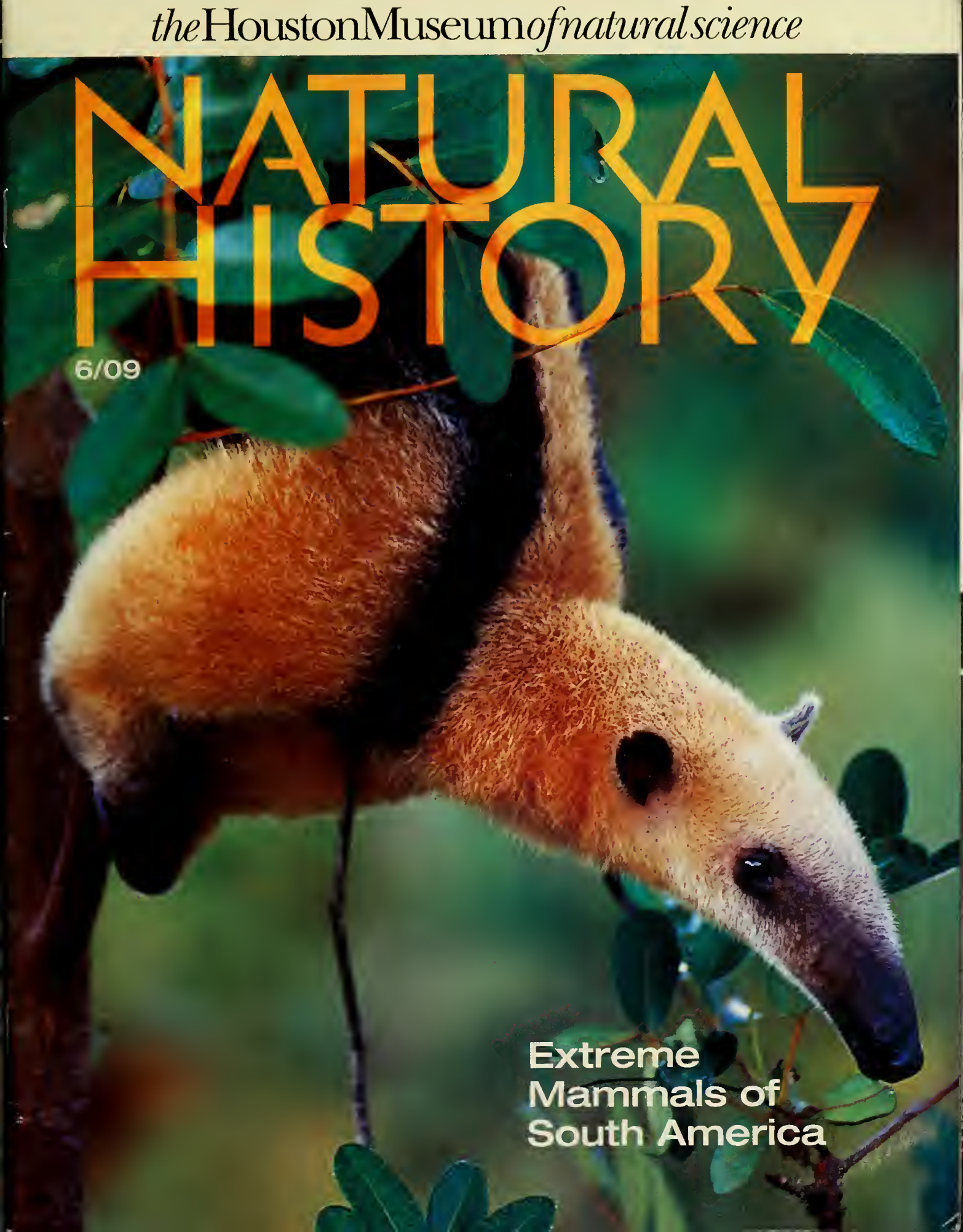


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NATURAL HISTORY

6/09

Extreme
Mammals of
South America



DAVID DOUBILET

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Marine naturalist and protector of the ocean habitat.
Author of a dozen books on the sea.
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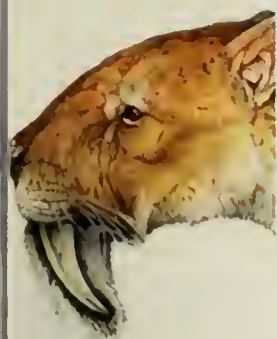
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JUNE 2009

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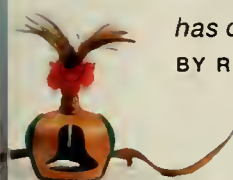
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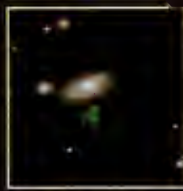
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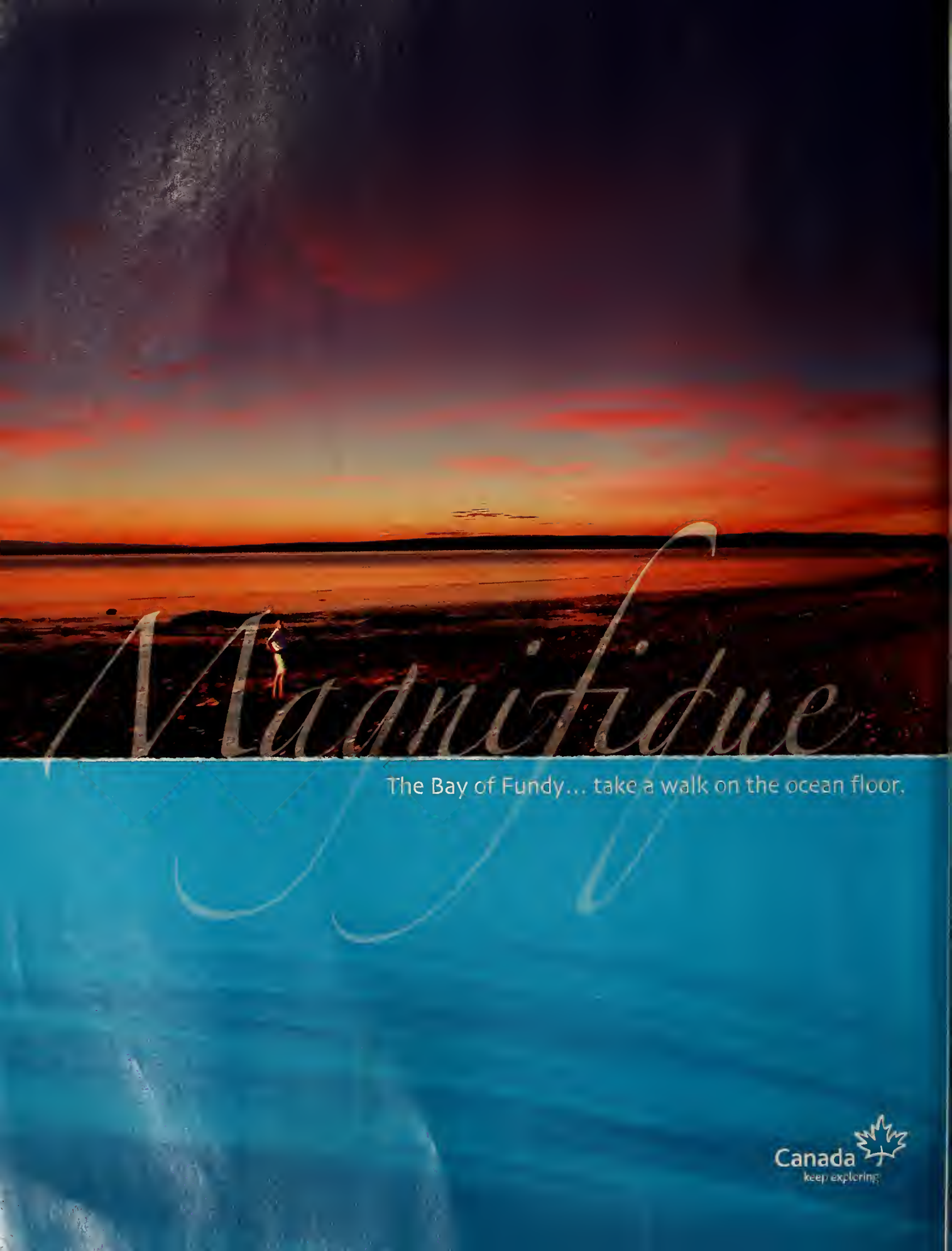
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ON THE COVER: Lesser anteater, or tamandua (*Tamandua tetradactyla*), in the Pantanal
Image by Thien Alviols



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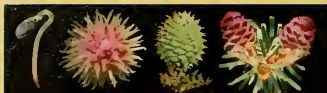


THE NATURAL MOMENT

ANGLING WITHOUT AN ANGLE

Photograph by David Hall





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◀ See preceding two pages

THE NATURAL EXPLANATION BY ERIN ESPELIE

In the style of a lone, languid fisherman who infrequently casts a line, the typical anglerfish hunts by the motto, *If you bait and wait, they will come*. For most, that bait is conveniently built-in, near the mouth: the modified tip of a dorsal-fin spine in the shape of, say, a worm that can be wriggled or even illuminated. Of the thirty diverse genera of shallow-water anglerfishes, however, one genus, *Histiophryne*, lacks the anatomy for the trick—lost somewhere in the evolutionary tackle box.

A mere three species belong to that lureless set, which ranges from Taiwan to South Australia. All measure about five inches long as adults. For starters, there's Bougainville's anglerfish (*H. bougainvilli*), pictured on the previous page. The ghoulish creature was first reported in 1837 by French zoologist Achille Valenciennes. Seventy-six years later, German zoologist Max Wilhelm Carl Weber put the cryptic anglerfish (*H. cryptacanthus*) in print. Finally, earlier this year, the psychedelic frogfish (*H. psychedelica*) made a splash when photographer David Hall, along with ichthyologist Theodore W. Pietsch and graduate student Rachel J. Arnold, both of the University of Washington in Seattle, published a paper describing the fish's unusual looks, behavior, and genetic makeup [see *photograph on this page*]. Leading up to their coauthorship Arnold and Hall spent weeks doing fieldwork in the shallows of Indonesia, where they coaxed the fish out of hiding.



Psychedelic frogfish, a new species

A clear complexion is not something most shallow-water anglerfishes possess. Note the amorphous patch of reptilian green pigment on the back of the Bougainville's anglerfish photographed by Hall. Such irregularities, along with warts and splotches, help the fishes blend in on a rugged, variegated reef. Yet the psychedelic frogfish has a smooth, uniform suit of hallucinatory stripes that you'd think would stand out—until you see the similarly patterned hard coral it frequents.

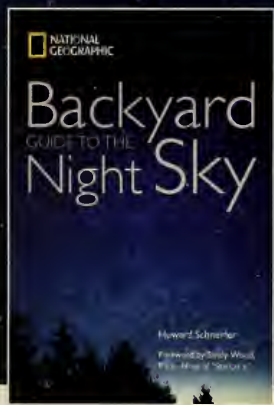
Equally odd, the shape of the psychedelic frogfish's face—unusually broad and fleshy—may have evolved as a new tool for hunting, in lieu of a lure. Hall speculates that, like a cat's whiskers, a fat face helps the fish feel its way within dark, tight spaces—as well as sense potential prey. And he watched the fish repeatedly worming into small crevices and holes, where he believes it may trap quarry by blocking the exit.

After earning degrees in zoology and medicine, David Hall embarked simultaneously on careers in wildlife photography and radiology. He eventually gave up the latter to pursue writing and photography full time. Hall has coauthored ten books on marine life and written or photographed for many scientific and popular publications. (He supplied the squid photograph for the "Natural Moment" in November 2002.) See www.seaphotos.com for more of his photography.



Mother Nature's Majesty and Might

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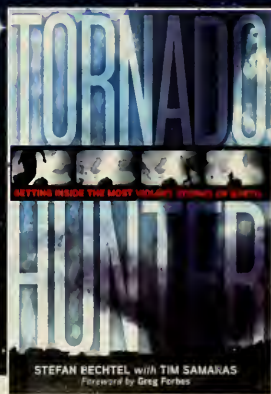
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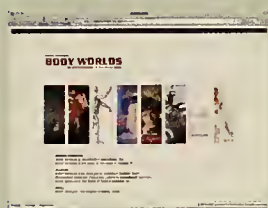


NATIONAL GEOGRAPHIC



nature.net by robert anderson

MUSCLE BOUND



My children tease me about my "fear" of giraffes. It all started after I visited the popular exhibition "Body Worlds," the creation of German anatomist Gunther von Hagens (www.bodyworlds.com/en.html). Even after viewing half a dozen "plastinated" and posed human cadavers, each one skinned and dissected to reveal all, I was taken aback by a sixteen-foot-tall giraffe stripped of its hide. With mouth open, I studied the enormous bands of flesh and tendon, once capable of propelling the ungainly creature across a savanna at thirty-five miles per hour. In addition to permanently altering the way I see giraffes, the exhibit revealed muscles in a whole new light. For my guide to Web sites exploring the specialized tissue that powers our every move, please visit the magazine online (www.naturalhistorymag.com).

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

WORD EXCHANGE



Beauty before Brains

The credit for photographer Thomas Vignaud, who took the opening image for "Brains of Beauties," by Paul S. Katz [5/09], was inadvertently omitted. With 10 million times the neurons of sea slugs, the editors can offer no excuse.

Linguistic Dinosaurs

Olivia Judson will be taking a break from her "Life Zone" column; along with her audience, we look forward to her return. Meanwhile, a reader questioned Judson's assertion that

"birds are dinosaurs: they are descended from a dinosaur lineage" ["Seeing the Light," 4/09]. "It is as wrong to say that birds are dinosaurs," runs the complaint, "as it would be to say that humans are actually the small mammals that coexisted with dinosaurs." I sympathize, but as an editor I have learned to accept it when paleontologists insist that 65 million years ago, only the "non-avian dinosaurs" became extinct.

To quote from the introduction to the American Museum of Natural History's booklet *The Halls of Dinosaurs: A Guide to Saurischians and Ornithischians* (1995): "The feature that can be found in all dinosaurs is a hole in the hip socket. This feature is related to the evolution of upright posture, in which the legs come straight down from the hips, instead of a sprawling posture, in which the legs stick out to the side. Because this feature is found in birds, it means that birds are a type of dinosaur."

Two large groups of creatures, the Saurischians and the Ornithischians, have been labeled "dinosaurs." (The names originally signified "lizard-hipped" and "bird-hipped"; ironically, birds fall within the first group.) So birds and dinosaurs are not mutually exclusive categories. But that is not to equate the birds of today with their ancestors. To say "a bird is a dinosaur" is comparable to saying a human being is a primate: as someone once said, "It depends on what the meaning of 'is' is."

In our editing of this current issue, we learned from John J. Flynn, author of "Splendid Isolation," that the term "monkey" is a misleading one, creating an imprecise category. We prevailed on him to let us use it, nevertheless.

Vittorio Maestro
Editor in Chief

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TOMOKI OKUDA

Courting zone of a male great bowerbird

Fireproofing for a Flame

To beguile females, some males build mansions, others build bowers. Male great bowerbirds (*Chlamydera nuchalis*) of northern Australia erect two walls of twigs partially flanking a six-foot-long passageway that they pave with conspicuous bits of bones, stones, shells, and fruits. There, the males strut their stuff, inviting females over for a tryst. Bower construction takes a week or longer, so it's no fun when brush fire sweeps through the savanna and threatens the males' handiwork. Yet, as a new study shows, the bowers seem strangely immune to fire.

In 2006, flames scorched part of a savanna outside the city of Darwin. A team led by Osamu K. Mikami of Kyushu University

in Fukuoka, Japan, found that of the nine bowers there, only three were destroyed. The other six sat intact in the middle of small patches of unburned ground. Yet according to the proportion of burned to unburned savanna, the chance of all bowers surviving should have been less than 8 percent. All nine should have toasted.

Bowerbirds remove flammable leaves and litter from around their bowers, or cover them with decorations. That behavior may have evolved because it creates a firebreak. On the other hand, baring the ground and decorating it also enhance a bower's visibility, so the habit may simply be a by-product of the bower's main function: impressing females. (*Journal of Ethology*) —Stéphan Reeb

Special-Occasion Dress

Caecilians are legless tropical amphibians that live mostly underground. Yet some of them sport bright stripes or solids in shades of yellow, pink, or blue—surprising, since visual signals aren't much use in their dark tunnels.

The reason for such gaudy attire seems to lie in the recent observation that caecilians are not entirely subterranean, say Katharina C. Wollenberg of the Technical University of Braunschweig in Germany and G. John Measey of the South African National Biodiversity Institute. Many species occasionally crawl on the surface during the day, an easier—though much riskier—alternative to underground travel. Wollenberg and Measey think that even sporadic appearances in daylight are enough to promote the evolution of conspicuous animal skin. They base their assertion on a statistical correlation they discovered in more than thirty species of caecilians between colorful or patterned skin and a tendency, however small, to spend time on the surface.

Maybe the color and markings are good camouflage on certain terrains where caecilians prosper. They could also advertise the presence of toxins to potential predators—as they do in other amphibians. Whether caecilian skin actually harbors any toxins remains to be determined, but

faking it is a useful Amphibia-class trick. (*Journal of Evolutionary Biology*)

—S.R.



G. JOHN MEASEY

Conspicuously colored caecilian (an amphibian)

Going Steady

The deep-sea coral *Mellogorgia melanotrichos* resembles a tree inspired by Dr. Seuss, with pink leaves and a long, thin trunk. Within that cotton-candy canopy, every coral harbors a single brittle star, *Ophiocreas oedipus*. Both species have been known to science for more than a century, but until recently no one had noticed their exclusive lifelong partnerships.

Celeste V. Mosher and her graduate adviser Les Watling, both then at the University of Maine's Darling Marine Center in Walpole, discovered the relationship during a series of deep dives, using submarines and remotely operated vehicles, along a New England seamount chain. Watling also later observed the coral-brittle star couples in the Bahamas. The team documented more than 150 pairs in various life stages—but never a lone *M. melanotrichos* or *O. oedipus*.

