

# NATURAL HISTORY



5/07

TRACKING THE  
ELUSIVE JAGUAR



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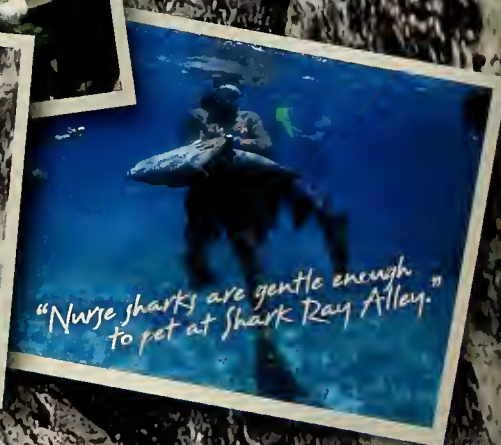
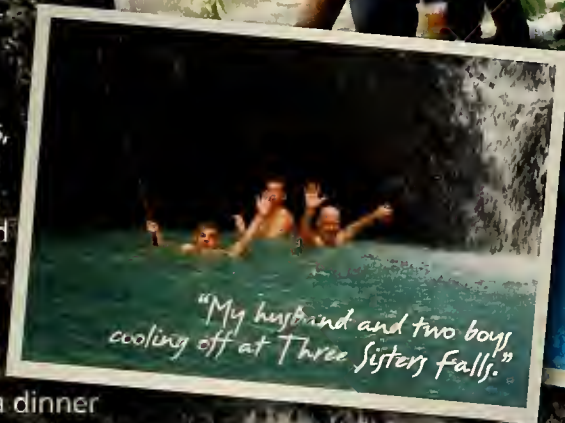
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That night we dined at Innies, a local restaurant where the whole Innies family served as hosts. We bantered back and forth with the family (we later found out the whole country pretty much speaks English), and at the same time managed to demolish a dinner of exquisite beef and fresh seafood. So much for roughing it!

Next it was on to Shark Ray Alley where we swam with the stingrays and nurse sharks. My two teenaged boys had a ball!

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— Nora Campisi —



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# NATURAL HISTORY

MAY 2007

VOLUME 116

NUMBER 4



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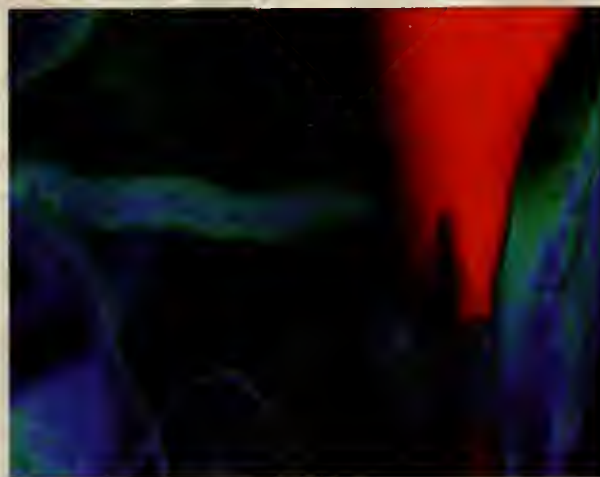
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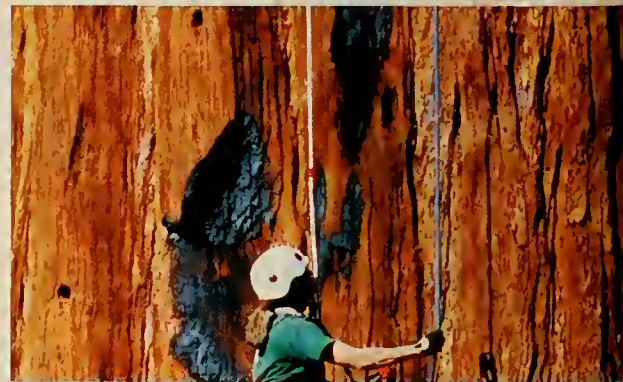
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On February 3rd, 2006, Rune Gjeldnes arrived in Victoria Land, finishing his conquest of skiing solo across Antarctica, from Queen Maud Land via the South Pole. After traversing 4,804 kilometers of the Earth's most inhospitable landscapes, he became the world's first explorer to cross Greenland lengthways, the North Pole ice cap and Antarctica on skis unaided. Congratulations, Rune. The world is yours, from top to bottom.



