"

Where does that extra mass come from, and how is it added to the original particles to create new ones? Wilczek's answer is a nonmathematical primer on the current state of particle theory, beginning with the basics of quantum mechanics and proceeding through the well-established theory of quantum chromodynamics to more speculative ideas such as supersymmetry.

As with most nonmathematical books on highly mathematical subjects, you have to keep a measure of faith that Wilczek's invocations of Granny Smith apples and cantaloupes are apt metaphors for what particle physicists are really getting at. If you can do that, you'll come to understand that the mysterious mass that particles pick up when smashed together comes from the energy imparted to them by the particle accelerator that accelerated them to close to the speed of light. The extra mass is a manifestation of an equation everybody knows: $E=mc^2$, where E is the energy of the particles' interaction, c the speed of light, and m the resulting gain in mass.

Now, since particles have mass even when they're at rest in a vacuum, and since that implies the manifestation of energy, it is possible to infer that space is not an empty void, but rather a rich quantum playground of interacting fields whose "embodied energy" (Wilczek's term) is what we call mass. This nonempty vacuum is Wilczek's "deep reality," an underlying quantum universe that he refers to as The Grid.

Read Wilczek's book, however, not for the details—that would require more mathematical sophistication than most of us can command—but to share some of the excitement and enlightenment that he and fellow particle physicists experience as the Large Hadron Collider (LHC) goes into operation in Switzerland. The mammoth accelerator, 16.8 miles in circumference, is expected to produce an as-yet-undiscovered resident of The Grid called the Higgs particle, and put the physicists' vision of a deeper reality to the test. "Unless our ideas are somehow *very* wrong," says Wilczek, "the LHC should be up to the job."

LAURENCE A. MARSCHALL is 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.

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SKYLOG BY JOE RAO

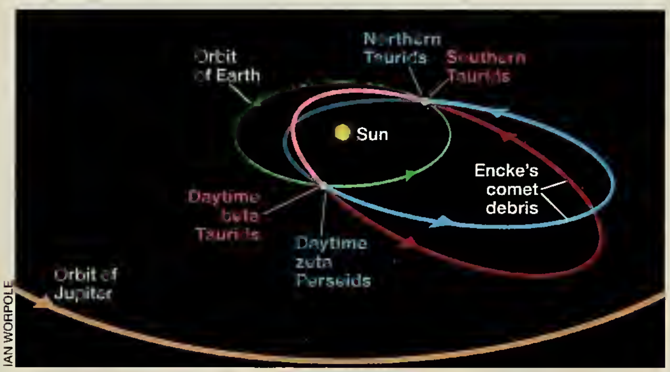
The Taurid meteors, sometimes called the "Halloween fireballs," show up between mid-October and mid-November, but the night of November 5 is likely to be the best time to look for them this year, taking into account both their peak of activity and the effect of moonlight on viewing conditions. Beginning after the Moon sets (around midnight), a dozen meteors may appear per hour. As meteors go, they will be unusually slow, and consequently often yellowish-orange. Their name comes from the way they seem to radiate from the constellation Taurus, the Bull.

Meteors—so-called shooting stars—are generated when debris enters and burns up in Earth's atmosphere. The Taurids are attributed to debris left behind by Encke's comet, or perhaps by a much larger comet that disintegrated, leaving behind Encke and a lot of rubble. Indeed, the Taurid debris stream contains large fragments that in certain years—2008 is predicted to be one—create some of those unusually bright meteors known as "fireballs."

Encke's has the shortest known orbital period for a comet, taking only 3.3 years to make one complete trip around the Sun. At aphelion, the point in its orbit that is farthest from the Sun, it is not as far away from the Sun as Jupiter is; at perihelion, when it swings closest to the Sun, it is about as close as Mercury is. Comets generally have much more elongated orbits, and usually return after a lapse of many years, if they return to the inner solar system at all. (Halley's comet, for instance, turns up roughly every seventy-six years.) On an approach around the Sun perhaps twenty millennia ago, however, Encke's (or its bigger parent comet) apparently was deflected by the gravity of Jupiter and other planets, which sent it into a tighter orbit. Since then, its trail of debris has been spread out by the gravitational tugs of the planets.