The youngest coral they found was a wisp five inches long with a tiny brittle star wound around it. Teen-age corals each housed a medium-size star. And every mature coral, about three feet tall, had a big star entangled



Brittle star (red) entwines the branches of its lifelong coral partner (pink).

in its pink canopy. One dead coral retained an old star, still clinging tight.

The researchers think larval brittle stars probably settle on young corals, and the pair ages together until death do them part, several decades on. The corals may provide brittle stars with shelter among their toxic polyps and access to food above the seafloor. What, if anything, the brittle stars give back remains unclear, but Watling thinks a few other species of coral and brittle star may prove similarly intimate. (Unpublished manuscript under review) —Rebecca Kessler

L. WATLING FOR NOAA/IEURI



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² FORTUNE, March 2009

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Botanic Mechanics

The seeds of many grasses are remarkable little mechanical devices. Each seed's hull has one or more bristle-like projections called awns, covered with tiny barbs pointing away from the seed. When a seed is partly buried in the ground with its awn pointing up, the barbs form a simple ratchet. Each time the soil swells and shrinks with daily humidity changes, the ratchet drives the seed ever so slightly downward. (Awns also cling to animal fur for seed dispersal; they can cause problems when

they ratchet their way into ear canals, nostrils, or other soft tissues.)

The basic blueprint of botanical ratchets has been known for more than a century, but figuring out exactly how the little gizmos work continues to inspire new research. Biophysicist Igor M. Kulić of Harvard University and four colleagues recently studied the foxtail grass *Hordeum murinum*. The team measured the movement of foxtail awns and seed heads lying on various shaking experimental surfaces

(including paper, fur, and fabric) and inside rubber tubes that were stretched to and fro. The awns always moved along "seedward," with longer awns making more efficient ratchets.

The team also modeled the foxtail ratchet mathematically. Kulić dubbed it "nature's most efficient ratchet," and thinks that high-tech gripping surfaces—of gloves or tires, perhaps—could profitably mimic its design. (*Proceedings of the Royal Society B*) —S.R.

Detour on the Silk Road

Your silk scarf or tie winds a long way back in history. By 1600 B.C., and possibly a millennium earlier, the Chinese had domesticated a wild silk moth, *Bombyx mandarina*, into *B. mori*, and had begun making fabric from the roughly half-mile strand of silk that constitutes its cocoon.

Scholars have long presumed that for many centuries sericulture was an exclusively Chinese industry. But a new study shows that South Asians mastered the craft at least as long ago as the Chinese.

Irene L. Good of Harvard University's Peabody Museum and two colleagues studied tiny bits of fiber attached to ancient copper jewelry fragments. The fragments came from Harappa and Chanhudaro, two archaeological sites in present-day Pakistan that were part of the great Indus civilization that flourished from 2800 to 1900 B.C.

Using an electron microscope, Good determined the Indus fibers to be silk, but not from *B. mori* moths. They came, rather, from two South Asian silk moth species not exploited in China: *Antheraea assamensis* and *A. mylitta*. (The species have distinctively shaped silk-extruding orifices, and the fibers' texture varies accordingly.) Some of the fibers were also not as highly processed as Chinese silk.

South Asians were apparently producing home-grown silk two millennia before the Chinese began officially exporting it, around 115 B.C. That may explain the origin of similar silk fibers found in Central Asia that predate the era of Chinese trade. (*Archaeometry*)

—Harvey Leifert

Copper jewelry preserved
ancient silk fragments.

Misaligned by Power Lines

To aesthetes, high-voltage power lines are a blight on the rural landscape. But zoologists at the University of Duisburg-Essen in Germany welcome them as a tool for testing the power of large ruminants to perceive Earth's magnetic field.

Last year, a team led by Hynek Burda and Sabine Begall discovered that free-ranging cattle and deer tend to align their bodies in a north-south direction. The animals sure seemed to be responding to the geomagnetic field. If so, the zoologists reasoned, they should lose their orientation when they graze or rest near power lines, because the current passing in the lines distorts Earth's magnetic field. If not, and the animals are reacting instead to the Sun or some other cue, power lines should have no effect.

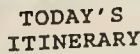
By observing wild roe deer and studying aerial images from Google Earth of cattle in European fields, Burda, Begall and three colleagues confirmed their hypothesis. In general, the animals faced every which way near the lines. (East-west power lines were an intriguing exception; cattle tended to align with them, for reasons still unclear.) What's more, cattle gradually regained their north-south body orientation the farther they moved away from the lines.

The study is the first strong demonstration of magnetic alignment in mammals other than rodents or bats. An internal compass could well be handy equipment in the roaming lifestyle of grazing animals. (*PNAS*)

—S.R.

Roe deer





- | | Time | Who | What |
|----------|-----------------------------------------|-----|------|
| 7:00 am | Shows on quick back | | |
| 7:05 am | Brush teeth a comb hair | | |
| 7:10 am | Get dressed | | |
| 7:15 am | Get in hotel lobby | | |
| 7:20 am | Don't see bus for today's tour | | |
| 7:25 am | Your director introduces him | | |
| 7:30 am | Should have used hotel weapons | | |
| 7:35 am | Think you can hold it | | |
| 7:40 am | Maybe not | | |
| 7:45 am | Two letters for Lake Malawi | | |
| 7:50 am | Take photographs to make friends | | |
| 8:00 am | Drive to the Gambia River | | |
| 8:05 am | Talk of Gambia River's medieval streets | | |
| 8:10 am | Wall of Gambia River | | |
| 8:15 am | Mail of Gambia River | | |
| 8:20 am | Back on bus | | |
| 8:25 am | Drive to Tyksa Tyksa | | |
| 8:30 am | Arrive at Tyksa Tyksa | | |
| 8:35 am | Continental breakfast in single apple | | |
| 8:40 am | Breakfast over | | |
| 8:45 am | Drive to Tessa Palace | | |
| 8:50 am | Tessa is all police here to offer | | |
| 8:55 am | Drive to Chantierma Palace | | |
| 9:00 am | Build leaving committee | | |
| 9:05 am | Washington over, those who were it last | | |
| 9:10 am | Back over, those who were it last | | |
| 9:15 am | Successful Washington over | | |
| 9:20 am | Can't appreciate 1980 century | | |
| 9:25 am | Leave bus for hotel | | |
| 9:30 am | Back on bus | | |
| 9:35 am | A few people were still staying | | |
| 9:40 am | Those people were still staying | | |
| 9:45 am | Don't get stuck down in street | | |
| 9:50 am | Manager to back out eventually | | |
| 9:55 am | People cannot be happy at Tessa | | |
| 10:00 am | Your director is happy at Tessa | | |
| 10:05 am | Drive to Tessa Palace and Tessa | | |
| 10:10 am | Drive to Tessa Palace and Tessa | | |
| 10:15 am | Drive to Tessa Palace and Tessa | | |
| 10:20 am | Drive to Tessa Palace and Tessa | | |
| 10:25 am | Drive to Tessa Palace and Tessa | | |
| 10:30 am | Drive to Tessa Palace and Tessa | | |
| 10:35 am | Drive to Tessa Palace and Tessa | | |
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Mum's the Word



Rhesus monkey mothers with young

STUART SEMPLE

When baby rhesus monkeys want to suckle, they do what human infants do: cry, cry, cry. Mothers often give in, naturally. When they don't, the babies' cries get on everyone's nerves—sometimes with nasty consequences.

In rhesus society, dominant individuals aren't shy about showing anger by chasing, pushing, hitting, or biting a mother and her youngster that aren't family. Stuart Semple, an anthropologist at Roehampton University in London, and two colleagues recently observed such hostile behavior in wild rhesus monkeys in Puerto Rico. The team calculated that bystanders are about thirty-five

times more likely to attack both mother and infant when the baby is crying than when it's hushed.

Quite understandably, mothers appear to pay attention to who's around when their young cry. Semple's team observed that when dominant bystanders were nearby, mothers acquiesced to their babies' demands about twice as often as when they were alone or in the company of close relatives, which are more forgiving of tantrums.

The study shows for the first time that, much like people, monkeys are aware of the social consequences of not only their own actions, but those of their babies, too. (*Proceedings of the Royal Society B*) —S.R.

Aphid Sandbag Brigade

Social aphids have a soldier caste whose recruits may tackle civic projects as well as military operations. Take *Nipponaphis monzeni*, which induces tree twigs to grow hollow, woody balls called "galls." The aphid colonies live inside those galls and feed on the plant material within. If a gall becomes damaged, a new study shows, soldiers can help the plant heal it.

A hole in a gall can expose a colony to desiccation or predator invasion. A few years ago, three researchers, including Takema Fukatsu at the National Institute of Advanced Industrial Science and Technology in Tsukuba, Japan, reported that when a hole appears in a gall wall, soldier aphids emerge and discharge body fluids into the breach to plug it. The soldiers get stranded outside. Some get stuck in the plug. All perish.

Back inside the gall, other soldiers continue the repair work for many days, Fukatsu, Mayako Kutsukake, and two colleagues have now shown. By periodically inspecting wounded galls, the team found that the soldiers plaster more body fluid onto the plug's interior surface to maintain the seal, and then stimulate the surrounding plant tissue to grow and eventually to replace the plug. Just how the aphids get the tree to mend itself remains unknown, but a gall won't heal if the aphids inside are killed.

The observations show that some aphids have a degree of job specialization comparable to the more celebrated insect societies of bees, ants, and termites. (*Proceedings of the Royal Society B*) —S.R.



Hole in a gall has been repaired by soldier aphids (white dots).

MAYAKO KUTSUKAKE



THE WARMING EARTH

Dust Up

The surface temperature of the tropical North Atlantic Ocean—between Senegal and the Lesser Antilles—has risen faster than that of any other tropical ocean basin. It's been warming by about one-half a Fahrenheit degree per decade since 1980. Global warming or changes in ocean circulation have been taking the blame, but new research links most of the rise to decreasing dust and volcanic particles in the air.

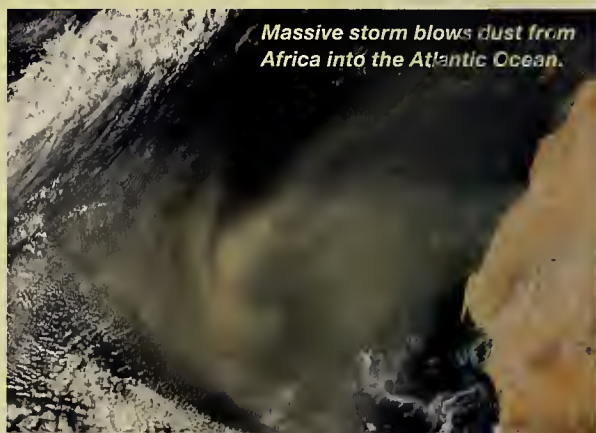
Such airborne particles, called aerosols, reflect sunlight and thus shield the ocean's upper layers from heat. The tropical North Atlantic gets bombarded with dust from Africa's Sahara and Sahel regions, receiving more dust than any other ocean basin. But the volume varies

greatly by season and year, and it has been trending downward.

Amato T. Evan of the University of Wisconsin at Madison and several colleagues analyzed twenty-six years of satellite data on sea-surface temperature and atmospheric conditions. The researchers attribute a fifth of the region's upward temperature trend to a long-term decrease in dust from Africa. A full half they attribute to the gradual subsidence of dust and volcanic sulfuric-acid particles from the eruptions of El Chichón in Mexico in 1982 and Mt. Pinatubo in the Philippines in 1991. The remainder—just 31

percent—is due to other factors, including climate change, the team says.

Warming North Atlantic waters have spawned intense hurricanes in recent years. Dust from Africa and volcanic eruptions—both difficult to predict—may affect the number and force of future storms. (*Science*) —H.L.



Massive storm blows dust from Africa into the Atlantic Ocean.

NASA/COURTESY AMATO EVAN

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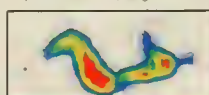


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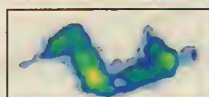
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The Good, the Bad, and the Oily

Finding beauty in an unlikely place: Cholesterol

The poet Lord Byron—vain, athletic, and often cruel—was characteristically scornful of people whose bodies were swathed in too much fat. He called corpulence the “oily dropsy.” His biting description was quoted by the great physician William Osler, one of the four founding professors of Maryland’s Johns Hopkins University School of Medicine. Writing in his *Principles and Practice of Medicine*, the premier textbook of the 1890s and early 1900s, Osler declared that people were inclined to eat too much and too richly, exercise too little, and become too fat. He felt those habits made people less healthy, but—surprisingly from our modern perspective—he was not particularly worried that they might cause heart problems.

Osler reckoned there were approximately 6,000 American heart-attack deaths in 1917. (In 2008, for comparison, there were 24,000 heart-related deaths in New York City alone.) He didn’t see diet and obesity as the biggest triggers for the problem. Heart disease, wrote Osler, was “met with most frequently in keen business men, who work hard, drink hard and smoke hard.” In fact he was anxious that it typically threatened doctors: “The life of stress and strain, particularly of worry, seems to predispose to it, and this is perhaps why it is so common in our profession.” He felt such stresses gave rise to high blood pressure, leading in turn to arteries furring up with the fatty plaques of atherosclerosis.

During the early decades of the twentieth century, the Western world saw a vast decline in the burden of infectious disease. As a result, doctors such as Osler increasingly turned their attention to the rising numbers of heart attacks and strokes. They could offer few treatments, making it vital to discover some means of prevention. Even so, the effects of stress and fat were not well studied until 1948, when the National Heart Institute (now called the National Heart, Lung, and Blood Institute) began a project to monitor the health and lifestyles of more than 5,000 citizens of Framingham, Massachusetts. The aim was to gather more information about why some people had heart problems and others did not.

The researchers were particularly suspicious about the influence of a fat that could be measured in the

bloodstream, a fat whose levels were not simply a reflection of overall weight. That fat was cholesterol, a sterol, or steroid alcohol—a group of waxy, insoluble substances. Cholesterol already had a poor reputation, and was headed toward its present-day vilification. Yet it is a substance that is also essential to our lives. To lift a mouthful of cholesterol-rich food to one’s lips may seem tantamount to taking poison, but the health effects of such indulgence are far harder to assess.

In 1665 the English scientist Robert Boyle noticed mammals had a specific system for moving fats around the body. Experimenting primarily on dogs, he saw that lymphatic ducts became clouded after rich meals as fats were transported in from the gut. About a century later, cholesterol itself

was first isolated from gallstones. Most of those stones are formed when the liver secretes excess cholesterol as a component of bile but the cholesterol fails to dissolve and instead clumps solidly together. First impressions do make a difference: in the early nineteenth century the French chemist Michel Eugène Chevreul coined the term cholesterol, which means “solid bile” in Greek. It was not a substance people seemed predisposed to like.

Cholesterol, however, turned out to be vital for

Physician William Osler conducts a clinic at the Royal Victoria Hospital in Montreal, 1905.



WILLIAM OSLER PHOTO COLLECTION. OSLER LIBRARY OF THE HISTORY OF MEDICINE, MCGILL UNIV., MONTREAL, CANADA

With 18,000 miles of coastline, finding some much-needed breathing room is easier than you think.

There should be a sign somewhere that tells you just how much there is out here. At least that way you'd be prepared and not left breathless upon arrival. Because with enough of it wrapped around this place to stretch back and forth across Canada four times over, there's definitely no shortage. And practically all of it comes with a great ocean view – millions of seabirds, thousands of Humpbacks, and hundreds of freshly carved icebergs.



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life. During the first half of the twentieth century, chemists began to clarify cholesterol's structure and essential nature. It became obvious that the molecule plays a key structural role in cell membranes. Moreover it forms the basis for much of our internal communication, both diffusing over short distances within single cells and traveling through the blood from one part of the body to another. Steroid hormones, including testosterone and estrogens, are made from cholesterol, as is vitamin D. It turns out that cholesterol is so basic to multicellular life that it is essential not only in mammals but in other animals—even in plants and fungi. Our bodies get some cholesterol directly from our diet, but we manufacture most of it in our liver. That holds true for other species too.

It took until 1961 for the Framingham study to show that higher

cholesterol levels were linked with increased rates of heart disease. Even then, the researchers were cautious. All it proved was the existence of a correlation: simply recording observations cannot reveal whether correlations are causal. It might not have been high cholesterol, in other words, that caused heart disease. There was the possibility that some people possessed traits that caused both heart disease and the high cholesterol levels, or that heart disease caused an elevation in cholesterol levels. The difference mattered. Muddle up causality and correlation in human health and at best you end up telling people things that are wrong and useless, wasting their time. At worst you kill them.

In 1976 two groups of researchers isolated a drug that blocked normal cholesterol synthesis. They had found that it existed naturally

in a *Penicillium* mold. For those interested in distinguishing among members of this useful genus of fungi, the drug came from *P. citrinum* and *P. brevicompactum*—not from *P. camemberti* or *P. roqueforti*, which give us delicious cheeses, nor from *P. notatum*, the source of the antibiotic penicillin. And it is worth remembering that “antibiotic” did not start out meaning a drug that made us better. Rather, it meant a drug that was against life (“anti-bios” in Greek)—a substance manufactured by one species to wage chemical warfare against another. The drug that was isolated in 1976 was an antibiotic (in the original sense) belonging to a group now known as 3-hydroxy-3-methylglutaryl-acetyl-coenzyme A reductase inhibitors. Their catchier and more commonly used name is *statins*.