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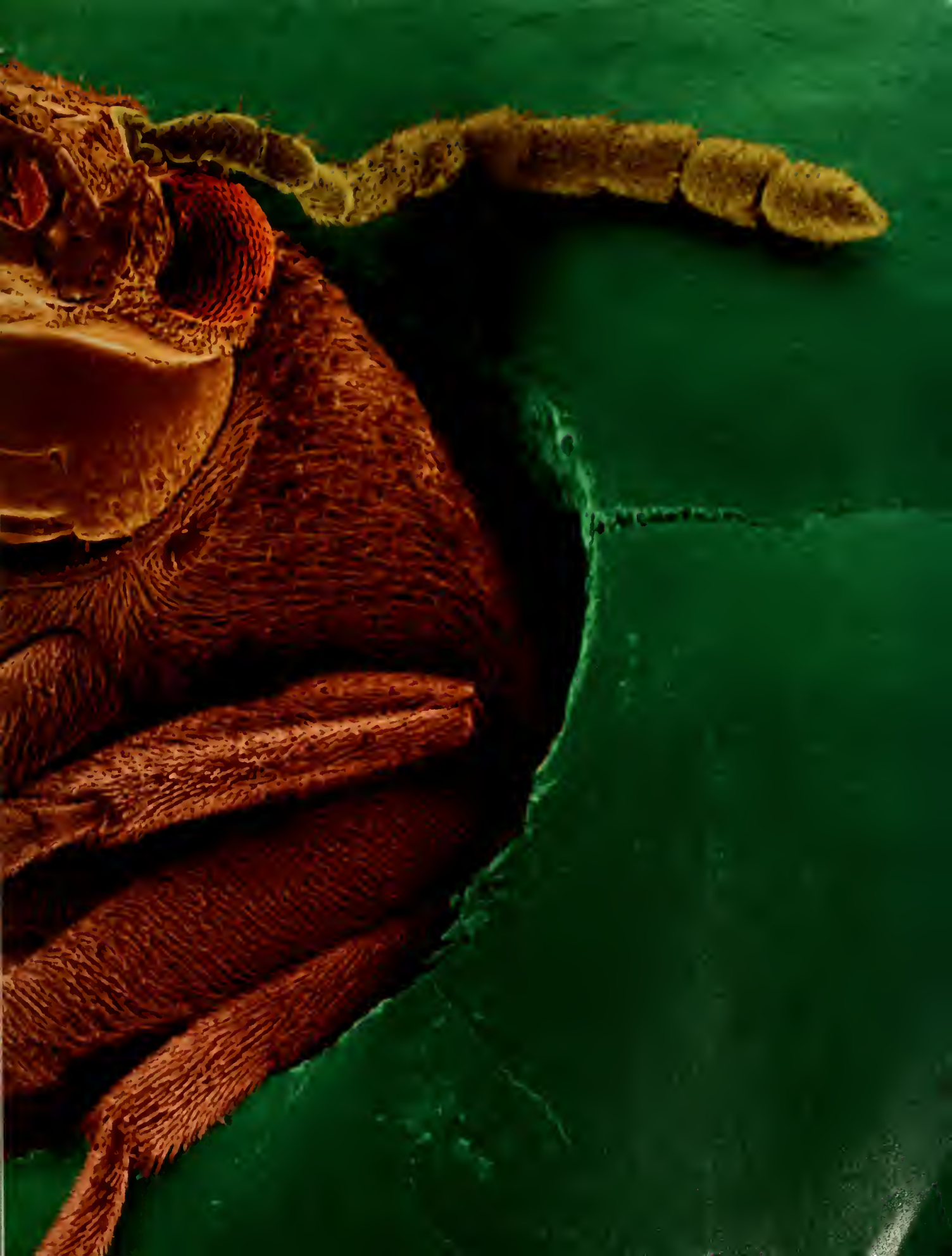
A close-up photograph of a brown, fuzzy Beanie Baby toy, possibly a sloth, against a dark green background. The toy's head is in the upper right, showing its eyes and ears. Its long, thick, fuzzy limbs are spread out across the frame. The lighting is dramatic, highlighting the texture of the plush material.