The Taurids are actually divided into the Northern Taurids and the Southern Taurids, depending on whether the meteors appear to emanate from the north or south regions in Taurus. That division arises because some of the debris intersects Earth's orbit from above the ecliptic (the plane on which the planets orbit the Sun) and some from below it. Earth passes through the debris trail in late June and early July as well, giving rise to two more meteor showers, known as the beta Taurids and the zeta Perseids. At that time of year, however, our planet's position in relation to the Sun is such that the debris burns up on Earth's daytime side, so the meteors do not form a visible spectacle.

Joe Rao (hometown.aol.com/skywayinc) is a broadcast meteorologist and an associate and lecturer at the Hayden Planetarium in New York City.



IAN WORPOLE

Debris stream of Encke's comet is so spread out that some of it crosses the plane of Earth's orbit from above and some from below (that difference is schematically represented here by two separate loops). From mid-October to mid-November, Earth sweeps through the debris, and observers see the Northern and Southern Taurid meteor showers. Earth intercepts the debris stream again later in the year, but then the meteors appear in daytime.

NOVEMBER NIGHTS OUT

1 Mercury rises in the southeast, shortly after the beginning of morning twilight.

2 "Fall back!" Daylight saving time gives way to standard time. At 2:00 A.M., clocks need to be set back one hour.

3 A six-day-old Moon hovers below and to the left of Jupiter, in the southwest.

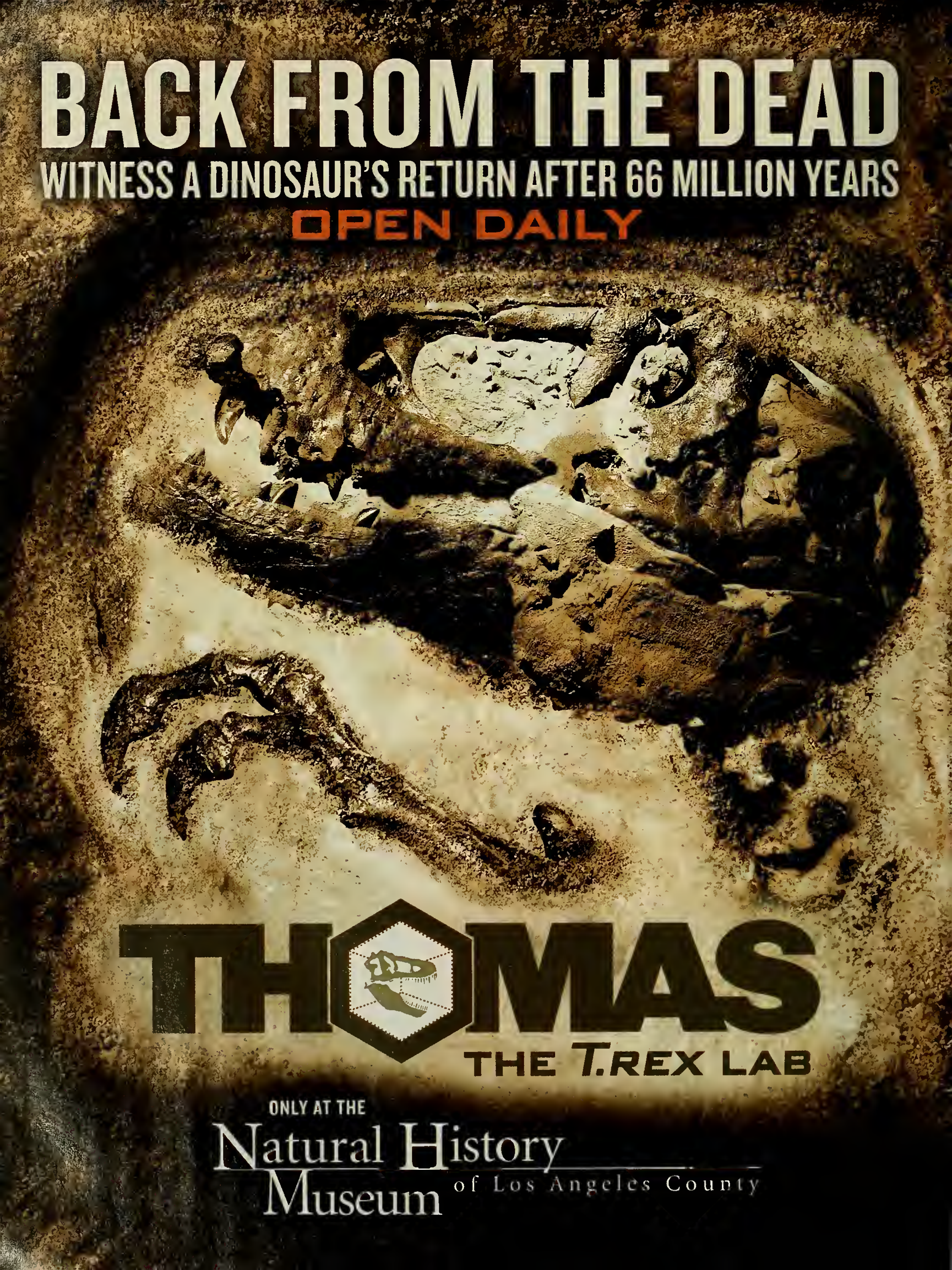
5 The Moon waxes to first quarter at 11:03 P.M. eastern standard time (EST). The Taurid meteor shower is ripe for viewing (see story at left).