Although *Penicillium* evolved statins because they blocked cho-

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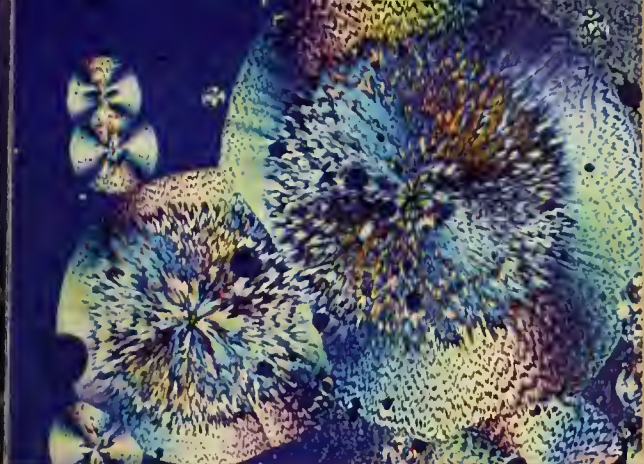
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Cholesterol crystals

that they could revisit their observation that cholesterol was linked to disease. It had become a hypothesis that could be tested. Correlation and causality could now be told apart.

By that time, cholesterol was understood to consist of various compo-

nents performing different jobs. The main two components are low-density lipoproteins (LDL), so-called "bad" cholesterol, and high-density lipoproteins (HDL), or "good" cholesterol. LDL was known to correlate with atherosclerosis and vascular disease, and statins lowered the blood levels of those molecules. The evidence for their consequent clinical effects began to appear in the 1990s. By 2005, an overview of all the available data found fourteen trials that together included more than

90,000 patients. The results were clear: statins worked. They lowered LDL cholesterol and, as a result, lowered the risk of heart problems.

Today, much attention has turned to levels of HDL cholesterol. High blood levels are correlated with good health, and the molecule's physiological function appears to be to reduce atherosclerosis. Raising it should be a good thing. So far, however, every well-designed trial that has intervened in order to raise people's HDL levels has been a disappointment. Current ways of raising HDL are ineffective at best, and, unexpectedly, they may even be harmful. There is a vital message here: the human body is so phenomenally complicated that the impact of an intervention cannot be reliably determined on the basis of thoughtful argument and clever theory. Correlations and theories are marvelous ways of generating

lesterol synthesis in competing microorganisms, statins affect such a basic biological mechanism that they work in humans too. Not for the first time, scientists took a substance that was naturally poisonous and tried to find a way of adjusting it to become therapeutic. (The notion that "natural" means "safe" whereas "artificial" means "dangerous" is ludicrous for many reasons.) Doctors now had a way of effectively and efficiently lowering levels of cholesterol in their patients. That meant

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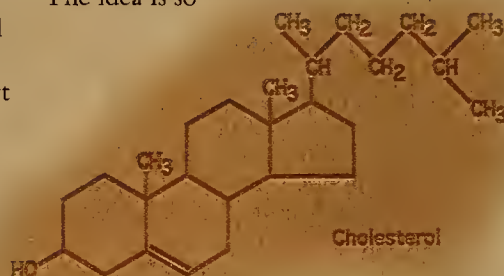
How frightened should we be of cholesterol-rich foods? We are showered with different pieces of health advice. Some matter a great deal. Osler was right about smoking: it kills. No matter how old you are, stopping smoking is good for you. Eating more fiber, by contrast, although it is something we are often advised to do, is another story. Studies have shown a correlation between eating fiber and having a lower risk of gut cancer. Actual trials, however, show no such benefits. It is possible that they have been too small or too short to pick up small benefits, but it is very clear that eating fiber is not as good for you as smoking is bad. That matters. There's only so much effort we're willing to make in pursuit of health. If you love smoking and hate eating fiber, maybe you can face changing only one thing in your life at the moment. Between the two, your choice should be clear.

Eating less fat lowers your LDL cholesterol. To put it in perspective, though, it is helpful to consider the impact of lowering LDL by other means. Statins are the commonest, and like most medicines their benefits are moderate. If you've already had a heart attack, then you're at high risk of having another. For every five years you swallow your statin you gain a one in ten chance of avoiding a heart attack. If your cardiac risk is lower, the chance of the statin helping you is reduced. At the moment most doctors, myself included, don't believe statins are worthwhile for people who are at really low risk of heart trouble.

It seems sensible to think that same way about foods designed to lower LDL—spreads and drinks (such as Benecol products) fortified with plant sterols. Are they worth the trouble? Assuming that lowering

LDL via these molecules does the same as lowering it with a statin, you can estimate the benefits. At the age of forty-five, around 40,000 people need to eat sterols for a year in order to avoid just one of those 40,000 dying from a heart attack or a stroke. By eighty-five years of age we're much more vulnerable and therefore much more likely to benefit. Only around five octogenarians need to eat sterols annually to prevent one of their deaths. Your chance of benefit depends on your initial risk.

Applying that reasoning to dietary fat intake is difficult. Our information is shamefully incomplete. No trial has ever shown that reducing dietary fat makes you live longer. The idea is so



widely assumed to be true that there's been little effort to test it—always a worrying situation. The limited data we possess do point to a low-fat diet being a real cause of heart health, albeit without great confidence. Those studies suggest that people who manage to change their diet over the long term—something most people find remarkably difficult to do—may possibly reduce their risk of cardiovascular disease by one-sixth. For comparison, those who manage to take their statin pills cut their risk by a third. Diet seems to matter, but other things can matter more.

It is easier to think in black and white than in shades of gray. Doctors—and I am as guilty of this as any other—too easily offer dichotomies. We talk of healthy ways of living and unhealthy ones; of good and bad diets. We do not do a good job of communicating

the magnitude of harms and benefits, or how confident we are in them. We correctly say that cheese and butter appear to be bad for you, just like smoking, but we fail to express the very different degrees to which these things are true. Smokers have a one in two chance of dying from their habit. Cheese eaters do not.

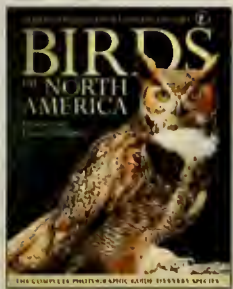
Perhaps because we doctors are so used to making decisions for our patients, we don't often give them the information they need to make their own. But it is also because the moment you try to move away from presenting simplified pictures of what is healthy and unhealthy, you have to start using numbers to express your-

self. Statistics, even simple ones, do not come easily to most of us. Nevertheless, there is no excuse for doctors not doing their best to use them in as helpful a manner as possible. At medical school we get trained how to do so. Politicians—the other big group of professionals who like to advise us how to live—have more of an excuse. They simply don't get that statistical training.

Doubt can be as healthy as certainty. Not everything that seems good or bad turns out to be so, nor are all health risks equally serious. Cholesterol is like the iron in our blood and the oxygen in our lungs: essential for life and deadly in excess. There is the risk that we do more harm from worrying about cholesterol than from eating it. *Penicillium notatum* did us a great favor by providing penicillin. I submit that *P. camemberti* is just as much to be gloried in. Understanding the impact of diet on health should make you thoughtful about what you eat, not destroy your pleasure in eating. Pass the cheese, please.

DRUIN BURCH is a medical resident and a tutor at the University of Oxford. His first book, Digging Up the Dead (2007), profiles the pioneering surgeon Astley Cooper; his second, Taking the Medicine (2009), is the story of how doctors have historically killed more than cured, but have finally learned to improve.

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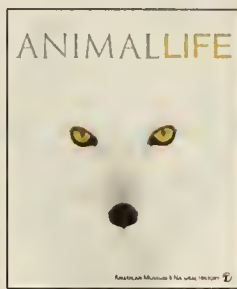
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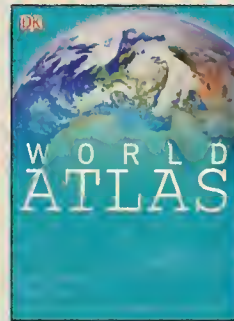


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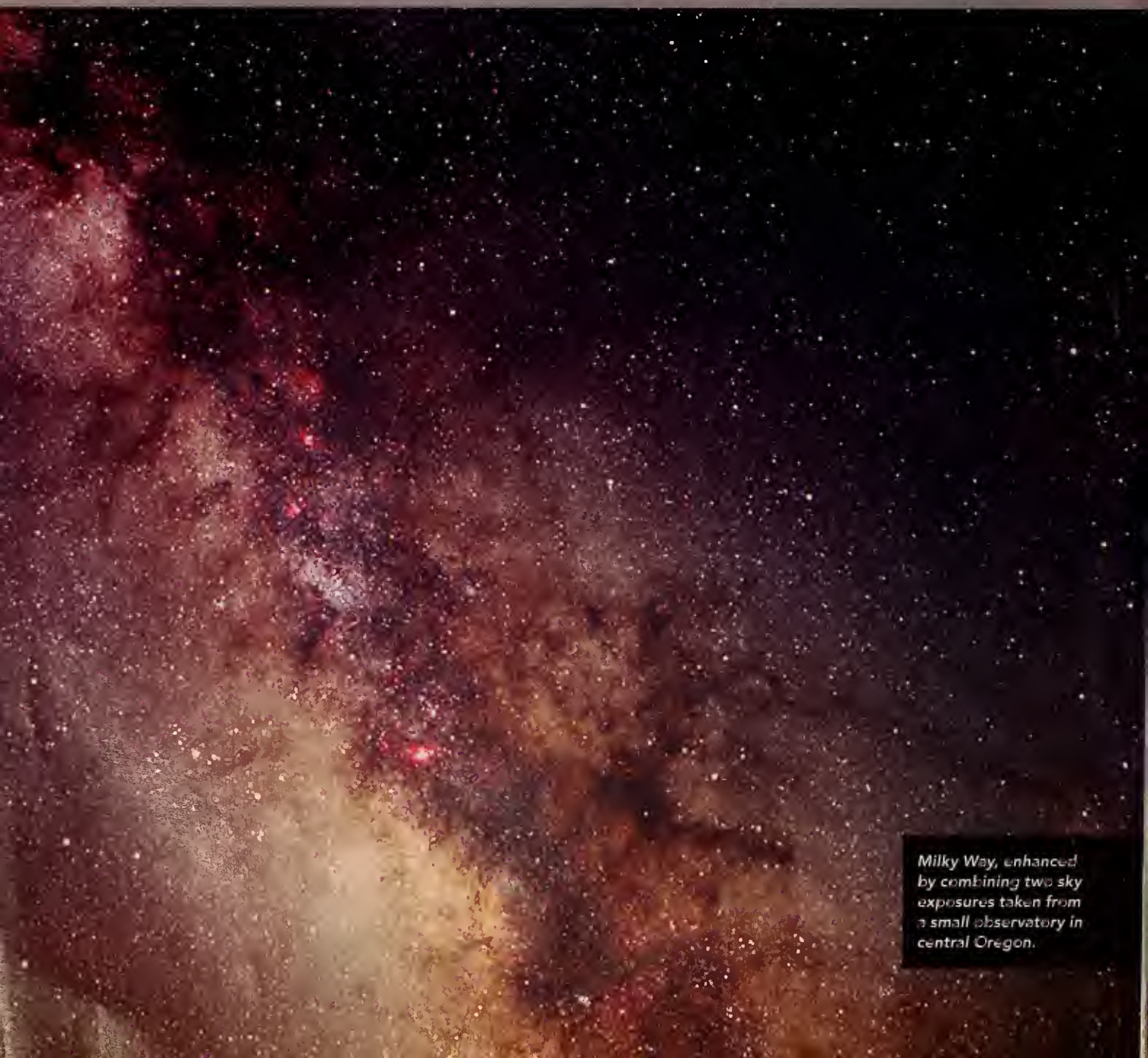
CELEBRATING ASTRONOMY

The Day We Found the Universe:

January 1, 1925

By Marcia Bartusiak

Edwin Hubble's close observation of the Cepheids revealed that our galaxy is not alone.



Milky Way, enhanced by combining two sky exposures taken from a small observatory in central Oregon.

The twenties were not just roaring, they were blazing. Moviegoers flocked to the cinema to watch Moses part the Red Sea in Cecil B. DeMille's silent epic *The Ten Commandments*. Majestic ocean liners crossed the Atlantic in less than five days, while Clarence Birdseye introduced the public to the novelty of frozen food and a failed artist named Adolf Hitler published *Mein Kampf*.

It was also an era of immense scientific fervor. On December 30, 1924, a record-breaking 4,000 scientists descended upon Washington, D.C., to attend the annual conference of the American Association for the Advancement of Science. Taking advantage of the gathering, the American Astronomical Society held its three-day meeting in the capital at the same time, with nearly eighty astronomers attending from across the United States.

A presentation made on Thursday, New Year's Day, ultimately overshadowed all other events at the meeting. A paper modestly titled *Cepheids in Spiral Nebulae* was presented to the assembled audience. Despite its lackluster title, the paper was no less than the culmination of a centuries-long quest to understand the true nature and extent of the cosmos. January 1, 1925, was the day that astronomers were officially informed that the universe had been discovered.

The author of the paper was thirty-five-year-old Edwin Hubble, a staff astronomer at the Mount Wilson Observatory in southern California. Hubble had aimed Mount Wilson's 100-inch reflector, the largest telescope in its day, toward a pair of celestial clouds known as Andromeda and Triangulum, the only spiral nebulae in the nighttime sky that can be seen with the naked eye. He was able to resolve individual stars in the outer regions of the two mist-like clouds. Some turned out to be Cepheids, special stars that regularly dim and brighten like slow-blinking cosmic stoplights.

By measuring the time between blinks, astronomers can calculate distance, and the Cepheids were signaling Hubble that the Andromeda and Triangulum nebulae were very distant, situated far beyond our galactic borders. The Milky Way, our celestial home, suddenly became just one of a multitude of galaxies residing in the vast gulfs of space. In one fell swoop, the visible universe was enlarged by an inconceivable factor, eventually trillions of times over.

It was the astronomical news of the century, and yet Hubble, astonishingly, was not present at his moment of triumph. He was concerned that he hadn't countered every feasible argument against his finding. Back in California the young astronomer was fretfully asking himself, Could I possibly be wrong?

Indications of the Milky Way's true place in the universe had been cropping up for years, but the evidence was indirect, conflicting, and controversial. Two decades before Hubble's seminal paper, most astronomers didn't have the means to determine cosmic distances with any great accuracy. The existence of other galaxies seemed unimaginable, and so they clung fiercely to what they perceived to be their pivotal place in the cosmos.

Around them, however, astronomy was undergoing a spectacular technological transformation that had started in the waning years of the nineteenth century and that would soon shatter their contentment. Cameras became standard equipment on telescopes, enabling observers to gather light over an entire night. And spectroscopes, devices that separate starlight into its component colors, allowed as-

tronomers to figure out what the stars and other celestial objects were truly made of.

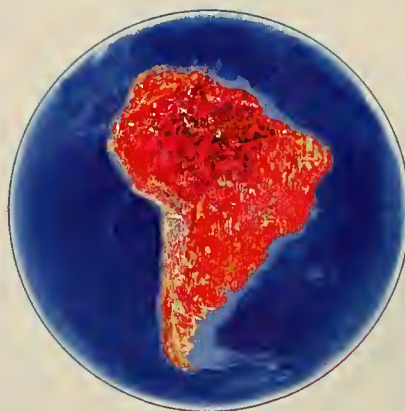
The swift emergence of those improvements, along with textbook accounts, give the impression that Hubble's historic achievement took place overnight. In reality, Hubble stood on the shoulders of a series of astronomers: answers did not arrive in one eureka moment, but only after years of contentious debates over hotly disputed conjectures and measurements. Yet Hubble deserves credit for finally providing the decisive proof, to everyone's satisfaction, of our place in the universe. He even gained enough fame at the time to be joked about: "Professor Edwin Hubble announces that he has found another universe," declared *The Nation* magazine in 1926. "Some people never seem to know when they have enough."

It's difficult to remember that less than a hundred years ago, as far as we knew, there were no quasars, no distant galaxies, no exotic black holes or wildly spinning neutron stars. What was called "the universe" consisted of a single, disk-shaped collection of stars that cuts a magnificent swath across the celestial sky. Known since ancient times as the Milky Way because of its ghostly white visage, our galaxy a century ago was not just the sole inhabitant of the cosmos. It *was* the cosmos—a lone, star-filled oasis surrounded by a darkness of unknown depth.

MARCIA BARTUSIAK is a science writer with a master's degree in physics who has been covering astronomy and physics for three decades. She is the author of five books on astronomy, including *Archives of the Universe* (Pantheon Books, 2004) and *Einstein's Unfinished Symphony* (Joseph Henry Press, 2000).

In recognition of 2009 being the International Year of Astronomy, this article is the first of several on the events and scientists that have advanced our understanding of the cosmos during the last hundred years. This article was adapted from *The Day We Found the Universe*, by Marcia Bartusiak, © 2009. Reprinted with permission from Pantheon Books. All rights reserved.

Splendid Isolation



South America was an island for millions of years, fostering an evolutionary explosion of unique mammal species.

BY JOHN J. FLYNN

MENTION Australia, and kangaroos, koalas, and platypuses spring instantly to mind. Madagascar? Lemurs, of course! What about South America's native mammals? Llamas, alpacas, and jaguars, right? Think again. Like many familiar South American animals, those species represent descendants of relatively recent invaders from North America. South America's original native mammals were far more unusual by today's standards: elephant-size ground sloths, tanklike armadillo relatives weighing as much as two tons, tiny burrowing marsupials, and hundreds of hoofed species that looked like impersonations of modern rhinos, horses, and camels.

South America, like Australia and Madagascar today, was largely isolated from other landmasses by ocean barriers for millions of years. The importance of such geographic isolation in generating new species is a basic tenet of modern evolutionary theory. Species can diverge rapidly from their mainland relatives once geographic separation has occurred—a process known as “allopatry.” This “island effect” has repeatedly led to a remarkable profusion of unique animals at a variety of spatial scales, ranging from small islands with just a few specialized species to island continents like Australia and ancient South America, dominated by hundreds of forms found nowhere else.

On a relatively modest scale, the isolation of small islands off the mainland may lead to dwarfism or gigantism in species, such as the evolution of (now extinct) dwarf mammoths on the California Channel Islands, or giant rabbits and shrews on some Mediterranean islands [see “*The Island Sweepstakes*,” September 1986]. In fact, my colleagues and I recently described a new species of dwarf water buffalo, no more than a few tens of thousands of years old, from the Philippine island of Mindanao. It stood only two and a half feet high at the shoulders and weighed about 350 pounds—an amazing miniaturization considering that its ancestors were six feet tall and weighed a ton.