THE NATURAL MOMENT

# Beanie Baby

Photograph by Dennis Kunkel





◀ See preceding two pages



Ready to plant his spring vegetable garden, Dennis Kunkel rooted out a packet of bean seeds, half-used from the year before. On pouring out the remaining seeds, though, Kunkel noticed they were covered in powder and pocked with round holes. Weevils—he was sure of it! A magnifying lens confirmed that a few straggling adults—each about four millimeters long—were squeezing out of the tiny holes. On impulse, Kunkel dunked the occupied seeds in preserving alcohol.

The common bean weevil (*Acanthoscelides obtectus*) starts life as an egg, strategically laid on a bean seed or a bean pod. When the weevil hatches, as a pale larva, it instinctively worms its way inside the nearest bean. There the weevil eats for several days before pupating. Unlike many other weevils, *A. obtectus* doesn't require extra moisture and thrives on dry beans in storage. Eventually it emerges from its tunnel with a new body, all set to find a mate.

Kunkel was lucky, he said, because one weevil—the one pictured here—got stuck inside its home bean. Kunkel dried and mounted the entrapped weevil for its portrait under the scanning electron microscope. He then added color to a black and white image, here magnified about 90×. This weevil, trapped by gluttony in its escape hatch, was the only one captured on film—all its slimmer companions came out in the alcohol wash.

—Erin Espelie

## Muzzling Scientists

As a big fan of natural history, I follow the science of nature the way a baseball fan follows baseball. I'm thrilled to learn that jaguars, in some places, are making a comeback ("Tracking the Elusive Jaguar," by Eduardo Carrillo, page 30). I'm fascinated by the new findings about how a mother's immune system reacts to the "challenge" posed by her newly implanted embryo ("Pregnancy Reconceived," by Gil Mor, page 36). And I'm riveted by the creepy signs of human sacrifice in a complex of tombs, sealed for more than 4,000 years, that archaeologists have recently unearthed ("Hidden Tombs of Ancient Syria," by Glenn M. Schwartz, page 42).

In other words, I'm a happy fan whenever I can watch the exceptionally gifted players—the scientists—who play my favorite game. But I bristle when someone tries to play politics with the players. Here is what's going on inside an agency, the U.S. Fish and Wildlife Service (FWS), that deals with some of the topics closest to the hearts of readers of *Natural History*.

According to *The New York Times*, and confirmed by FWS officials, an internal memorandum circulated to its Alaska division in early March instructed agency staff not to publicly discuss climate change, polar bears, or the status of sea ice, unless specifically authorized to do so. Let's be fair: if you're an FWS scientist, the ruling applies to you only if you want to travel to an international meeting; then you'll have to sign a document that you understand "the administration's position" on those three issues, and that you "will not be speaking on or responding to" them. The *Times* quoted H. Dale Hall, the director of FWS, as saying that the new policy was "consistent with staying with our commitment to the other countries to talk about only what's on the agenda."

Now when scientists *do* science—when they play their game—they debate passionately and disagree openly, often with brutal honesty toward party lines, sacred cows, or other people's feelings. In short, they express themselves. So if you were, say, an FWS biologist invited to an international meeting, you might expect to be asked for, and should be prepared to give, a candid scientific assessment of issues within your expertise. You might even suppose there would be little point in spending taxpayers' money to send you to the meeting if you were barred from responding to such requests. On both suppositions, you would be wrong.