13 The Moon becomes full at 1:17 A.M. EST

19 The Moon wanes to last quarter at 4:31 P.M. EST

27 The Moon becomes new at 11:55 A.M. EST

30 Venus and Jupiter, just 2 degrees apart, are low in the southwest at sundown and remain visible until they set, around 7:30 P.M. Jupiter, the one above and to the right, is more dimly lit because it is much farther from the Sun.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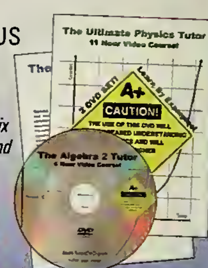

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PICTURING HISTORY

A dinosaur tail hauled past exhibits, a diorama of nesting flamingoes no longer on display, a teeth-cleaning job for a Killer Whale replica: it's all just part of the rich photographic history of education and exhibition at the American Museum of Natural History, now online in *Picturing the Museum*.

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Children gather for story hour near the gemsbok diorama in the Akeley Hall of African Mammals, 1944.

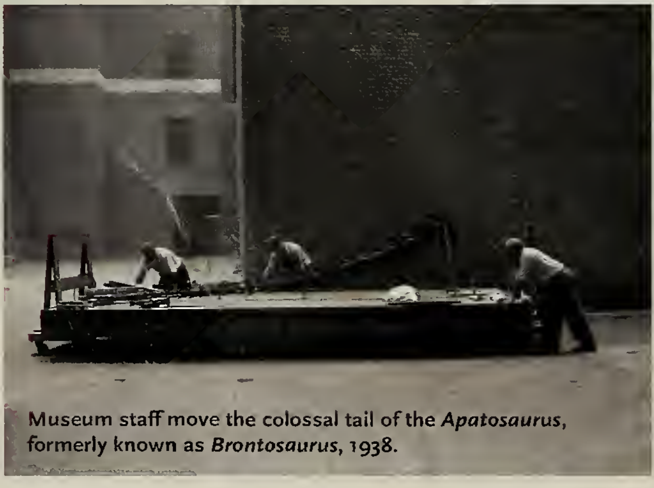
332578 © AMNH/ H.S. RICE

The jaws of a fossil shark, or *Carcharodon megalodon*, undergo restoration, 1927.

Picturing the Museum is an exhibit of nearly a thousand images for those interested in Museum history, looking for artful inspiration, or curious about natural history. The Museum has a long tradition of and mandate for public education that began at the Museum's inception: founder Albert Bickmore gave lectures illustrated with lantern slides to expose the public and teachers to the wonders of the natural world. The Research Library began this current project after receiving a digitization grant from the Metropolitan New York Library Council. They are now continuing the work by engaging many volunteers to scan photographs. "We have three machines and hope to keep them operating all day, every day," says Mathé.

The ultimate goal is to create a comprehensive online database of over half a million images documenting the work of the Museum world-wide. In addition to the images on the current website, there are another 12,000 photographs scanned and online capacity for 186,000 more. Within two years, look for images from the famed Jesup expedition to the Pacific Northwest and Siberia between 1897 and 1902; the donated collection of Julian Dimock's portraits of life in the southern United States; and photos from Carl Lumholtz' expeditions to Mexico, documenting the Huichol and Tarahumara cultures.