At the intermediate scale are large islands such as Madagascar, which began to separate from mainland Africa at least 160 million years ago and arrived close to its present position some 120 million years ago. Although early mammals came along for the ride, they later were replaced by a few immigrant groups of modern mammals that made it to Madagascar from the mainland across a 250- to 600-mile-

wide channel. Four land-dwelling mammal lineages that still populate Madagascar, and at least another two groups now extinct there, participated in those rare events, termed “sweepstakes dispersals”—as did bats, which can more easily disperse over water barriers. Of the four terrestrial founders, one was ancestral to the island's living species of endemic carnivores, seven in total, which resemble cats,



Discovered in central Chile, the skull of *Santiagorothia* bears extremely high-crowned teeth, well-adapted for grazing on tough, abrasive grasses. This rabbit-size animal lived about 32 million years ago.

ROBERT MASEK, COURTESY OF AMNH

STEVE BLACK/TERMETRICS

MAURICIO ANTON

ation



civets, and mongooses. Another is represented by twenty-four living rodent species; thirty species of hedgehog-like tenrecs trace their origin to a third; and a fourth founder diversified into the fifty or more living (and fifteen to twenty extinct) species of lemurs—primates that do not occur anywhere else today.

But on a grander scale, the most striking example of mammal evolution in an isolated setting may be South America, in part because of its wide latitude spread and great variety of habitats, including equatorial rain forests, the high Andes Mountains, windswept grassy pampas, and the plains of Patagonia. Although today connected to North America by the narrow Isthmus of Panama, South America was an island continent for the bulk of the Cenozoic era, the so-called Age of Mammals (from 65 million years ago to present). That “splendid isolation,” a phrase adopted almost three decades ago by the famed

***Thylacosmilus* (about 7 million to 2 million years ago, Argentina and elsewhere)**

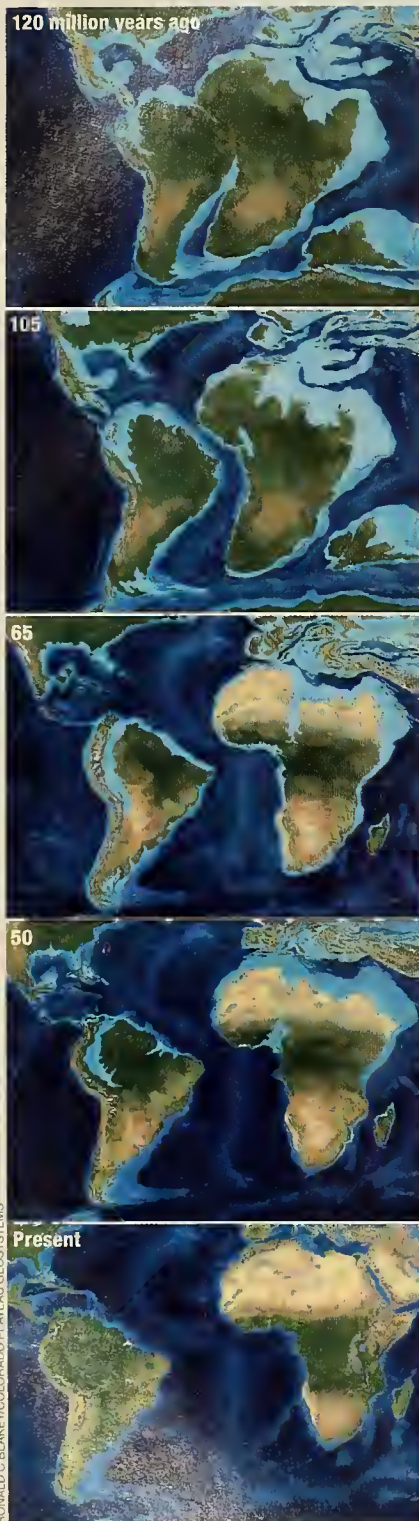
Providing a remarkable example of evolutionary convergence, the jaguar-size, saber-toothed “possum” *Thylacosmilus* was a marsupial that resembled placental predators such as the saber-toothed cat *Smilodon* (whence the “smilus” in *Thylacosmilus*). Like *Smilodon*, which lived in Late Pliocene and Pleistocene times, this member of a group known as borhyaenoids possessed incredibly long, bladelike canine teeth, with flattened sides and extremely sharp edges. Both may have hunted similarly, perhaps ambushing prey, immobilizing it with powerful forelimbs, and then delivering a killing slash to the throat or belly—away from hard bones that might break the long sabers. But because they belonged to such distantly related orders, they also had plenty of differences. *Thylacosmilus* walked on the soles of its hind feet, had ever-growing sabers protected by a deep scabbardlike flange of bone on each side of the lower jaw, and possessed nonretractable claws, whereas *Smilodon* was similar to modern cats in walking on its toes on all four feet, retracting its claws, and lacking a deep jaw flange.

***Scarrittia* (about 29 million to 26 million years ago, Argentina)**

A large, powerful mammal with both horselike and rhinolike features, *Scarrittia* is known from numerous complete skeletons [see photograph on page 32]. It belongs to a group called notoungulates, native hoofed plant eaters that persisted in South America for most of the Cenozoic era, evolving a remarkable range of body forms. Spanning more than six feet in length, *Scarrittia* was one of the largest. Its massive head was equipped with sharp-crested grinding teeth to pulverize its plant food. The tips of its three toes had unusual flattened hooves, suggesting an adaptation for digging up roots and tubers.



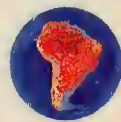
VELAZQUEZ/SMITHSONIAN, COURTESY OF JOHN J. FLYNN



RONALD C. BLANE/COLORADO PLATEAU GEOSYSTEMS

South America was joined to Africa 120 million years ago (top), but as a result of plate tectonic movement, a deep ocean barrier opened up between the two continents by about 90 million years ago, prior to the beginning of the Cenozoic era, often referred to as the Age of Mammals (middle). During most of the past 90 million years, South America was an island continent: it severed its last land connections with Australia by 55 million years ago and with Antarctica by 34 million years ago, leaving it with no direct connection to any other landmass until the Isthmus of Panama formed a land bridge to North America about 3.5 million years ago.

American Museum of Natural History paleontologist and evolutionary biologist George Gaylord Simpson, led to the evolution of a wondrous array of plants and animals—perhaps more species than on any other landmass. Among them were ancient lineages of mammals, the vast majority of which went extinct without leaving any descendants. The opossums, armadillos, anteaters, and tree sloths living there today only provide a hint of the continent's homegrown treasures.



To begin at the beginning, the earliest evidence of mammals, dating at least as far back as the early Jurassic period, about 195 million years ago, comprises fossils of creatures resembling small shrews that coexisted with the dinosaurs. At the time there was only a single supercontinent, Pangea, that had begun to fragment, and the climate was much warmer. Mammals diversified as Pangea continued to break apart, first into a northern supercontinent, Laurasia, and a southern one, Gondwana. These long retained a few intermittent connections, but between 180 and 34 million years ago, various parts of the southern supercontinent gradually broke apart. During the same period, Laurasia lay across the Northern Hemisphere, but later split into North America and Eurasia.

The three major groups of mammals surviving today arose as those major events unfolded: monotremes (the small group of egg layers such as the platypus and spiny echidnas); marsupials (species whose young undergo much of their development as sucklings, usually in a pouch, such as kangaroos, koalas, and opossums); and placentals (mammals whose developing young are nourished for a long time in the womb through a placenta, such as cats, cows, humans, and whales).

Monotremes split from the ancestor of marsupials and placentals (the mammal group Theria) at least 165 million years ago, and their oldest fossils indicate they began to diversify in the ancient southern continents in the later stages of the Mesozoic, by 120 million years ago. Today monotremes live only in Australia and New Guinea, but a fossil platypus found not long ago in South America proves that this group once ranged more widely across the Southern Hemisphere.

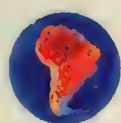
Marsupials originated in the north—the most ancient fossils known so far have been found in China and date back 125 million years—then dispersed through North America and across ephemeral north-south island chains into South America, Antarctica, and Australia, perhaps around 70 million years ago. Those three southern continents still retained some land connections with each other but at that time had broken away from Africa.

Placentals diversified on a number of different continents, but only a few lineages were present on the “southern three” during the end of the Mesozoic (the so-called Age of Dinosaurs) and early part of the Cenozoic (around 65 million years ago). In South America, and to a more limited extent Antarctica, archaic placental lineages included the edentates (sloths, armadillos, and anteaters) and a rich variety of native ungulates, or hoofed animals. At least one or two ancient lineages of ungulates from North America also made it to South America.

South America was already largely an island by about 90 million years ago, the time of its final separation from Africa. Its separation from Australia occurred between 60 million and 55 million years ago and from Antarctica between 40 million and 34 million years ago, during final fragmentation of Gondwana. The continent then remained isolated until its (geologically speaking) very recent reconnection to North America, around 3.5 million years ago. The continent's relentless westward drift created the 5,000-mile-long Andes Mountain chain. That massive western spine was born from volcanic eruptions and compres-

sive forces as tectonic plates underlying the Pacific Ocean were subducted beneath the continental margin. Beyond those dramatic events, mammal evolution in South America also proceeded hand in hand with local geological and environmental transformations and global climate changes.

In the 1950s Simpson proposed dividing the continent's mammal history into three time intervals, known as "strata," based largely on fossil finds from high latitudes [see illustration at right]. While his scheme remains a reasonable framework, subsequent research has greatly increased our knowledge of faunas from other parts of the continent, such as the tropics and the Andes. For example, my Chilean, U.S., and French colleagues and I have scoured the Chilean Andes for fossil mammals, yielding thousands of well-preserved specimens, including the oldest rodents from the continent, the oldest very complete New World monkey skull, and more than twenty-five new species that help to document the earliest grassland habitats on the planet. A more refined stratum picture is thus emerging.

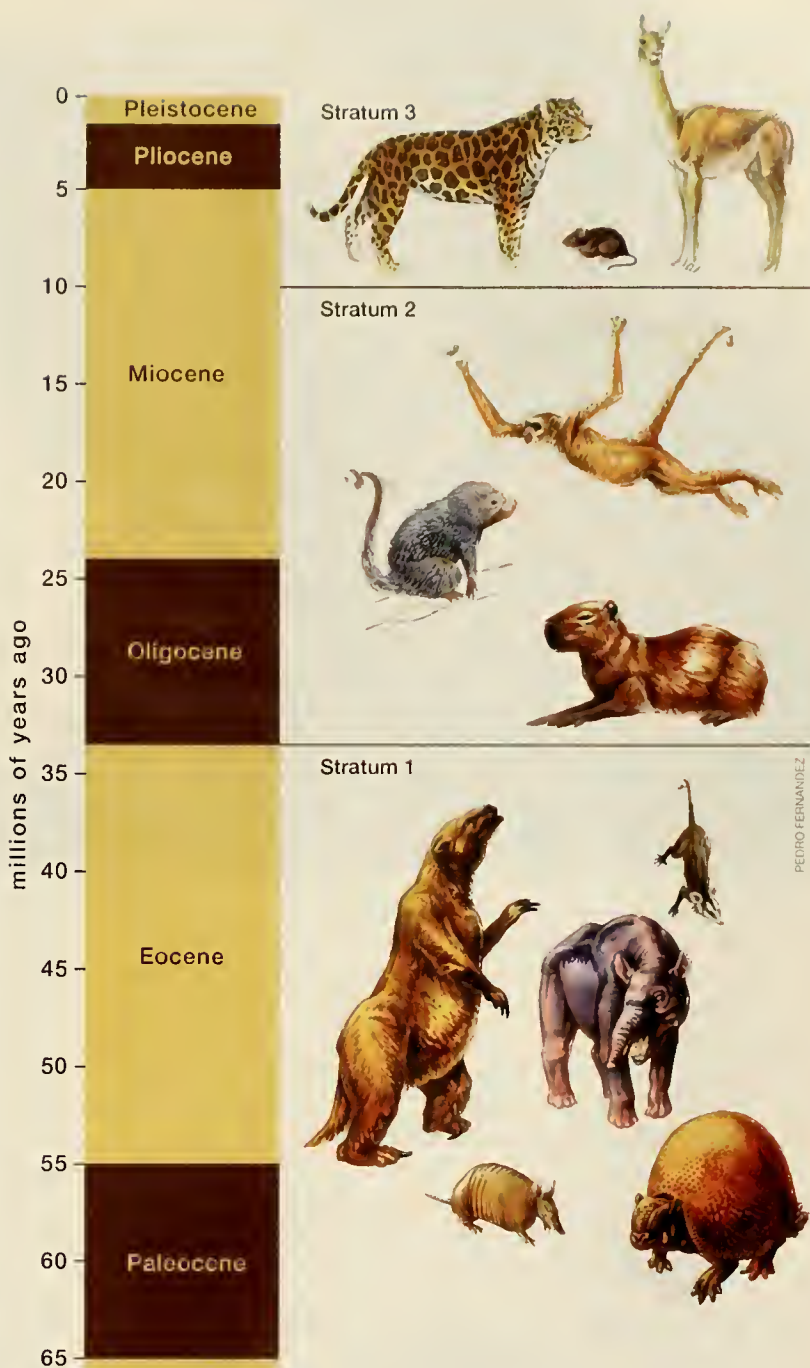


South America's initial phase of Cenozoic mammal evolution, from 65 million to 34 million years ago, is known as Stratum 1.

The continent was isolated except for limited interchange with North America and Antarctica-Australia. The land was mostly forested, and because the mountains were not as high as they are now, nor the high latitudes as cold and dry, the flora and fauna were probably more uniform across the continent. A diverse suite of "archaic mammals" dominated, including marsupials, at least five different groups of endemic hoofed herbivores (plus the few rare lineages shared with North America), and the edentates. In recent years we have learned that other mammals also were present early in this period, including gondwanatheres, an unusual rodentlike group also found in Madagascar and India.

The only notable mammalian predators were borhyaenoid marsupials: insect and meat eaters that were mostly arboreal and small. Plant eaters included the native ungulates, which arose from much more generalized, rat- to fox-size ancestors. The most diverse group of these hoofed mammals in South America were the notoungulates, eventually comprising hundreds of species. Notoungulates thrived for 60 million years—but all are now extinct. The lighter-bodied, long-legged litopterns were another important group that has since vanished.

An enigmatic group known as xenungulates, whose connection to other families is poorly understood, were represented by a few rare species in



Mammal history during the Cenozoic era in South America is often informally divided into three time intervals, illustrated here with fossil and living examples of mammal groups that first appeared in those "strata." In Stratum 1 so-called archaic mammals dominated the continent, including early relatives of giant sloths, armadillos, and anteaters; a variety of ungulates; and rodentlike creatures called gondwanatheres. During Stratum 2 many of the species belonging to these archaic groups "modernized" in response to changing climates and the appearance of new habitats, while ancestors of two major living mammal groups—caviomorph rodents and platyrrhine primates—arrived from Africa. Stratum 3 witnessed the joining of North and South America by the Isthmus of Panama, leading to the Great American Biotic Interchange. Ancestors of modern guanacos, pumas, and rats invaded South America from the north; armadillos, porcupines, and opossums successfully migrated the other way.



both the tropics and Patagonia. Somewhat better known are the pyrotheres and the astrapotheres, animals that could reach the size of rhinos or small elephants. Some evolved tusks and even trunks. Those animals often were specialized for life in wet habitats such as river margins, and therefore were less common than other native ungulates. Rounding out the plant eaters, some edentates and marsupials evolved herbivorous forms.



A major shift, heralding the start of Stratum 2, began about 34 million years ago, when a continental-scale ice cap first appeared on Antarctica and the planet's oldest grassland ecosystems arose in South America, some 15 million to 20 million years earlier than on other continents. Recent studies in Andean and tropical regions continue to build evidence that major geologic, climatic, and environmental changes began extremely rapidly and continued across the continent right through to today.

During that period of climatic upheaval, various mammal groups and communities “modernized” in response to new habitats, evolving adaptations to markedly different diets. For instance, grazers developed high-crowned teeth, like those that modern cattle use to grind gritty grass: the enamel, which covers the crowns of most teeth, extends far below the gum line in grazers to provide more hard material to wear down over time.

Edentates reached their apex of anatomical and species diversity during this time. Although only two types of

sloths exist today—both extremely slow-moving leaf eaters that live in the trees of tropical forests—their dozens of extinct relatives ranged across all of South America. Most of the vanished ones were fairly large to gigantic, roaming the open plains and woodlands to feed on grasses, shrubs, and leaves [see illustration above]. The armored glyptodonts, extinct relatives of armadillos, were among the most unusual mammals ever to evolve. Bony plates over their backs, covered with keratin (the substance in hair and fingernails), fused to form a solid carapace or shell for protection against predators. Some were huge: *Doedicurus* weighed about a ton, grew to be as much as twelve feet long, and was armed with a spiky tail club (which was probably used more in mating battles with rivals than for defense).

Ungulate lineages continued to undergo remarkable changes. Litopterns radiated in a number of different anatomical directions, with horselike forms evolving extreme specializations for running, such as losing all but one long toe on each foot. Others vaguely resembled a pastiche lover's cross between camels, giraffes, and elephants, with robust bodies, broad-hoofed feet, long necks, and prominent trunks. With hundreds of species, the notoungulates provide textbook examples of evolutionary convergence in mammals. Teeth, skulls, and body shapes comparable to those of rats, rabbits, primates, hyraxes, sheep, horses, and rhinos all evolved.