Unfortunately, the Fish and Wildlife fiasco is no isolated instance. For a review of the recent history of political agendas running roughshod over science, see the report on the Web ([http://ncac.org/science/political\\_science.pdf](http://ncac.org/science/political_science.pdf)) by the National Coalition Against Censorship. The principle should be clear: telling scientists—on the government payroll or not—that they can't express *scientific* findings in their own words, is not only a gag on free speech, as NCAC argues; it's also a perversion of the scientific enterprise.

• • •

With this issue, I'm delighted to welcome Olivia Judson to *Natural History* as the author of a new column about all things biological, titled "Life Zone." Judson is a research fellow in biology at Imperial College London, and the author of a best-selling book, *Dr. Tatiana's Sex Advice to All Creation*. Her inaugural voyage, "A Terrible Scrooge," begins on page 22.

—PETER BROWN



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## CONTRIBUTORS



images, visit [www.education.denniskunkel.com](http://www.education.denniskunkel.com).

Formally a microscopist, **DENNIS KUNKEL** ("The Natural Moment," page 4), specializes in photographing what can't be seen with the naked eye. Neurons, spider silk, anthrax cells—all of them have become subjects of his images. Kunkel earned his doctorate in botany from the University of Washington in Seattle, then pursued an academic career at that university and at the University of Hawai'i in Honolulu. For more of Kunkel's



When **EDUARDO CARRILLO** ("Tracking the Elusive Jaguar," page 30) was growing up in San José, Costa Rica, in the early 1970s, he often visited the country's newly created national parks. There, he became enthralled with the wildlife, and went on to work as a field assistant in the parks, studying deer, peccaries, and small felines. Jaguars didn't formally enter Carrillo's studies until he won a Fulbright scholarship to pursue his doctorate at the University of Massachusetts, Amherst. Carrillo has since taught at the Tropical Agricultural Research and Higher Education Center, in Turrialba, Costa Rica, and at the National University in Heredia, Costa Rica.

**GIL MOR** ("Pregnancy Reconceived," page 36) is an associate professor of obstetrics and gynecology at the Yale University School of Medicine. He is also the director of the Reproductive Immunology Unit and the Discovery to Cure Translational Research program at Yale. Mor's research focuses on the immunology of implantation, the role of apoptosis in tissue remodeling and reproductive cancer, and the role of inflammation in cancer formation and progression. He earned his doctorate in immuno-endocrinology from the Weizmann Institute of Science in Rehovot, Israel, and his M.S. and M.D. degrees from Hebrew University in Jerusalem. Mor is the editor of a recent book, *Immunology of Pregnancy* (Springer, April 2006).



A student of early civilizations and the way their rural and urban sectors interrelated, **GLENN M. SCHWARTZ** ("Hidden Tombs of Ancient Syria," page 42) has concentrated on the rise and fall of early complex societies in Syria. With a colleague, he is codirecting excavations at Umm el-Marra. Schwartz is Whiting Professor of Archaeology at the Johns Hopkins University. His books include *The Archaeology of Syria: From Complex Hunter-Gatherers to Early Urban Societies (ca. 16,000–300 B.C.)*, coauthored with Peter M.M.G. Akkermans (Cambridge University Press, 2003), and *After Collapse: The Regeneration of Complex Societies*, coedited with John J. Nichols (University of Arizona Press, 2006). Schwartz's article in this issue is based on work supported in part by the National Science Foundation (see grant credit in Picture Credits, below).

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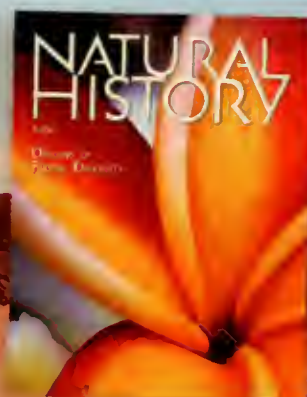
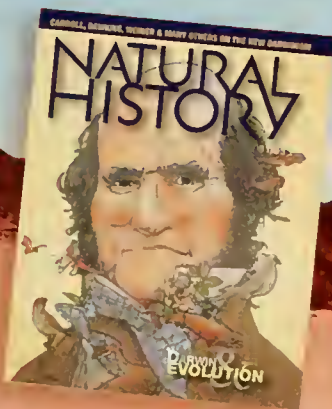
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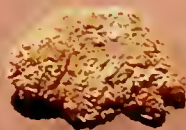
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## LETTERS