"Every time I look, I find a new favorite," says Tom Baione, Acting Director of the Library. "Right now, it's the image of 'story hour' in front of a diorama—the gemsboks appear to be listening in." Visit images.library.amnh.org to find your favorite.



28951 © AMNH/C.COLES

Museum staff move the colossal tail of the *Apatosaurus*, formerly known as *Brontosaurus*, 1938.

31969 © AMNH/A. ROTA

Artists put the finishing touches on a Killer Whale model in the Hall of Ocean Life, 1967.

1914 BILLBOARD, COURTESY OF BILL UTLEY

Art and Anthropology at the 2008 Mead Festival

Edward S. Curtis, an artist and ethnographer, was one of America's best known photographers of Native American culture. In his lifetime, he produced more than 40,000 photographs of different tribes. His passion for performance and commitment to documentation are deeply evident in the spectacular silent film *In the Land of the Head Hunters*. The New York premiere of the newly restored version of the film will be held on Friday, November 14, in the LeFrak Imax Theater at the American Museum of Natural History, marking the start of the Margaret Mead Film & Video Festival.

Curtis created this melodramatic account of love and war among the Kwakwaka'wakw communities in British Columbia in 1914, capturing a visually rich culture before European contact. The hero, Motana, embarks on a quest to win over the Proud Princess Naida, "the maiden of his dreams," and praying, dancing, hunting, and celebrating ensue in the first feature-length film to star members of the Kwakwaka'wakw communities.

Though the film has been largely treated as a documentary, it displays Curtis's embellishments (like whaling practices borrowed from neighboring tribes, depicted with a rented dead whale!) alongside culturally authentic elements. Curtis has been praised for including—and preserving—many actual Kwakwaka'wakw rituals that were banned at the time under the federal Potlach Provision, which intended to hasten indigenous peoples' assimilation into Canadian society.

Complementing the dynamic camera work and beautiful color tinting of this expertly restored film is an ambitious musical score performed by a live orchestra. Curtis most likely supplied John J. Braham, the composer, with his own wax cylinder recordings of Kwakwaka'wakw songs, though the final results fuse the popular sounds of the time with the "familiar thrum of the 'tom-toms.'" The original sheet music has been recovered and restored for the current presentation of the film in a series of North American cities, its first public appearance since 1914. Blending American cinematic ideals with the historically rich Kwakwaka'wakw culture, this film broke the boundaries of stereotypical "Indian films" to become a truly innovative and artistic feat.

Now in its 31st year, the Margaret Mead Film & Video Festival, which runs through Sunday, November 16, is the longest-running documentary film festival in the United States. The Festival was founded in 1977 by the Museum in honor of pioneering anthropologist Margaret Mead's 75th birthday and to mark her 50th year at the Museum.

The Mead Festival is made possible with public funds from the New York State Council on the Arts, a state agency; The Experimental Television Center's Presentation Funds Program, which is supported by the New York State Council on the Arts; the Goethe-Institut, New York; Arts and Culture Network Program, Open Society Institute, Budapest; PocketVisions/London International Documentary Festival; the Netherlands Consulate-General, New York; and the Shelley and Donald Rubin Foundation.

Museum in Miniature

When the Origami Holiday Tree is unveiled this month, it will not only kick off the holiday season but also serve as a unique celebration of the Museum itself. Following the chosen theme, "Folding the Museum," the 13-foot tree will be covered with colorful paper models representing denizens of the habitat dioramas, permanent halls, and special exhibitions.

This year, visitors can expect to see paper shaped, as if by magic, into a marvelous parade of creatures (past, present, and prehistoric) and recognizable elements of cultural exhibition halls. The tree will feature a variety of reptiles, amphibians, mammals, birds, sea creatures, and insects.

Origami is the traditional art of paper-folding and has been part of Japanese culture since the sixth century. (In Japanese, "ori" means "folding," and "kami" means "paper.") Today, origami is considered a worldwide art form. Every summer, local, national, and international volunteers from OrigamiUSA begin folding their contributions to complete the 500 or more models displayed during the holiday season. In previous years, the holiday tree has been decorated with such other compelling themes as Fantastic Creatures: Mythic and Real; Origami in Flight; and Under the Sea.