Misled by those resemblances, the pioneering Argentine paleontologist Florentino Ameghino believed that most major mammal groups originated in South America, as



PEDRO FERNANDEZ

Megatherium (about 2 million to less than 10,000 years ago, across much of South America and even into North America)

Megatherium means "giant beast," and that name is certainly fitting: these ground sloths, estimated to have weighed as much as a modern bull elephant (four to five tons), had massive limbs, curved claws more than a dozen times the size of bear claws, and three-foot-long heads. That might sound like the makings of a mighty predator, but this behemoth was an herbivorous edentate whose great size enabled it to browse peacefully on forage from grasses to treetops. When perched on the tripodlike support of its hind legs and tail, the eighteen- to twenty-foot-long animal could easily raise its head more than sixteen feet into the air. Its powerful forelimbs and dexterous, three-clawed "hands" enabled it to reach even higher to pull branches to its mouth. *Megatherium*'s long tongue helped it strip off leaves, which it shredded with unusual back teeth—hard, with high, deeply ridged crowns, but no enamel. As their name suggests, today's sloths are among the slowest-moving living mammals, traveling at a ground speed of only about a sixth of a mile per hour. Their extinct ground sloth relatives, walking on the knuckles of their hands and on the sides of their in-turned hind feet, also likely did not set any speed records.

suggested by the prosaic names he applied to many species, such as *Notohippus* ("southern horse"), *Archaeohyrax* ("ancient hyrax"), *Notopithecus* ("southern ape"), *Homunculus* ("little man"), and more. But we now know that many of the species were not ungulates, and none were closely related to any of the groups on other continents for which they were named. Still other South American mammals, because of their distinct ancestry and unique adaptations, resembled nothing found on the other continents. Such extreme examples of convergence and divergence epitomize evolution in isolation.

Although South America did not witness the rise of

many large native predators, during Stratum 2 some borhyaenoid marsupials evolved into bearlike animals with powerful jaws and crushing teeth, such as *Borhyaena*, and even into a saber-toothed killer, *Thylacosmilus* [see illustration on page 27]. Other native predators were the Phorusrhacidae, or "terror birds": at least one 15-million-year-old species of these carnivorous ground birds towered nine to ten feet tall and sported a sharp, hooklike beak as part of its two-foot-long head.

The other major mammal events during this time were the arrivals of rodents and primates in South America. But from where? The existing fossil record shows they were absent for all of Stratum 1: the earliest well-dated rodent fossil on the continent is 32 million years old, and the earliest primate fossil is about 28 million years old—the oldest well-preserved skull of a New World monkey is our team's fossil find, 20-million-year-old *Chilecebus* [see illustration below]. Close relatives of

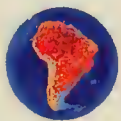
***Chilecebus* (20 million years ago, Chile)**

One of the most interesting new fossils recovered from the remote and rugged terrain of the Andes Mountains of Chile is a skull of the New World monkey *Chilecebus carrascoensis*. New World monkeys are considered anthropoids, or higher primates, as are the Old World monkeys and apes, including humans; but all the living Old World anthropoids are more closely related to one another than to the New World group. High-precision dating of the enclosing rock shows the fossil to be 20.09 million years old (plus or minus 270,000 years). That makes this almost complete specimen the oldest well-preserved and well-dated South American primate skull. Based on the fossil, *Chilecebus* is estimated to have weighed about one and one-third pounds and to have had a smaller brain relative to its body size than any living anthropoid. Since early fossil Old World anthropoids also had small brains, this skull provides strong evidence that brains expanded independently in the Old and New World anthropoid primates.



VELUZAR SIMIONOVSKI, COURTESY OF JOHIL J. FLYNN

both groups lived on other continents well before that. Long-standing arguments exist about where South America's rodents and primates originated. But the characteristics of the earliest South American fossils indicate that the first immigrants arrived from Africa, by at least 32 million years ago in the case of the rodents. They could have crossed the Atlantic Ocean—still a relatively narrow barrier—on rafts of vegetation.



The final interval, Stratum 3, began inconspicuously enough about 10 million years ago, but major changes were precipitated when the Isthmus of Panama joined North and South America, about 6.5 million years later. The new barrier between the tropical Atlantic and Pacific Oceans dramatically changed ocean currents, helping to initiate a series of alternating ice ages and interglacial periods. Grassland and forest environments grew or shrank in rapid pulses in response to the accompanying fluctuations in moisture and temperature. In addition, the bridge between North and South America was the basis for the Great American Biotic Interchange, with species crossing into new regions and radically altering faunal competition, adaptation, and extinction.

Even before the isthmus was fully formed, rare “waif dispersals,” or migrations of only one kind of creature across a difficult barrier, had occurred over island archipelagoes. Members of the raccoon family spread to South America about 10 million years ago, for instance, and ground sloths later reached North America. But all bets were off once a continuous, long-lasting land bridge connected the two continents. An unpredictable hodgepodge of species migrated north and south, some replacing unrelated but ecologically similar mammals on the other continent. Many migrants from the north flourished in South America, possibly helping to drive native groups to extinction. The invaders included the ancestors of what are now familiar South American mammals such as llamas, pumas, spectacled bears, “false” foxes, and coatimundis, as well as less well-known but remarkably diverse sigmodontine mice and rats. Some native South American groups, such as caviomorph rodents, New World primates, and

Complete skeleton of *Scarrittia*



PHOTOGRAPH BY MATT SHAWLEY

EXTREME MAMMALS: *The Biggest, Smallest, and Most Amazing Mammals of All Time* opens at the American Museum of Natural History on May 16. This special exhibition explores unusual examples of both living and extinct species. Highlights include a fleshed-out model of a “walking whale” (*Ambulocetus*); a skeleton of the six-horned, saber-tusked, rhinoceros-like *Uintatherium*; a life-size model of *Indricotherium*, the largest land mammal that ever lived; one of the oldest fossilized bats ever found; and the smallest mammal known to have existed, the shrewlike *Eutamias vanhouteni*. Organized by the American Museum in collaboration with the California Academy of Sciences, San Francisco; the Canadian Museum of Nature, Ottawa; and the Cleveland Museum of Natural History, the exhibition will remain on view in New York City through January 3, 2010, and then travel to other venues.

several lineages of marsupials and edentates, persisted. Even the largest of the ground sloths, the gigantic *Megatherium*, survived until relatively recently. And the dispersal was not all one-way: Virginia opossums, armadillos, and porcupines represent migrants from the south that successfully ranged into North America.

Yet a vast array of South American lineages, both long-lived native groups and later invaders, went extinct during the past 3.5 million years. The ultimate causes of those extinctions remain a subject of controversy, but some of the contributing factors may have been climate change, habitat modification, competition, diseases brought by the invaders, a comet impact, human hunting (which may have begun as much as 20,000

years ago), and just plain chance effects.

Fast-forward to the present, and South America is one of the most species-rich regions on Earth, hosting almost one-fourth of all known mammal species, from rodents (including the water-loving capybara, the world’s largest living rodent) to opossums, from anteaters to armadillos, from furry mountain-dwelling chinchillas to tree-dwelling, prehensile-tailed porcupines. The tropical tree-dwelling New World monkeys alone number some ninety species. It is hard to imagine that such diverse and remarkable creatures boast even more diverse and remarkable antecedents. But they do—the splendid result of millions of years of splendid isolation.

Curator of the “Extreme Mammals” exhibition, **John J. Flynn** is Frick Curator of Fossil Mammals and Dean of the Richard Gilder Graduate School at the American Museum of Natural History in New York City. His research focuses on the evolution of mammals in relation to geology and time scales. Author of more than a hundred scientific publications, Flynn has led dozens of paleontological expeditions in Chile, Peru, Colombia, Madagascar, and the Rocky Mountains.



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Talon Hunt



Updated by modern-day economics and science, the “sport of kings” retains its ancient fascination.

BY REBECCA KESSLER

Kit-chup! Kit-chup! Kit-chup! Kit-chup! Kit-chup! Tom Cullen calls, approaching his aviary. The sun warms a March afternoon; raptor breeding season has just begun. Stray feathers and dry leaves litter the entryway to the wood-frame building. A dusty, acrid odor of guano tinges the air.

Kit-chup! Kit-chup! Kit-chup! Kit-chup! Zephyr, a male Barbary falcon (*Falco peregrinoides*), responds from inside an adjacent room. Cullen keeps up his end of the high-pitched conversation as he grabs a broad hat off a peg and pops it on his head. It's a hat like few others: black rubber, with a tubular brim, a ripply dome, and a tuft of shag carpet on top. He enters the chamber and approaches Zephyr, who is calling from a shoulder-high shelf covered with pea gravel to mimic a nesting area. Kit-chup! Kit-chup! Kit-chup! Kit-chup! Cullen offers more assurance that he's ready to mate. With a rush of wings, the falcon flaps over and lands on Cullen's hat. After repositioning himself a few times, Zephyr lifts his wings, extends his tail, and flies off to his shelf, all in a matter of seconds. “Good boy!”

Exiting the chamber, Cullen doffs the hat and collects a few drops of semen from the brim with a pipette, transferring them

REBECCA KESSLER



Gyrfalcon, above, sports a transmitter. Falconers let their trained raptors fly freely; transmitters aid retrieval should a bird decline to return. Below left: Zephyr, a male Barbary falcon, mates with a special hat worn by Tom Cullen, a New York falconer and raptor breeder. Cullen will collect semen from the hat to inseminate a female falcon.

NICK DUNLOP

into a small plastic vial. Down the hall lives a female Barbary that, like Zephyr, is imprinted on, or sexually oriented toward, Cullen, and so won't mate naturally. Later on, Cullen will put similar moves on her, sans hat. She'll turn up her tail feathers for him, exposing the opening to her reproductive tract. He'll insert a loaded pipette and complete the two birds' union. Such is the work of a raptor breeder—the ultimate go-between.

A falconer for forty-plus years, Cullen has been breeding raptors since the 1970s. He has nearly six dozen adult exotic birds of prey at his home in rural Goshen, New York. Last year he raised fifty-six baby falcons—Barbaries, lanners, luggers, sakers—mostly for sale to other falconers. And this year is shaping up to be a good one, too. (Some of his other work with birds has gotten him into trouble in the past. Most recently, he served four months in federal prison for illegally importing black sparrowhawks in 2000, a charge he disputes.)

Cullen's operation represents a fairly new development in the ancient sport of falconry. The past four decades

have seen advances in captive breeding, tracking technology, and veterinary care, as well as the advent of an extravagant form of falconry practiced in the Middle East. Those developments have changed the sport substantially—and sometimes controversially.

Falconry originated at least 4,000 years ago, probably in Central Asia, and has been practiced for millennia throughout Asia, the Middle East, North Africa, and Europe. Initially a means of hunting, the practice was adopted by aristocrats as a leisure activity. In the United States, the sport took hold in the 1930s. Today there are 4,200 licensed falconers nationwide. In essence, falconry is a hunting partnership between a person and a bird of prey, and it is that cooperative relationship with a wild animal that falconers cherish. The thrill comes as much from the chasing as from the catching. Peregrine falcons, for instance, hunt their mostly avian prey from staggering heights. Their aerial maneuvers and high-speed dive-bombing at-



Training gear: leather lure on a line

tack, and the audible crack when they collide with their target in midair, are candy to a falconer's sweet tooth.

Falconers use several species of falcon, hawk, and less commonly, buzzard, eagle, and owl. Traditionally, falconers trap young wild birds in summer; mold their hunting and train them to return when called; hunt with them in the fall and winter; and then free them in the spring. Increasingly, however, the birds are bred in facilities like Cullen's, either naturally or by artificial insemination. Whether wild caught or captive bred, birds may be kept for years. The quarry is usually a game bird or a small mammal, but a big eagle can take down a small deer, even a wolf. A morsel of meat is the bird's reward.

The sport is demanding: each bird needs hours of training, care, and exercise, plus hundreds of dollars' worth of housing, gear, and daily meat. Subject to federal and state law, it's also one of the most heavily regulated sports. It requires a permit, testing, abundant paperwork, a two-year apprenticeship, and, to achieve the rank of master falconer, five more years of experience. State inspectors make home visits to scrutinize raptors' housing and care. The blood sport inspires passionate dedication. Four centuries ago, England's King James I described falconry as "an extreme stirrer up of the passions." Today, Peter Capainolo, a falconer and an ornithologist at the American Museum of Natural



J. L. KLEIN AND M. L. HUBERT/BIOSPOTO.COM

History in New York City, explains that "marriages and relationships end over these bloody things. It's an all-absorbing thing."

The captive breeding of raptors emerged from a crisis. By the late 1960s, raptor populations across the U.S. had collapsed as a result of exposure to the pesticide DDT, which causes females to lay thin-shelled, easily crushable eggs. Peregrine falcons (*F. peregrinus*) vanished from the East Coast. Alarmed, falconers and biologists jumped in to help. In 1970 Tom J. Cade, a falconer and biologist (now emeritus) at the Cornell Lab of Ornithology in Ithaca, New York, established the Peregrine Fund, which has since relocated to Boise, Idaho. The group pioneered artificial-insemination techniques and figured out how to breed raptors in quantity, largely using parent birds donated by falconers. DDT was banned in 1972, and two years later the Peregrine Fund began releasing captive-bred birds into the wild. Thanks in no small measure to falconers, among others, peregrines and other wild raptors have now staged a remarkable comeback.

Falconers in the U.S. and Europe took up the new captive-breeding methods with gusto. Over time, they've selectively bred specialized lineages. A few breeders advertise nearly pure white or pure black gyrfalcons (*F. rusticolus*), for example. In nature those color morphs are extremely rare at best, and falconers, particularly in Persian Gulf states, will pay a premium for them. Less sensational captive-bred lines may also be subtly diverging from their wild brethren, as breeders—sometimes deliberately, sometimes inadvertently—select for such traits as



NICK DUNLOP

California falconer trains his falcon to stoop, or dive, to a lure to exercise the bird and enhance its hunting skills.

TOP LEFT AND MIDDLE RIGHT, BARRY MASON/ALAMY



Golden eagle returns to a falconer of the Kazakh ethnic group in Mongolia.

between \$1,500 and \$4,000 domestically—and add a zero for what wealthy Arab buyers might pay for a spectacular bird—some breeders, particularly European ones, have done a lucrative business.

Not everyone loves hybrids. Some biologists and falconers worry that escaped hybrids could change the genetic makeup of their wild, full-blooded cousins through interbreeding—a phenomenon called genetic introgression. In artificially reuniting bloodlines separated for millennia by geography, biology, and behavior, people could unleash a new predator into the landscape. “Once you’ve added the genes, natural selection can take hold,” says Jim Bednarz, an avian ecologist at Arkansas State University and the conservation committee chair of

athleticism, willingness to breed in captivity, ease with people, trainability, and disease resistance. “We haven’t got to the point yet where we have breeds of raptors, but I think we will,” says Capainolo. Raptors, so emblematic of wildness, may be on the road to domestication.

Breeders also began hybridizing different species of falcon. Early on, peregrines were so scarce it was hard to find a pair to mate. Breeders tried crossing them with other *Falco* species and soon discovered that the genus hybridizes readily via artificial insemination. So began a craze for hybrid falcons. To their aficionados, hybrids are glamorous, souped-up versions of the natural species. For example, in one bird you can have the accuracy, strength, and flight speed of the gyrfalcon along with the 200-plus-miles-per-hour dives of the peregrine. A two-pound peregrine isn’t quite big enough to take out a six-pound sage grouse: maybe one in ten perfect “stoops” (dives) will end in a kill. But the bigger gyr-peregrine (aka “superfalcon”) can make the kill often and with style. “You’d have the best fun you’ll ever have by flying that,” says Cullen.

Most crosses are within the genus *Falco*; some carry genes from three or more distinct species. Rarely, breeders cross eagle species within the genus *Aquila*. Adding to the hybrid menagerie are occasional crosses between different genera, such as Cooper’s hawk (*Accipiter cooperii*) or the red-tailed hawk (*Buteo jamaicensis*) with Harris’s hawk (*Parabuteo unicinctus*). With a decent hybrid fetching

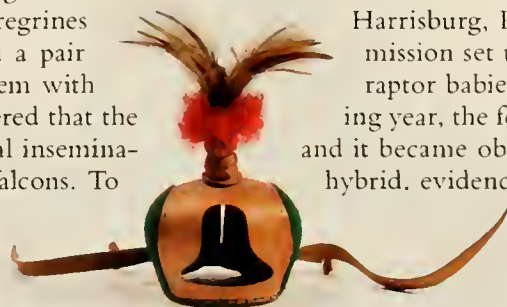
the Raptor Research Foundation. “That would definitely change the trajectory of evolution of a species, and I don’t think that would be a good thing.”

One striking case came to light a decade ago. A juvenile female falcon nested in 1997 with her peregrine mate on the Rachel Carson State Office Building in Harrisburg, Pennsylvania. The state game commission set up a webcam for the public, but no raptor babies were born that year. The following year, the female developed her adult plumage, and it became obvious that she was a part-peregrine hybrid, evidence of an artificial crossing. That put

the kibosh on the planned hoopla, says ecologist Dan Brauning of the Pennsylvania Game Commission. Brauning had the hybrid removed to an education facility, typical protocol in such cases.

But that wasn’t the end of it. The hybrid had a band on her leg, and following that lead, wildlife managers soon learned she was the wild-born daughter of a falconry escapee—a male peregrine–prairie falcon cross—and a wild peregrine. Managers suspect her father sired a few broods in Washington, D.C., before being recognized as a hybrid and captured. His daughter appeared to be sterile, and perhaps any sisters she may have are, too—many female hybrids are. But there’s a decent chance that any brothers are fertile.

Cases of hybrids breeding in the wild are rare: perhaps two dozen have been documented worldwide. Still, notes Alastair Franke, a biologist and falconer at Alberta University in Canada, “The ones we know of in North America are urban sites. What about all of the wild sites that no-



Hood for reducing stimuli and calming a falcon



Falcons and their handler await check-in at the Dubai Airport, United Arab Emirates. To reduce illegal trade in wild falcons, the U.A.E. issues passports to legal falconry birds.

body's looking at?" And even if hybrids don't breed, some biologists argue, they could compete with wild raptors for food, habitat, nesting sites, or fertile mates.