### Bear Watch

In “Bad News for Bears” [3/07] Bill Sherwonit has done a creditable job reporting on a complex controversy. The issue of hunting McNeil River bears just outside the sanctuary boundaries has been profiled by some as a pro-hunting versus anti-hunting confrontation. Nothing could be further from the truth. The tradition of ethical hunting runs strong and deep in Alaska, and hunting is managed well.

The point is that in the past few years a new form of wildlife appreciation and use has emerged—bear viewing. If wildlife and wild land are to persist into the future, they need the support of all user groups.

Nurturing the best place in the world to view brown bears (the McNeil River ecosystem) is a great way to accomplish that goal.

*Larry Aumiller  
Missoula, Montana*

BILL SHERWONIT REPLIES: AS Larry Aumiller has probably since learned, and as others who read my article may be heartened to know, this past March 6 the Alaska Board of Game, reversing its decision of two years ago, voted unanimously to keep the Kamishak Special Use Area closed to brown-bear hunting.

### Gas Bags

On reading Adam Summers’s “Biomechanics” column “No Bones About

’Em” [3/07], it occurs to me that the largest cartilaginous fish species all lack air bladders. That may also help explain why sharks have cartilaginous skeletons: the only buoyancy organ they have is the oily liver, so they must do all they can to save weight. But why don’t bony fishes, with their more effective buoyancy-regulating organ, reach the large size that the cartilaginous fishes do? Is a gas-filled bladder not enough to compensate for the heavier skeleton?

*Eriks Perkons  
State College, Pennsylvania*

ADAM SUMMERS REPLIES: An air bladder must scale with the cube of length—

just as the weight of the skeleton does—so larger fish species must carry around proportionately much bigger gas bags. The difficulty lies in maintaining the correct amount of air in a large bladder, because the gas compresses or expands with changes in depth. Either the fish would have to restrict its movements to one depth or orient itself completely to the surface. Some large freshwater fishes adopt the latter strategy.

### Latrine Duty

Stéphan Reeb’s “Sampling” titled “400-Yard Dash” [3/07] tells of recently discovered Dead Sea Scroll texts that describe the Essenes’ practice of



# essential, the POLICE 2



defecating away from their settlements. The commandment for those sanitary acts was written centuries before the Dead Sea Scrolls, in Deuteronomy 23:12–14: "Designate a place outside the camp where you can go to relieve yourself. As part of your equipment have something to dig . . . a hole and cover up your excrement. For the Lord your God moves about in your camp. . . . Your camp must be holy, so that he will not see among you anything indecent. . . ."

*Arthur Smilowitz  
East Norwich, New York*

**JOE E. ZIAS REPLIES:** Our article on which the "Sampling" is based mentions that the Essenes did

indeed base their rules on passages from the Bible. As it says in Ecclesiastes 1:9, "There is nothing new under the sun."

**Brer Coyote  
and Brer Badger**

Nick Atkinson's "Sampling" about cooperative hunting by groupers and eels ["Double Trouble," 3/07] states that cooperative hunting between species had previously been noted only among humans hunting with dogs or dolphins. But such behavior also occurs with coyotes and badgers. The badger, an excellent digger, pursues prey, such as prairie dogs, underground, while the coyote, a swift runner, patrols the surface, catching any

animals that try to flee. The strategy is often employed in times of drought, when prey is scarce.

I observed this behavior in Chaco Canyon, New Mexico, where I saw a badger flush a rabbit out into the path of the waiting coyote. After disposing of the rabbit, the two hunters sniffed noses, and ambled off down the road together. This encounter inspired my children's picture book *Coyote and Badger: Desert Hunters of the Southwest*.  
*Bruce Hiscock  
Porter Corners, New York*

**NICK ATKINSON REPLIES:** The main thrust of Redouan Bshary's findings was that examples of inter-specific cooperative hunt-

ing are exceedingly rare in organisms such as fishes, which are often regarded as lowly animals. Humans and birds have the neural processing power to organize a coordinated effort, but no one had suspected that fishes were capable of the same. Perhaps the most surprising aspect of the findings was the degree of collaboration, despite the indivisibility of the prey.