The 2008 Origami Holiday Tree will be on view from Thanksgiving week through New Year's Day, in the Theodore Roosevelt Memorial Hall on the first floor. During that time, volunteers will be on hand to teach visitors of all ages the art of origami.

© AMNH/R. MICKENS

At the Museum

AMERICAN MUSEUM of NATURAL HISTORY

www.amnh.org

EXHIBITIONS

Climate Change: The Threat to Life and A New Energy Future

Through August 16, 2009

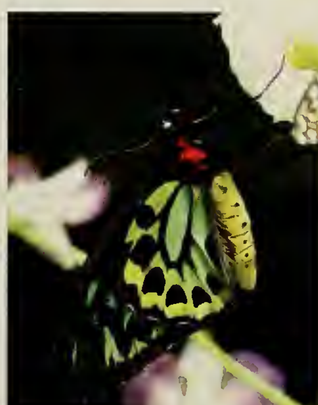
This timely new exhibition explores the science, history, and impact of climate change on a global scale, providing context for today's most urgent headlines. Realistic dioramas, dynamic animations, and interactive stations allow visitors to witness potential effects, such as the flooding of lower Manhattan as a result of melting ice and ocean warming. This exhibition lays the groundwork for potential solutions, empowering and inspiring visitors of all ages.

Climate Change is organized by the American Museum of Natural History, New York (www.amnh.org), in collaboration with the Abu Dhabi Authority for Culture & Heritage, United Arab Emirates; The Cleveland Museum of Natural History; The Field Museum, Chicago; Instituto Sangari, São Paulo, Brazil; Junta de Castilla y León, Spain; Korea Green Foundation, Seoul; Natural History Museum of Denmark, Copenhagen; Papalote Museo del Niño, Mexico City, Mexico; and Saint Louis Science Center.

Climate Change is proudly presented by Bank of America.

Additional support has been provided by The Rockefeller Foundation.

Additional support for *Climate Change* and its related educational programming has been provided by Mary and David Solomon, the Betsy and Jesse Fink Foundation, the Linden Trust for Conservation, and the Red Crane Foundation.



© AMNH/H. DAVIES

The Butterfly Conservatory

Through May 25, 2009

Mingle with up to 500 live, free-flying tropical butterflies in an enclosed habitat that approximates their natural environment. Learn about the butterfly life cycle, defense mechanisms, evolution, and conservation.

The Horse

Through January 4, 2009

This exhibition reveals the enduring bond between horses and humans, and explores the

© AMNH/D. FINNIN

origins of the horse family, which extends back more than 50 million years.

The Horse is organized by the American Museum of Natural History, New York (www.amnh.org), in collaboration with the Abu Dhabi Authority for Culture & Heritage; Canadian Museum of Civilization, Gatineau-Ottawa; The Field Museum, Chicago; and the San Diego Natural History Museum.

The Horse at the American Museum of Natural History is made possible, in part, by the generosity of Rosalind P. Walter and the Eileen P. Bernard Exhibition Fund. Additional support has been provided by an anonymous donor.

Lizards & Snakes: Alive!

Through January 5, 2009

Meet over 60 live lizards and snakes, and discover some of their remarkable adaptations.

Lizards & Snakes: Alive! is organized by the American Museum of Natural History, New York (www.amnh.org), in collaboration with the Fernbank Museum of Natural History, Atlanta, and the San Diego Natural History Museum, with appreciation to Clyde Peeling's Reptiland.

Saturn: Images from the Cassini-Huygens Mission

Through March 29, 2009

This stunning exhibition reveals details of Saturn's rings, moons, and atmosphere with images sent over half a billion miles by the Cassini spacecraft.

The support of the National Aeronautics and Space Administration is appreciated.

Special thanks to the Cassini imaging team, especially those scientists at Cornell University's Department of Astronomy, along with the staff of Cornell University photography. The Eastman Kodak Company of Rochester, New York, printed the images.

On Feathered Wings

Through May 25, 2009

This exhibition brings together the work of renowned wildlife photographers whose artistry showcases the majesty of birds in flight.