But fans of hybrids argue that all those worries are exaggerated. Escapees may not survive long in the wild, and those that do are likely to be rejected as mates because of their foreign looks, calls, and behavior. Many captive-bred birds are sexually imprinted on people rather than birds, and many hybrids are sterile. And, defenders say, introduced genes are more likely to disappear after a few generations than to spread. Their strongest argument, Franke and Bednarz agree, is that there may just be too few hybrids to pose a substantial risk, especially in North America. A few thousand may be bred worldwide each year, the bulk for falconers in the Middle East.

Finally, falconers will go to great lengths to prevent escapes. One falconer spent four days tracking his lost peregrine around suburban Long Island. He and a friend would follow the bird until dusk, when it would settle into a tree for the night; then they'd return at 4 A.M. to resume the chase. Finally, weary and covered with poison ivy, they managed to capture her.

Mindful of the hybrid debate's potential to reflect badly on their sport and the possibility for "over-restriction," the North American Falconers Association, a nonprofit fraternal and advocacy group, convened an international committee on hybrids. The committee—cochaired by two biologists, both success-

ful hybrid breeders—issued a report in 1999, updated in 2004. The document largely dismisses the potential for harm, but acknowledges that concerns are "not *totally* unfounded" and recommends precautions to prevent escapes.

U.S. federal falconry regulations reflect that perspective—though a few states are more restrictive. In 2008, the Fish and Wildlife Service updated the regulations to prohibit the permanent release of hybrids to the wild. (Young birds may be freed for several weeks to learn to hunt on their own.) Hybrids must now wear two radio transmitters when they're flown, to aid recapture. In Europe, hybrids are more controversial than in the U.S. Six nations have banned hybrids altogether, and last year Bird-Life International, a U.K.-based conservation group, called for a European Union ban on their breeding and flying.

Patrick Redig, a falconer for four decades, is a pioneering raptor veterinarian and cofounder of the Raptor Center at the University of Minnesota in St. Paul. He observes that falconry has undergone a rapid modernization in two areas, in addition to captive breeding: radio telemetry and veterinary medicine. Telemetry has been used since the 1970s, augmenting ankle bells that jingle brightly as a bird flies. A falconer can attach a small transmitter to a raptor's body and track the bird from miles away using a radio receiver. Traditional falconers motivate a bird to hunt by carefully

managing its body weight. A hungry bird—by no means a starving one—will return to its master for a meal. Although it's not foolproof, telemetry has shifted the focus off weight control. "Because people don't fear losing their birds, birds are flown at a lot higher condition, higher body weights, and they're stronger. And because of that, they tend to fly higher and wider and you get more spectacular flights," says Redig.

As a result, falconry raptors are healthier than ever. Advances in avian medicine have helped, too. Since time immemorial, falconers' birds have been plagued by two lethal diseases: frounce, or trichomoniasis, in which a protozoan induces cankers in the mouth, throat, and crop that disrupt eating; and aspergillosis, a



Live falcons, part of a shipment of thirty-two sakers, luggers, and peregrines intercepted in 2006 at a United Arab Emirates seaport: wild-falcon smuggling is a multimillion-dollar affair.

KIZILKAYA/IMAGES & STORIES

JACKIE STRICK

fungal infection of the respiratory system. New drugs developed within the past two decades have largely controlled both. Since 1999, however, another threat has emerged in North America: West Nile virus. The disease has not only killed hundreds of thousands of wild birds in the U.S., but dozens of falconry birds as well. It has tapered off lately, and Redig and his team are working on a raptor vaccine.

A dozen or so raptor hospitals have sprung up in the Persian Gulf states, specializing in the birds' veterinary care and disease research. That's testament to falconry's intense regional popularity. Traditionally, it was a source of sustenance among Bedouins, who trapped and hunted with migratory sakers (*F. cherrug*) and peregrines. Fueled by the surge of oil wealth in the late 1970s, falconry grew extremely popular among royals, who make luxurious, multimillion-dollar hunting pilgrimages abroad and may acquire hundreds of birds annually. (Ordinary people have since taken up the sport, too.) "Falconry is our form of golf, a place to relax and conduct business," the Saudi emir Prince Fahd bin Sultan has said.

With demand for migratory falcons outstripping the local supply, thousands of raptors, particularly sakers, have been imported to the Gulf states from throughout Eurasia. International trade is restricted under the Convention on International Trade in Endangered Species (CITES) and illegal in several nations, so smuggling is common. Often bound in fabric, drugged, their eyes stitched shut (to keep them docile), falcons have been discovered concealed under clothing, in luggage, and stuffed into TVs and thermoses. Needless to say, many die en route, or arrive at their destinations in terrible shape. Locals who trap them stand to gain hundreds or even thousands of dollars per bird—a king's ransom in some places. And wealthy buyers at the end of the line have paid astonishing sums: \$20,000 to \$40,000, even more than \$100,000 for particularly desirable falcons.

Consequently, ornithologists are keeping an eye on the saker. Since 2004, the bird has been listed as endangered by the International Union for Conservation of Nature (IUCN). The listing was prompted by a sharp global population decline blamed

Hitching a ride on a "T perch," a female Harris's hawk goes rabbit hunting on Long Island, New York. Hawks, which often hunt from trees, will also follow their handler through woody habitat.



REBECCA KESSLER

largely on capture for the falconry trade. (New evidence suggests, however, that current populations may actually be much bigger, and the listing is under review.) Captive breeding of purebreds and hybrids may be easing the pressure on wild sakers. There's a catch to that, however—the risk of genetic introgression from hybrids.

Another conservation concern is a decline in the houbara bustard, *Chlamydotis undulata*, the ultimate quarry for many Arab falconers. In addition to hunting the birds outright, falconers trap live houbara to use in training their falcons. Several Arab captive-breeding and reintroduction projects are helping, but the houbara has a long path to recovery.

The unprecedented wealth, technology, and globalization of the twenty-first century have extended the reach of falconry into the natural world. Where the saker, the houbara, and hybrids are concerned, it may have gone a measure too far. Yet in many ways falconers are proven and committed stewards of nature. They made possible the recovery of the peregrine and other species, and they participate avidly in conservation projects, wildlife rehabilitation, science, and public education. Falconry techniques have even gained new relevance in the deployment of raptors to shoo nuisance birds away from airports, parks, and agricultural fields.

At a time when most Americans' lives are increasingly divorced from the out-of-doors, falconers sustain an age-old bond with wildlife. The sport, says one young falconer, probably speaking for most, is "the best way to see what wildness really is. You can actually have this relationship with a wild animal . . . and it's amazing."

Rebecca Kessler is a senior editor at *Natural History*, where she edits features and the "Samplings" column. She also writes about science, the environment, and food for other publications. She has a background in botany and holds a master's degree in science journalism from New York University.

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OUT THERE BY CHARLES LIU

Science en Masse

Modern astronomy proceeds with telescopes, computers—and lots of eyeballs.



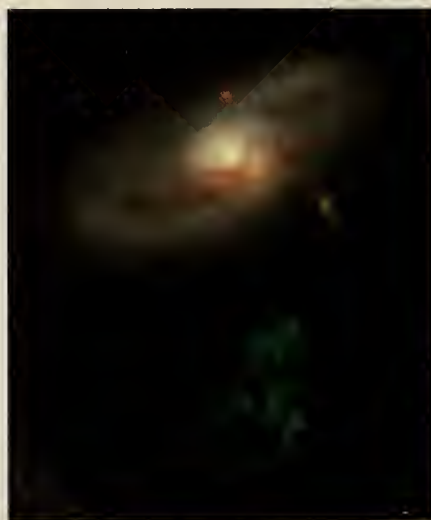
The size of the observable universe, with its roughly 100 billion galaxies, each containing billions of interesting objects such as stars, planets, nebulae, and black holes, is one of astronomy's greatest assets. Alas, it's also one of astronomy's greatest frustrations. There will never be enough telescope time to observe everything out there. Even if there were an unlimited supply of telescopes, there wouldn't be enough astronomers to use them: only about 7,000 people worldwide make their living in astronomy research, and that number isn't going up very fast.

More frustrating, the world's existing telescopes far outpace our capacity for study. Hundreds of gigabytes of data are piling up hour after hour, twenty-four hours a day, seven days a week. There's no way that we 7,000 professional astronomers could analyze all those gigabytes thoroughly. Top-priority scientific questions can usually be investigated with the available time and resources; the rest of the data are stored in archives in hopes that someday they can be properly examined.

There may be untold astronomical discoveries hidden in those archives, like buried bones waiting to be unearthed by a curious hound. You'd need an army of pooches to do justice to even a portion of the available data. Thanks to some creative astronomers and a lot of dedicated volunteers, however, that's exactly what's been set into motion. A phalanx of scientific sleuths—including a Dutch schoolteacher, Hanny van

Arkel, who recently made news—is sniffing out buried scientific treasures through an online project called Galaxy Zoo.

Galaxy Zoo recently yielded surprising results on blue elliptical galaxies, in a study led by Kevin Schawinski of Yale University. Elliptical galaxies, also called “early-type” galaxies—flattened-rugby-ball-shaped collections of billions of stars—generally have very few, if any, young, hot stars. Young stars



While examining an image of a galaxy, top photograph, Dutch schoolteacher Hanny van Arkel noticed a blue cloud (arrow). The mystery “object,” which appears green in the close-up above, is a huge energized cloud of intergalactic gas.

emit mostly bluer visible light and old stars emit redder light, so elliptical galaxies tend to be reddish in color. Every once in a while, though, an elliptical galaxy is dis-

covered that is blue. Those exceptions to the rule could provide important clues about how galaxies form, age, and evolve; but since they're rare, nobody had really been able to study blue ellipticals systematically. Schawinski wanted to do so, but first he had to find them, and that was not a trivial task.

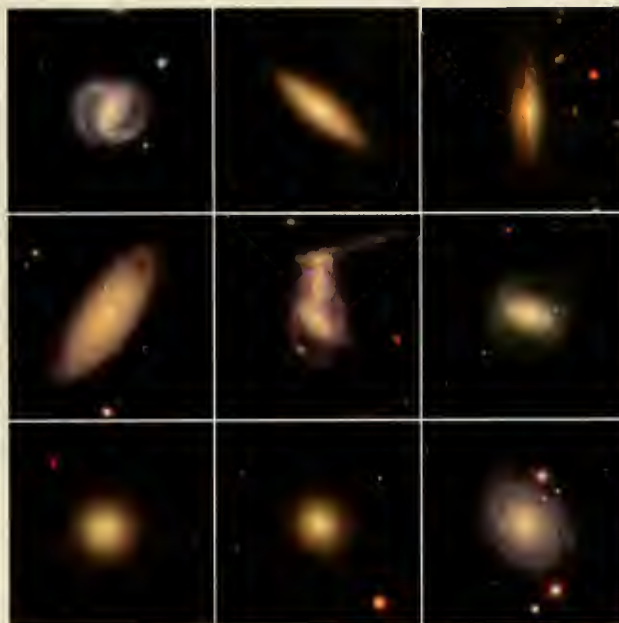
The most time-consuming part of the project was to identify enough elliptical galaxies, because their classification can't be automated well. Galaxies are complex objects, and the best pattern-recognition software is still much less reliable than human eyes. Happily, Schawinski wasn't working alone. He's one of the principal scientists behind Galaxy Zoo, which at the time had posted images of nearly a million galaxies—from the massive Sloan Digital Sky Survey archive—on a publicly accessible Web site. Anyone who's interested in classifying galaxies can register for free, get a little training, and have at it.

So far, some 220,000 people worldwide have contributed to Galaxy Zoo, and every galaxy has been classified many times over by dozens of people. In the same way that Wikipedia or other public-domain databases tend to self-adjust for accuracy, large numbers of people looking at the same pieces of information generally cluster around the correct result. So with the proper statistical treatment, Galaxy Zoo classifications are not only efficient, but they're just as accurate as classifications by professional astronomers.

Schawinski examined one particular region of space where Galaxy Zoo participants had identified about 3,500 ellipticals. Among those, Schawinski found 204 blue ellipticals—the largest sample ever identified. The data showed that fully half of them are forming stars about as vigorously as spiral galaxies do. (In our Milky Way, considered an actively star-forming galaxy, about a half-dozen new stars are born each year; usually, ellipticals form no new stars at all.) Furthermore, the stars in those blue ellipticals move at about half the speed typical for stars in elliptical galaxies; that means those ellipticals are probably not very massive, and may be evolving rapidly. Thanks to the Galaxy Zoo team, an important subpopulation of galaxies—low-mass, star-forming ellipticals—is now ready for further study.

When deciding a galaxy's makeup, Galaxy Zoo participants are looking at a picture of a patch of sky, and that patch contains objects other than the particular galaxy being targeted. So each image is sort of its own cosmic *Where's Waldo?* puzzle. Whatever interesting objects or patterns a volunteer finds could be the seeds of new and important discoveries.

Enter Hanny van Arkel. On August 13, 2007, the then twenty-four-year-old galaxy classifier posted on the Galaxy Zoo online forum: "What's the blue stuff below? Anyone?" Displayed beneath her query was a link to a Sloan Digital Sky Survey image of a galaxy; near the center of the image, below the galaxy, was an intensely blue, odd-shaped, loopy-looking structure about one-third the galaxy's size. Within minutes, a thriving dialog took place: "Looks like a cloud?" "This is very weird. . . ."



Examples of images posted online to help Galaxy Zoo volunteers learn how to classify galaxies: two of these nine are elliptical galaxies.

"Some weird little nebula maybe?"

When the Galaxy Zoo scientific team took a look, they soon realized that van Arkel had found something that no other astronomer had noticed. In the months that followed, Hanny's Voorwerp (*voorwerp* is Dutch for "object") was observed in earnest with telescopes around the world and in space. It turns out that it's the only object of its kind known to science within a billion light-years of Earth! A huge cloud of highly energetic gas, Hanny's Voorwerp has a hole through its center 16,000 light-years across and has an average temperature of more than 20,000 degrees Fahrenheit. Plus, even though it has enough gaseous raw material to make a small galaxy's worth of stars, it appears to contain no stars at all.

The working hypothesis right now is that this strange object is a glowing, gaseous mass that has been blasted by the powerful radiation beam of a long-dead quasar. The quasar—a gargantuan energy source powered by the gravitational engine of a supermassive black hole—probably resided at the heart of IC 2497, the galaxy that van Arkel was classifying when she dis-

covered the Voorwerp. The quasar has since shut down, but its radiation is still plowing through intergalactic space and energizing the matter in its path.

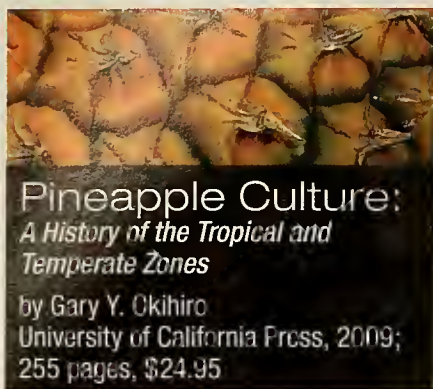
It may sound strange that cutting-edge astronomical research is being conducted by amateurs and volunteers, and even, in the case of the Galaxy Zoo classifications, democratically by mass consensus. Actually, it shouldn't be strange at all. As early as 1907, the British scientist and statistician Francis Galton recognized the mathematical soundness of the wisdom of crowds—especially well-informed

ones. But with the rapid advances in science and technology, people too often assume they aren't vital participants in discovery.

Thinking that scientific subjects are beyond their grasp, many blindly take the word of experts. That's the antithesis of science—deferring to authority, rather than confirming findings through experiment and observation—and it leads to accepting misinformation in scientific guise. Worse, it gives demagogues the opening they need to conflate science and nonsense: "Teach the controversy," some smugly say—knowing full well that the controversy is political, not scientific.

People like Hanny van Arkel are often referred to as amateur astronomers. Well, they may not have advanced astronomy degrees or draw a salary for their contribution. But they are vital, valued members of their research teams—and bona fide scientists.

CHARLES LIU is a professor of astrophysics at the City University of New York, College of Staten Island, and an associate with the American Museum of Natural History. He is the author of *The Handy Astronomy Answer Book* (Visible Ink Press, 2008).



To know the pineapple is to love it. "This is one of the most beautiful fruits . . . in the whole world," wrote Gonzalo Fernández de Oviedo y Valdés, whose 1535 *Historia General y Natural de las Indias* contains the first published drawing of a pineapple. Gonzalo praised the pineapple's form, fragrance, flavor, and ease of cultivation, describing how the local population of the Caribbean region used it not only as a succulent treat but also as a natural medicine and as a base for wine.

So appealing was the pineapple, according to Columbia University historian Gary Y. Okihiro, that it quickly came to be regarded by the European colonial powers as the quintessential fruit of the tropics—a sensual treat, rich in its evocation of steamy jungles and laid-back native populations. Since the bulky fruit tended to lose its flavor and firmness during transatlantic voyages, it was at first a luxury item, reserved for wealthy British and Continental aristocrats with hothouses a short walk from their dining tables. But as faster sea transport and better methods of cultivation came into use in the nineteenth century, pineapples became more affordable to the middle class, and enterprising farmers began to establish extensive pineapple plantations in the tropics.

It is not clear when the pineapple first made its appearance in Hawaii,

but by the beginning of the twentieth century, that Pacific archipelago was on its way to becoming the world center of the burgeoning pineapple culture. A key figure in that development was James D. Dole, who came from a missionary family with strong financial and political ties to the islands. Starting on ten acres in 1903, Dole grew an empire that quickly outstripped all previous pineapple growers in size and productivity. His first year's harvest amounted to less than 2,000 cases of canned fruit; in 1930, his canneries produced almost 100,000 cases in a single day. By the time Japan attacked Pearl Harbor in 1941, Dole and two other Hawaiian firms were rulers of the pineapple trade, producing more than 80 percent of the world's supply.