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## Infection Selection

Not all parasites are created equal; biologists have struggled to explain why some are more contagious than others. One well-regarded theory suggests that parasites are most infectious when their hosts move around a great deal and come into frequent contact with one another. But when hosts roam less, highly infectious parasites soon find themselves surrounded by infected individuals, which limits their further advance. Under such conditions, parasites do well to become less infectious, thereby increasing the odds of encountering new victims. Michael Boots, an evolutionary ecologist at the University of Sheffield in the United Kingdom, and Michael Meador have now corroborated the theory in an unusual experiment with breakfast cereal and virus-ridden, cannibalistic caterpillars.

In the laboratory, Boots and Meador infected caterpillars—larvae of the moth *Plodia interpunctella*—with a virus that spreads naturally when an uninfected cat-

terpillar cannibalizes an infected one. They placed infected caterpillars among healthy ones in bins of food, a honey-sweetened cereal. Some caterpillars lived in dry, crunchy cereal and could mingle readily. The others lived in the same cereal, but moistened and sticky, which hindered their movement and reduced contact between them.

After forty weeks (about eight *P. interpunctella* generations) Boots and Meador fed the viruses from each group to a fresh, healthy batch of caterpillars, then measured the rate of infection. Sure enough, viruses in slow-moving, gruel-dwelling caterpillars had evolved to be a third less infectious than the viruses in mobile, crispy-cereal caterpillars.

The results probably hold outside the cereal box, too. As extensive travel and trade bring people and wildlife into ever more frequent contact, parasite strains may become more infectious. (Science) —Corey Binns

## Unbound by Fog

Navigating under clear skies is relatively straightforward, but the ancient Vikings sailed northern seas that are frequently shrouded in fog and clouds. Their sagas mention enigmatic “sunstones,” held aloft on

overcast days to locate the position of the Sun. Such sunstones could have been useful for navigation, but given their obvious romantic appeal, they may have been just literary inventions—none have ever been found. In 1967, however, the late Danish archaeologist Thorkild Ramskou pointed out that cordierite—a crystal common among pebbles on Norwegian coasts—changes color and brightness when rotated in polarized light. Cordierite stones, he suggested, might have enabled Vikings to perceive polarized light in the sky, from which they could reliably deduce the Sun’s position.

It’s possible to detect polarized light in patches of open sky; many insects rely on it

to find their way if the sun is invisible. It has been unknown, however, whether light that has passed through fog or clouds is strongly enough polarized—or makes an appropriate directional pattern across the sky—to serve as a sun compass. Now Ramón Hegedüs and his graduate adviser, Gábor Horváth, a biophysicist at Eötvös University in Budapest, and two colleagues have confirmed that foggy and cloudy skies at northern latitudes exhibit a polarization pattern similar to that of open skies.

That makes the use of sunstones plausible. Still, the polarized light under foggy skies is extremely weak; under cloudy skies it’s stronger, but whether cordierite (or another natural material, such as tourmaline or calcite) are sensitive enough to reveal it needs further study. For now, how Vikings navigated in gloomy weather remains obscure. (Proceedings of the Royal Society A)

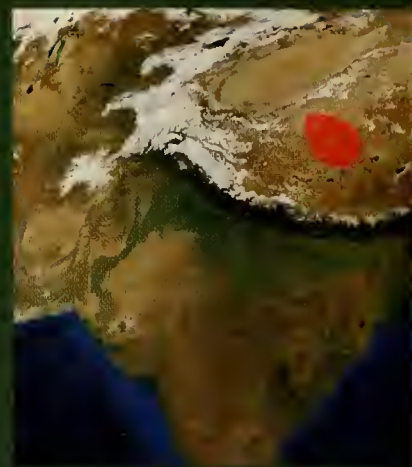
—Stéphan Reeb

## Missing Mass

The Plateau of Tibet is a geological puzzle. Comprising nearly 900,000 square miles and rising 16,000 feet above the surrounding terrain, it is the largest and highest plateau on Earth. It also has the thickest crust—at an average thickness of more than forty miles, the crust is double that of most landmasses. How did the plateau come into being? Geologists have floated numerous hypotheses over the decades, but strong evidence either for or against them has been sparse.