The presentation of both *Saturn* and *On Feathered Wings* at the American Museum of Natural History is made possible by the generosity of the Arthur Ross Foundation.

© MIGUEL LASA

Two eagles in flight compete for the day's catch.

Unknown Audubons: Mammals of North America

Through January 18, 2009

The stately Audubon Gallery showcases the last great works of John James Audubon.

Major funding for this exhibition has been provided by the Lila Wallace-Reader's Digest Endowment Fund.

Public programs are made possible, in part, by the Rita and Frits Markus Fund for Public Understanding of Science.

GLOBAL WEEKEND

Native American Storytelling with Herb Rice

Saturday, 11/8, 1 and 3 pm

In recognition of Native American Heritage Month, renowned Northwest Coast artist and lecturer Herb Rice will present two sessions of interactive storytelling for families.

COURTESY OF HERB RICE

Herb Rice, a renowned mask carver, draws from both traditional and modern forms in his designs.

Global Weekends are made possible, in part, by the City of New York, the New York City Council, and the New York City Department of Cultural Affairs. Additional support has been provided by the May and Samuel Rudin Family Foundation, Inc., the Tolan Family, and the family of Frederick H. Leonhardt.

SCIENCE & SOCIETY

Margaret Mead: American Icon

Thursday, 11/13, 6:30 pm

Special guests present memories and images of Margaret Mead. A book signing will follow. Visit www.amnh.org/mead for a complete list of guests.

Co-presented with Barnard Center for Research on Women.
This program is supported, in part, by Sara Lee Schupf.

Margaret Mead Film & Video Festival

Friday–Sunday, 11/14–11/16

Experience the best in international documentary film with screenings, premieres, and panel and post-screening discussions. See page 53 for more information.
Visit www.amnh.org/mead for complete schedule.

This festival is made possible with public funds from the New York State Council on the Arts, a state agency.

HAYDEN PLANETARIUM PROGRAMS

TUESDAYS IN THE DOME

Virtual Universe

The Grand Tour

Tuesday, 11/4, 6:30 pm

These programs are supported, in part, by Val and Min-Myn Schaffner.

LECTURES

Thirteen Things That Don't Make Sense

Monday, 11/10, 7:30 pm

Michael Brooks, physics consultant to *New Scientist* magazine, explains how the most baffling mysteries have led to our most significant scientific breakthroughs.

Cosmic Collisions

Journey into deep space to explore the hypersonic impacts that drive the formation of our universe. Narrated by Robert Redford.

Cosmic Collisions was developed in collaboration with the Denver Museum of Nature & Science; GOTO, Inc., Tokyo, Japan; and the Shanghai Science and Technology Museum.
Made possible through the generous support of CIT.

Cosmic Collisions was created by the American Museum of Natural History with the major support and partnership of the National Aeronautics and Space Administration's Science Mission Directorate, Heliophysics Division.

IMAX MOVIES

Sea Monsters: A Prehistoric Adventure

Travel back 82 million years to a time when strange creatures filled the seas that once covered what is now the middle of North America.

Funded in part by the National Science Foundation, *Sea Monsters: A Prehistoric Adventure* was produced by National Geographic Cinema Ventures.

LATE NIGHT DANCE PARTY

One Step Beyond

Friday, 11/21, 9 pm-1 am

Visit www.amnh.org/onestepbeyond for details.

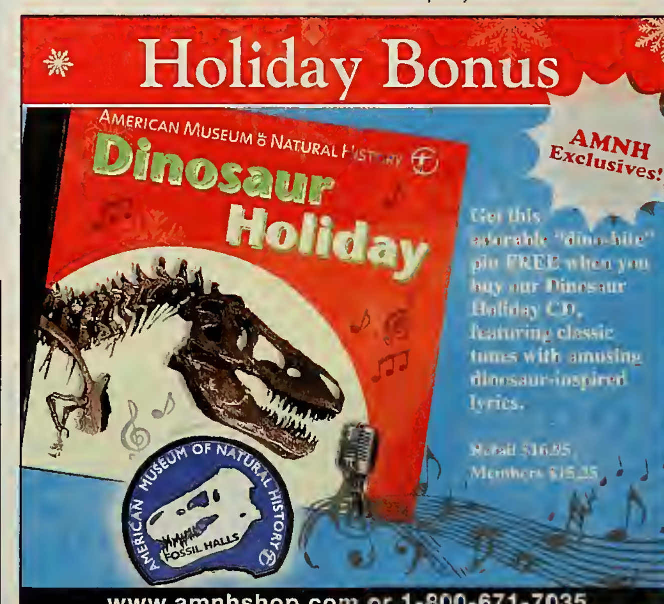
INFORMATION

Call 212-769-5100 or visit www.amnh.org.