Okihiro's narrative is filled with juicy tidbits of pineapple lore, including an amusing account of how artist Georgia O'Keeffe was recruited to produce paintings for Dole's advertising campaigns in the 1930s. His writing is especially clear and fluid in those chapters on the Hawaiian pineapple, in contrast to the dreary academic prose of the opening and closing sections of this book. There, rather than letting the story make the point that pineapple culture offers insights into the relation between European empires and their tropical colonies, Okihiro piles on Theory in convoluted sentences that would make a freshman English teacher shudder: "And yet, revealed in history's designs, insofar as themes emerge, are the workings and calculations of actors who build upon, disassemble, and reconstitute toward certain ends."

For readers who find things dragging at the outset, take a lesson from this wondrous tropical fruit and read on. After all, you have to cut away the pineapple's hard and spiky covering if you want to enjoy the nourishment and sweetness inside.



Claustrophobes beware: the key scenes in outdoor-adventure writer Cary J. Griffith's action-packed book are set in dark, dank places where it's hard to move, or breathe, or both. The location is southeastern Minnesota, a region rich in limestone and riddled with natural caverns. In the winter of 1984, a group of amateur cavers exploring a sinkhole on a farmer's property discovered an extensive network of underground tunnels and crevices they called Goliath Cave. As cavers penetrated farther and farther over the years, Goliath Cave lived up to its name—it was one of the longest systems of interconnected caverns in the state. How a bunch of amateur explorers opened up that remarkable place, and the natural and political difficulties they faced in the process, is the underlying thread that ties the narrative together.

The parts that will give you goose bumps, though, are Griffith's taut descriptions of caves behaving badly. These are the times when even the best-intentioned and most experienced cavers find themselves in jams that threaten to prematurely end their explorations. There's the case of five suburban Twin Cities high school students who took advantage of a nice spring afternoon to clamber down into one of St. Paul's many caves, entrances to which dot the bluffs along the Mississippi. Originally excavated

as sand mines or as storage areas by local breweries and factories, the man-made caverns are filled with a century's worth of debris, some of it the result of unsuccessful attempts to block the entrances and fill the tunnels. You know from the title of the section—"A Perfect Storm"—that no good is going to come of that excursion, but it is still shocking when three of the students are killed.

As if to underscore how dangerous cave exploration can be, such true tales prove that you can be in deep trouble only a few hundred feet from cave entrances, and (if one measures vertically through the rock and soil) only a few dozen feet from the Earth's surface. Seen from that perspective, one can't help but marvel at how close we live to the frontier: we don't have to travel to other planets to encounter hostile alien worlds. Nevertheless, for the great silent majority who prefer to cheat death by staying aboveground—in other words, for those who don't suffer from that peculiar mental affliction called caving—Griffith provides a safe and sane way of exploring the underground realm.

Flotsametrics and the Floating World: How One Man's Obsession with Runaway Sneakers and Rubber Ducks Revolutionized Ocean Science

by Curtis Ebbesmeyer
and Eric Scigliano
Smithsonian Books/Collins, 2009;
286 pages, \$26.99

Because water makes pages stick together, I have not experimented to see if this book floats, but it's light and lively enough to make me reckon it might. If it did, Curtis Ebbesmeyer would no doubt use his promotional copies to track the great swirls of water that circulate

around our oceans, as he has with so many other ordinary items. Some of the seaborne wanderers he describes are the stuff of legend, like the 78,932 Nike shoes that went overboard in the mid-Pacific on May 27, 1990. Their arrival on Oregon beaches the following year launched Ebbesmeyer, a consulting oceanographer, on a long and distinguished career as a scientific beachcomber and expert on ocean currents. He has inspired a far-flung network of like-minded flotsam lovers who

coordinate the search for beached items of oceanographic interest through the Web site Beachcomber's Alert (<http://beachcombersalert.org>).

With the help of Eric Scigliano, a Seattle journalist, Ebbesmeyer shares tales of drifting objects he's encountered over the years, from bathtub toys to bowling balls. The latter, we learn, are cast adrift not by inept shipboard keglers, but by amateur cannon makers, who employ them as handy ammunition. While such

Continued on page 50



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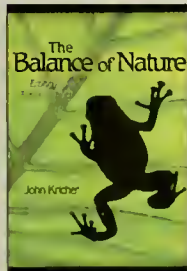
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A Is for Akeley and Apes

By Richard Milner

Hired by Chicago's Field Museum to create a series of dioramas of North American mammals, Carl E. Akeley (1864–1926) pioneered a new method of taxidermy. He measured an animal's muscles and bones when it was freshly skinned, then modeled its flesh in clay over an armature made of wood, wire, and sometimes parts of the skeleton, all arranged in a realistic action pose. A plaster mold was cast from the sculpture, then a light, hollow shell made from that mold, and finally the tanned hide carefully fitted over it. So startlingly lifelike were the results that the Akeley method was soon adopted by all world-class museums.

Akeley went to Africa on behalf of the Field Museum in 1896 and again in 1905, and fell in love with the continent's wildlife. After his superb African dioramas at the Field Museum won fame, he was hired by the American Museum of Natural History in New York City. In 1909, while on safari to "collect" animals for the museum, he was attacked by a bull elephant and almost killed.

As he recuperated, Akeley conceived of a Great Hall of African Mammals for the American Museum, a wide-ranging depiction of the continent's ecology and wildlife. Fascinated by accounts of the gorillas of the Virunga volcanoes in the Belgian Congo, he returned to Africa in 1921. Despite feelings of affection and kinship for the gorillas, Akeley shot five of various ages and sexes, made casts of their faces and hands, and brought their skins back to New York for his African hall.

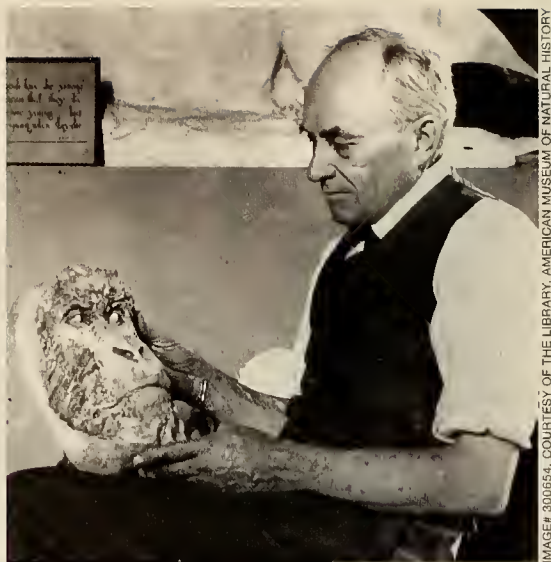
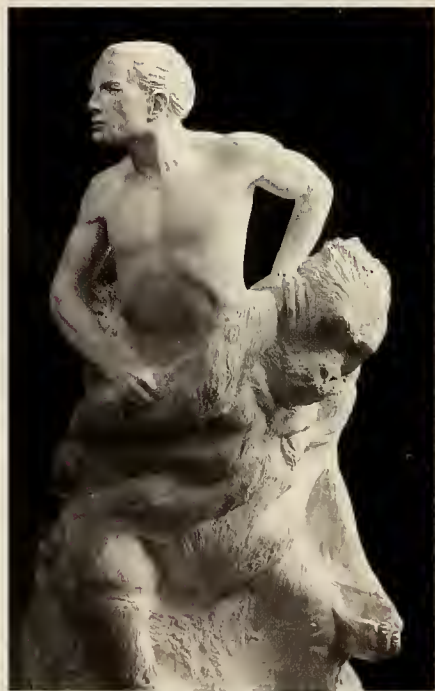
Akeley became an insistent, lone voice calling out for conserving gorillas as a world treasure, finally taking his case directly to King Albert

of Belgium, who convinced his government to create the Parc National Albert in 1925. In 1926, Akeley returned there to work with photographers, artists, and botanists on the background for his gorilla diorama.

Although afflicted with dysentery, he led his party through the soaking, misty forests to the heart of the gorillas' homeland, which he considered "the most beautiful spot in all the world." There, Carl Akeley died and was buried by his wife, Mary, and a small group of friends.

Two years before his final, fatal trip, Akeley had created a bronze sculpture depicting a handsome "modern" man (resembling the youthful Akeley himself) emerging from a cracked-

Plaster cast of *The Chrysalis*, Akeley's controversial sculpture



Carl Akeley contemplates a gorilla's death mask.

open gorilla skin. He called the statue *The Chrysalis*, implying that humans had emerged from apes. When the piece was rejected for exhibition by the National Academy of Design, the Reverend Charles Francis Potter of New York City's West Side Unitarian Church expressed admiration for the sculpture and asked Akeley whether he could display it in the church. Said Potter, a staunch supporter of evolutionary theory, "I know of no concrete symbol which so well expresses the religious message which I am trying to preach every Sunday."

Some defenders of traditional religion were outraged. The Unitarian pastor was unperturbed. "The point of the statue," the Reverend Potter explained, "is not the gorilla but the man, who has risen above his animal ancestry." Akeley, when asked his own ideas about religion, told a reporter: "Most of my worshipping has been done in the cathedral forests of the African jungles with the voices of the birds and animals as music."

RICHARD MILNER is a contributing editor at Natural History and an associate in anthropology at the American Museum of Natural History in New York City. He also performs his one-man musical, *Charles Darwin Live & in Concert*.

This article is adapted from *Darwin's Universe: Evolution from A to Z*, by Richard Milner (University of California Press, 2009).



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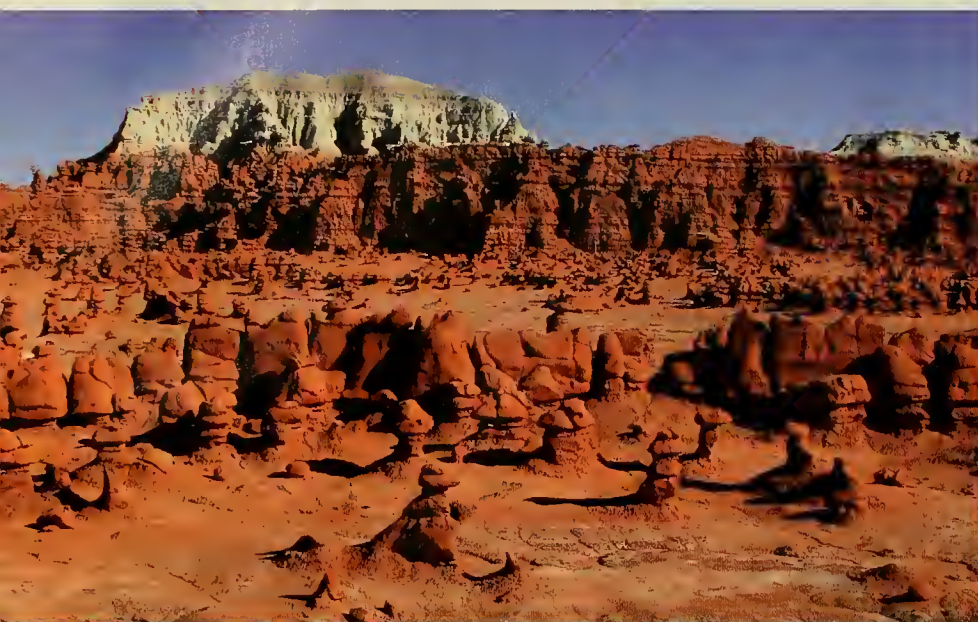
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Goblins on the March

Utah does the hoodoo very well.

by Richard L. Orndorff, Robert W. Wieder, and David G. Futey

In southeastern Utah, west of the Green River, a tributary of the Colorado, and east of a prominent ridge known as the San Rafael Reef, red rock buttes stand like wayward ships lost in a sagebrush sea. The marine metaphor is fitting, because the character of the landscape owes as much to the inland sea that once covered the region as it does to today's arid climate. Deposits left by that ancient tidal environment turned into layers of sandstone, shale, and siltstone. Subsequent uplift and faulting sliced that variable rock into tightly packed columns. And thanks to the

weathering and erosion of those columns, one desert valley harbors a veritable zoo of rock forms.

In the 1920s, Arthur L. Chaffin, a miner, engineer, and trader, stumbled upon that valley as he searched for a route from Caineville to the town of Green River. Returning in 1949, as the owner of a Colorado River ferry, he explored and photographed what he referred to as Mushroom Valley. The rocks in that landscape take more fantastic forms, however, than just what geologists today deem "mushroom rocks"—simple structures consisting of broad caprocks on narrow

pedestals. In 1964 Utah designated three and a half square miles, encompassing the central valley and the surrounding area, as Goblin Valley State Park, a name that befits its landforms.

There are four principal geologic units exposed in the park: from oldest to youngest, they are the Entrada, Curtis, Summerville, and Morrison Formations. The goblins exist only in the Entrada Sandstone, a layer of interbedded, or interleaved, sandstone, siltstone, and shale up to 425 feet thick, cemented with abundant iron oxide, which colors it red. Its original sediments were deposited in a tidal wetland about 170 million years ago, in middle Jurassic times. What is now eastern Utah was then a basin, bounded by uplifted highlands to the west and the Ancestral Rocky Mountains to the east. Waters flowing south from Canada filled the basin to form an inland sea, carrying in sediments eroded from the surrounding highlands.

The Entrada's variability reflects the nature of tidal zones. River and tidal channels carry coarse sediment across mudflats and into deeper, still pools. Waves break on isolated beaches, and dunes are moved by wind. In the later Jurassic, the sea fully retreated, and river systems laid down the sediments of the formations that overlie the Entrada Sandstone.

Stresses from the uplift of the Colorado Plateau, especially during the past 10 million years, gave rise to structures like the San Rafael Swell to the northwest of Goblin Valley (or perhaps earlier: some



Plants Because of water scarcity and salty, alkaline soil, vegetation is sparse in Goblin Valley. Shrubs include Mormon tea and rubber rabbitbrush. Nonwoody species include Indian ricegrass, narrowleaf yucca, prickly Russian

thistle, beavertail cactus and other prickly pear species, and the endangered Wright's fishhook cactus. The San Rafael Swell hosts scattered Utah juniper and piñon pine.

Mammals Large species are

bobcat, coyote, and pronghorn; cougar, desert bighorn sheep, mule deer, and wild (feral) burro and horse range nearby to the north. Small mammals include kangaroo rat, kit fox, white-tailed antelope ground squirrel,

black-tailed jackrabbit (really a hare), Plains pocket mouse, western harvest mouse, brush mouse, and northern pocket gopher; found nearby are white-tailed prairie dog and spotted skunk. Bat species include big brown bat,



geologists believe the Swell formed during a mountain-building event between 65 million and 60 million years ago). Faults and fractures cut across rock throughout the region. Imagine cutting a giant layer cake crisscross with a huge knife: you still have your whole cake, but it is made up of small pieces, columns of cake. In Goblin Valley the spacing of fractures tends to be about three feet apart, a span that bespeaks the rock's inherent strength as it resisted the stresses of uplift.

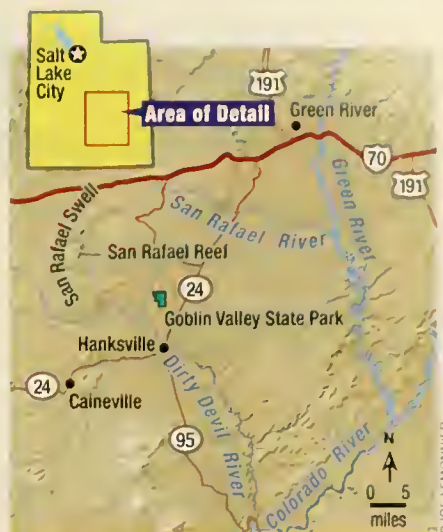
Once exposed, rock is subject to weathering (physical disintegration and chemical decomposition) and erosion (removal of the resultant granules by water or wind). Rocks have varying degrees of resistance to weathering; in southern Utah, most sandstones are highly resistant, and hence form steep cliffs. Shales and siltstones, which are less resistant and thus more vulnerable to erosion,

form shallow slopes. But the Entrada Formation, made up of both resistant sandstone layers and non-resistant shale and siltstone layers, is pulled in multiple directions.

Goblin Valley itself, which runs north-south, is about half a mile wide and two miles long. The eastern side of the valley is defined by a cliff of the red Entrada Sandstone overlain by the lighter colored Curtis Formation. From a prominent overlook, which faces east and south across the valley, goblins appear to march out of the cliff face. Of course, that's the reverse of what's actually happening: the disintegration of the cliff makes it retreat eastward, leaving goblins isolated behind.

Such eccentrically shaped pillars of rock created by differential weathering and erosion are properly known as "hoodoos." Those near the cliff may be made up of four or five layers of alternating resistant and nonresistant rock. The oldest hoodoos have but a single sandstone cap overlying a low shale base. Eventually the cap topples and the shale and silt layers are reduced to poorly defined mounds.

Even the hoodoos' resistant sandstone layers are quite rounded, giving them an organic look. Although the fractured columns that make up the east valley wall have very sharp edges and corners, those sharp edges are rapidly altered through a process called "spheroidal weathering." Weathering acts upon exposed surfaces, and the rate is a function of exposed surface area. At edges, where two surfaces join, chemical and physical processes attack both



VISITOR INFORMATION

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P.O. Box 637
Green River, UT 84525
435-564-3633
<http://stateparks.utah.gov/stateparks/parks/goblin-valley>

surfaces at once. At corners, they have three surfaces to work on. Consequently, weathering of edges and corners proceeds two to three times (respectively) as fast as on a broad rock face.

The best time to view and photograph the goblins is an hour or two before sunset on a clear day. In the soft light and deep shadows of evening, the forms of animals, caricatures of people, and other fantastic shapes emerge vividly from the rock.

*RICHARD L. ORNDORFF is Chair of the Department of Geology at Eastern Washington University, ROBERT W. WIEDER is a paleontologist and biologist, and DAVID G. FUTEY is a writer and photographer. The three coauthored *Geology Underfoot in Southern Utah* (2006), and Orndorff and Futey coauthored *Landforms of Southern Utah: A Photographic Exploration* (2007), both books under the imprint of Mountain Press Publishing Company.*



little brown myotis, pallid bat, Western pipistrelle, and Yuma myotis.