TICKETS AND REGISTRATION

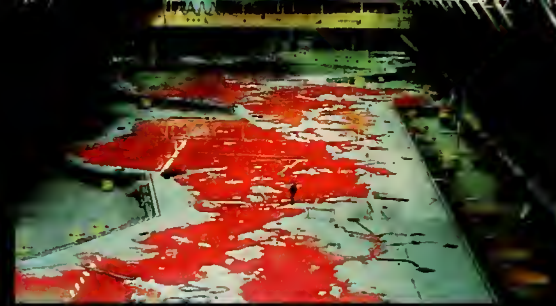
Call 212-769-5200, Monday–Friday, 9 am–5 pm, or visit www.amnh.org. A service charge may apply. All programs are subject to change.

AMNH eNotes delivers the latest information on Museum programs and events monthly via email. Visit www.amnh.org to sign up today!



A Mini Seto Sea

By Alexandre Meinesz



HIDEKI UESHIMA

Large-scale model of the Seto Inland Sea, which is pictured below

Ecologists must often compress the scales of space to better understand the impact of humans on nature. I experienced a beautiful illustration of this method a decade ago in Japan, when I was invited to give a lecture in Hiroshima Prefecture, a place reverberating with the destructive power of humanity. My host was Hideki Ueshima, a marine ecologist who for twenty years has overseen an immense model of the interior sea of Japan, the Seto Inland Sea.

Built and run by Japan's National Institute of Advanced Industrial Science and Technology, the model fills an airplane hangar nearly 1,000 feet long and 500 feet wide. Giant pumps faithfully reproduce the currents and tides of the Pacific Ocean and the Sea of Japan. Experiments are conducted to evaluate the impact of further development planned for the sea's already built-up shoreline. How will the currents change? Where will pollutants accumulate? To answer those questions, thousands of little floats can be liberated simultaneously, to be moved by the currents, and dyes injected into the water can show dilution patterns. Everything is filmed and analyzed to standardize the calculations derived from the model.

On my first visit, Ueshima and I jumped from island to island above the sea, like Gargantua and Pantagruel, spanning whole regions with each step. It was easy to see from there how much land had been modified by people.

In the past twenty years, more than 150 square miles of seashore have been sacrificed along the Seto Inland Sea so cities can expand. Ports, subdivisions, and factories have all been built, from Osaka to Hiroshima, where land was taken from the sea and attached to concrete.

That construction has destroyed subtidal ecosystems: shallow zones of marine life that form narrow belts parallel to the shoreline. Those that are biologically richest are near the surface, where ample light penetrates and allows for photosynthesis. But such zones are lost when walls are erected to protect the land won from the sea. The marine life never reconstitutes itself in the face of the concrete.

Ueshima's role was limited to advising builders so that construction would modify the currents as little as possible. But he had come to understand that the environment, little by little, was being irreversibly degraded. For instance, Osaka's Kansai International Airport, a monumental project built offshore as an artificial island, will never be torn down to save subtidal life.

The model of the inland sea is the most vivid demonstration I have seen of human dominance over nature. On my most recent visit to Hiroshima I met Ueshima again. Despite the dismal vision that confronts him daily, he has never given up; he has never accepted that reclamation and construction will be the fate of the *entire* coast of the Seto Inland Sea. Patiently, and with great diplomacy, he has tried with growing success to convince the various authorities of his country to think more carefully about what can still be preserved.

I encouraged Ueshima to paint parts of his model green, to represent coasts that have been saved.

Alexandre Meinesz, an ecologist specializing in algae, is a professor at the University of Nice-Sophia Antipolis in France. This essay was adapted from his book, How Life Began: Evolution's Three Geneses *(University of Chicago Press, 2008).*