Birds Raptors include golden eagle, northern harrier, peregrine falcon, prairie falcon, and red-tailed hawk. The

turkey vulture, a scavenger, may be seen soaring over the San Rafael Swell. Passerines include the common raven and the rock wren.

Reptiles and amphibians
There are seventeen spe-

cies of lizards and snakes, including the eastern fence lizard, long-nosed leopard lizard, orange-headed spiny lizard, side-blotched lizard, Great Basin gopher snake, midget faded rattlesnake, and striped whipsnake. After

a heavy rain, Great Basin spadefoot toads pop up from burrows to breed.

Insects and arachnids Scorpions abound, along with black widow spiders and darkling beetles, or stinkbugs.


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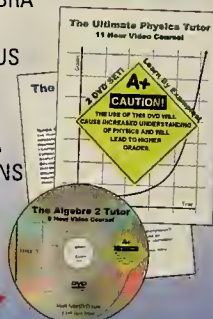
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Because Venus's orbit is smaller than Earth's, we see that planet go through phases as it swings around the Sun. On June 5, Venus will be at its greatest western elongation—that is, as far west of the Sun as it can get from our point of view. In theory, if you train your telescope on Venus early that morning, as it rises ahead of the Sun, its disk should appear to be exactly half lit, or at “dichotomy,” as veteran planet watchers call it. But then again, maybe it won't be!

Back in 1793, Johann Schröter first took note of the fact that Venus, whose crescent is waxing as it approaches western elongation, appears exactly half illuminated several mornings later than calculated. And at its next maximum eastern elongation, Schröter saw that Venus, now an evening object, appeared to wane to half lit several days ahead of schedule. Modern observations indicate that Venus's observed dichotomy occurs up to ten days after its greatest western elongation and as much as a week before its greatest eastern elongation. What's going on here?

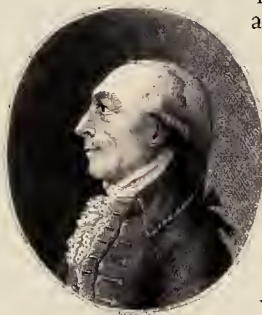
Although the “Schröter Effect” has been known for more than 200

years, it remains largely unexplained. One theory recently put forth is that the scattering of light high within Venus's persistent cloud deck—light that consequently is not reflected back to us—accentuates the concave appearance of the border between the planet's dark and lit sides

at the time of its predicted dichotomy. And yet, a somewhat similar effect has been noted for Mercury, which has no atmosphere.

Whatever the reason, you might want to try and estimate for yourself when Venus looks half illuminated, beginning your observations on the morning of the 5th, when the planet attains its greatest elongation. (To be precise, that event occurs at 5 P.M. eastern daylight time.) The planet comes over the horizon about two hours before sunrise. Telescopically, however, Venus is best seen in bright twilight or even daylight (it's less glary then). Check its progress on the mornings that follow to see when dichotomy finally occurs.

JOE RAO is a broadcast meteorologist and an associate and lecturer at the Hayden Planetarium in New York City (www.haydenplanetarium.org).



*Johann Schröter
(1745–1816)*

(Earth's equator projected onto the heavens). At this solstice, summer begins in the Northern Hemisphere and winter in the Southern Hemisphere. Mars and Venus, within 5 degrees of each other nearly all month, are closest this morning, only 2 degrees apart. Look for them about fifty minutes before sunrise, 20 degrees above the eastern horizon; Mars is above and to the left of Venus.

22 The Moon is new at 3:35 P.M. EDT.

27 That bright yellowish-white “star” hovering west-southwest, well above and to the Moon's right, is the planet Saturn.

29 The Moon waxes to first quarter at 7:28 A.M. EDT.

BOOKSHELF

Continued from page 43

flotsam is merely bizarre, there is a lot that is downright macabre, like the five human feet that beached along the Georgia Strait in southern British Columbia in 2007 and 2008. Ebbesmeyer notes that floating body parts are not uncommon, though it is usually the heads that come off first.

While the most scientifically informative tracers of currents are man-made objects whose time and point of entry are a matter of record, any object that floats can provide information on patterns of ocean circulation. Columbus, notably, embarked on his epochal voyage of discovery with more than blind faith—he had seen tropical seeds, stalks of bamboo, carved sticks, and abandoned kayaks washed ashore on the Azores. Clearly not European in origin, those unfamiliar objects beckoned him to follow the ocean drift back to where they came from. Flotsametrics, Ebbesmeyer implies, is as old as the sea itself.

Over the years, Ebbesmeyer and his colleagues have been able to trace the paths of eleven gigantic gyres, ocean-spanning circular currents that cover our planet like a system of interlocking gears. In the days of satellites and computerized buoys, the use of simple floating drifters to do cutting-edge research may seem counterintuitive. But Ebbesmeyer contends that too much information has led oceanographers to devote their time to studying minutiae, such as the tiny eddies that cause friction in waves. Shoes, messages in bottles, and floating rubber ducks have kept Ebbesmeyer's eye on the big picture. Besides, as readers will readily agree, they've been a lot of fun to study.

LAURENCE A. MARSHALL is W.K.T. Sahn Professor of Physics at Gettysburg College in Pennsylvania, and coauthor, with Stephen P. Maran, of Galileo's New Universe: The Revolution in Our Understanding of the Cosmos, published by BenBella Books.

JUNE NIGHTS OUT

5 According to geometry, Venus should be exactly half lit as it rises this morning, but it may not look that way for several more dawns (see story above).

7 The Moon becomes full at 2:12 P.M. eastern daylight time (EDT).


15 The Moon wanes to last quarter at 6:15 P.M. EDT.

20 Observers with binoculars have their best chance of detecting Mercury during this coming week. Search for the planet about fifty minutes before sunrise, 23 to 27 degrees to the lower left of Venus.

21 At 1:46 A.M. EDT, the Sun arrives farthest north of the celestial equator

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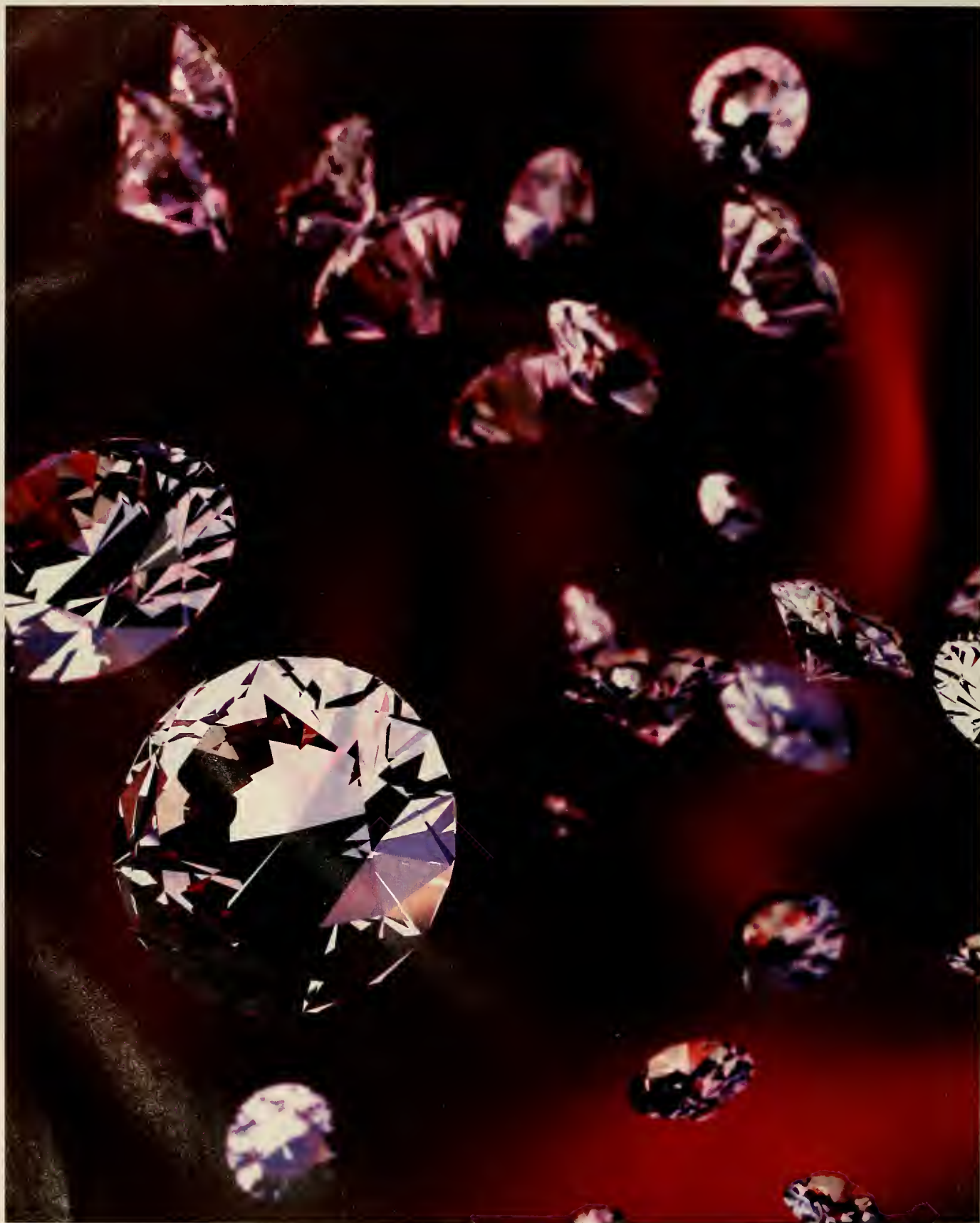
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SPECIAL EXHIBITION EXPLORES THE SCIENCE OF DIAMONDS AND THE HUMAN FASCINATION WITH THIS CAPTIVATING GEM

Marilyn Monroe popularized a certain highly-prized gem when she sang "Diamonds Are a Girl's Best Friend." And, there's that old saying, "diamonds are forever." For centuries, these stunning stones have inspired extravagant myths and unyielding desires in diverse cultures throughout the world. Marvel at these minerals, described as "dazzling," "cool," "elegant," "regal," "unyielding," "stylish" and "pure" when *The Nature of Diamonds*, the most comprehensive exhibition ever mounted on this fascinating subject, opens at the Houston Museum of Natural Science May 8.

The Nature of Diamonds explores humanity's fascination with diamonds and provides an in-depth look at diamonds as a natural substance—from its geological origins, place in history, art, adornment, and literature, to its numerous uses in modern technology and research.

"Understanding the nature of diamonds and appreciating the science behind what makes these dazzling crystals sparkle, makes this precious gem even more magnificent to behold," said Joel

A. Bartsch, president of the Houston Museum of Natural Science.

The special exhibition features dozens of breathtaking gems and jewels on loan from public and private collections all over the world. Highlights of the show include a stunning, layered gold mesh necklace sprinkled with rough diamonds and cultured keshi pearls - created by noted architect Frank Gehry for Tiffany & Company; an 1855 corsage ornament studded with more than 2,000 diamonds, owned by Princess Mathilde, the niece of Napoleon Bonaparte; a Cartier flapper headband from the 1920s; the Elton John Cartier shoulder brooch; and the giant *Aurora Butterfly of Peace*, an artistic arrangement of 240 naturally colored diamonds, on loan from Aurora Gems, New York.

Also on view are spectacular single diamonds such as the Old Stone from the Diamond Trading Center and the Arkansas Diamond from Tiffany & Co., alongside a diverse array of other exhibits, all illuminating the many roles and qualities of diamonds.

What is a diamond?

A crystalline form of carbon, diamond is one of the world's most precious mineral resources. It is the hardest of all substances, ideal as an abrasive or unscratchable surface, with numerous—and ever-growing—technological uses, ranging from windows for space probes to heat spreaders in critical electronic devices. Yet diamond, whose brilliant refractivity and superb dispersion of light create flashing rainbow colors, is most renowned as a peerless, glittering gem, unparalleled in its use as adornment. This dichotomy—as a stone that is at once utilitarian and decorative—has given rise to the allusions and symbolism that create a mystical aura around this mineral.

The Nature of Diamonds is organized by the American Museum of Natural History, New York, in collaboration with the Houston Museum of Natural Science; the Royal Ontario Museum, Toronto; and The Field Museum, Chicago.

The Nature of Diamonds is on display through Sept. 7, 2009. For more information, or to purchase tickets, visit www.hmns.org.

FASCINATING FACTS ABOUT DIAMONDS

SCIENCE OF DIAMONDS

- Most diamonds are over 3 billion years old; two-thirds are the age of the Earth. There are a few “youngsters,” though, which are only 100 million years old.
- Most diamonds were formed more than 100 miles below the surface of the Earth, some at depths of up to 400 miles.
- Although diamonds are perceived as a white — actually colorless — gem, they come in a spectrum of colors; colored diamonds are called “fancies.”
- Some diamonds are composed of carbon that is recycled organic matter, previously incorporated in marine organisms.



- “One-hour eye-glasses” have only become possible with the use of diamond tools, which can quickly and accurately shape the lenses.
- Because diamonds can withstand extremely high temperatures and corrosive conditions, and because they are transparent to most forms of light and electromagnetic radiation, they are ideal for use as windows in industry and in space probes.
- Every copper wire in your computer, television, and house has been shaped with a dye — the device that squeezes wire to the desired diameter — made from diamond.
- Diamond scalpels are particularly effective because their sharp, hard edges never dull, and because diamond’s hydrophobic surface — its resistance to being wetted — ensures that wet tissue does not adhere to the blade.

CULTURE OF DIAMONDS

- India was the only known source of diamonds before the sixth century, and the predominant source for over 2,000 years, until the mid-eighteenth century.
- Romans believed that diamonds had the power to ward off evil and wore them as talismans. They inherited this belief from Indian mythology.
- A law in thirteenth-century France decreed that only the King could wear diamonds.
- Diamonds were not used as gems in European jewelry until the late thirteenth century. They were initially used for such purposes as engraving other gems, such as sapphire cameos, and for drilling holes in hardstone beads (such beads, drilled by diamonds, have been dated to archaeological sites as early as 400 BCE).
- The most recent diamond discoveries have been made in North America — in the Northwest Territories of Canada and in Colorado $\frac{3}{4}$ where explorers found diamond pipes in 1990.
- The largest rough diamond ever found was the Cullinan, 3,106 carats, discovered on January 26, 1905, in the Premier mine of South Africa. It was cut into 9 major stones, including the largest gem diamond, the Cullinan I, or Star of Africa, 550.20 carats. This is mounted in the British Royal Scepter and housed in the Tower of London.

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Sweetness and Mites

By Diana Sammataro



Varroa destructor astride the bristly leg of a honey bee (magnified approximately 450x)

They live inside monkey lungs, snail slime, sea snake nostrils, and human hair follicles: mites, invertebrates in the superorder Acari. There are about 50,000 named species of them, and probably a million more yet to be identified. When people hear that I study mites, they often say, “Oh yes, dust mites,” thinking perhaps of their allergies. But the best-studied mites are those that affect humans as pests, parasites, or carriers of disease. Spider mites damage crops, mange mites plague our pets, and deer ticks carry Lyme disease—to name a few. I study mites associated with the invaluable honey bee.

I first encountered honey bee mites thirty years ago, when I was a Peace Corps volunteer in the Philippines. My work as a teacher there revolved around an apiary of imported European honey bees, *Apis mellifera*—which I watched succumb to a deadly mite infestation. As many as eighty-six different mite species have been found in bee colonies, though only three genera solely parasitize honey bees: *Acarapis*, *Varroa*, and *Tropilaelaps*. My bees died from a then-local varroa mite.

The first mite ever deemed a serious threat to *Apis mellifera* was *Acarapis woodi*. In the early 1900s, bees were dying on the Isle of Wight, and when scientists started investigating why, they found

mites clogging up the bees’ tracheal tubes (their breathing system) and drinking bee hemolymph (bee blood). That led the United States Department of Agriculture to ban all importation of bees into the U.S. in 1922. But the ban did not block bees hitching a ride on cargo ships, nor did it help patrol land borders, thus those mites made their move.

Varroa mites were first observed on Asian honey bees in 1904 and identified as *Varroa jacobsoni*. In 1987 that species—the same that killed my bees in the Philippines—supposedly breached U.S. shores. However, in 2000 the invader was declared to be a new species and given the apt name of *Varroa destructor* [see micrograph above]. Now it sucks the life out of colonies around the world, carrying with it pathogens such as viruses. We undoubtedly owe the recent decline in global honey bee populations in large part to this mite.

Unlike putting a flea collar on a dog, controlling mites in bee colonies is a delicate enterprise. Any application of a pesticide could potentially accumulate as unwanted residues in the beeswax and honey. Moreover, it could disrupt the intricate chemical signaling that maintains the social structure of a honey bee colony. Currently, bee researchers, myself included, have been focusing on novel mite controls based on essen-

tial plant oils, formic and oxalic acids, mite-eating fungi, and a varied assortment of bee compounds.

On the horizon is another type of mite, *Tropilaelaps*, now found on honey bees from Pakistan and Afghanistan east to Papua New Guinea, including European honey bees kept in Asia. The mite is poised to wreak havoc on North American populations, perhaps on a par with the varroa mite. Yet relatively little is known about its biology and management.

Honey bees began disappearing across North America in 2006 in a phenomenon that was dubbed Colony Collapse Disorder, which subsequently spread to Europe. Its origins remain mysterious. Yet new pathogens, poor nutrition, pesticide exposure, reduced natural forage, and (in the case of commercial bees used for pollination) the stress of being moved across country all likely contribute. And even though my experience in the Philippines gave me an early indication, I continue to be amazed at how destructive—and at the same time, how fascinating—mites and the microbes they carry can be.

DIANA SAMMATARO is a research entomologist at the USDA-ARS Carl Hayden Bee Research Center in Tucson, Arizona, and an adjunct professor at the University of Arizona.

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