According to one hypothesis, when the Indian and Eurasian plates plowed into each other 55 million years ago, the Eurasian plate’s lithosphere (the outer crust plus an underlying layer) crumpled and pushed the Plateau of Tibet upward into being. Then, about 15 million years ago, a massive block of rock at least 60,000 square miles in area detached from the bottom of the Eurasian plate. As the rock sank, the plateau above it buoyed upward another mile, until it reached its present height.

For decades, investigators



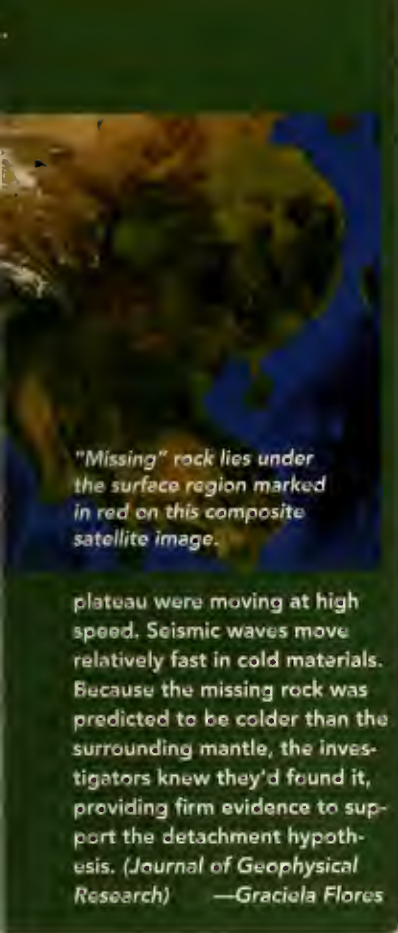
have been looking for signs of the sunken hunk of lithosphere without success. But recently Tai-Lin Tseng and her graduate adviser, Wang-Ping Chen, a geophysicist at the University of Illinois at Urbana-Champaign, demonstrated that the missing rock is just where everybody expected it to be, centered some 350 miles north of the border between Nepal and Tibet and 400 miles beneath the Earth’s surface.

Tseng and Chen made the discovery after collecting seismic signals from some 300 monitoring stations in India, Nepal, Tibet, and beyond, which indicated that seismic waves traveling beneath the



Viking ships, woodcut, 1879





"Missing" rock lies under the surface region marked in red on this composite satellite image.

plateau were moving at high speed. Seismic waves move relatively fast in cold materials. Because the missing rock was predicted to be colder than the surrounding mantle, the investigators knew they'd found it, providing firm evidence to support the detachment hypothesis. (*Journal of Geophysical Research*) —Graciela Flores

## But Who's Gonna Read It?

Today's exploding volume of data resides on stacks of paper, reels of magnetic tape, piles of compact disks, or banks of silicon chips. But those media are fairly fragile and last, at most, a few thousand years. For truly long-term storage, something nearly indestructible is needed. A new study suggests an intriguing possibility: the DNA of bacteria.

Nozomu Yachie and his graduate adviser, Yoshiaki Ohashi, a molecular geneticist at Keio University in Tsuruoka, Japan, together with several colleagues, encoded the message " $E=mc^2$  1905!" in the DNA of *Bacillus subtilis*, a tough bacterium that lives in soil.

After

assigning the letters and symbols to specific sets of DNA nucleotides, they prepared coded nucleotide sequences, which they inserted into the genomes of bacteria. A few days—and numerous bacterial generations—later, they extracted the DNA and decoded the sequences to read the message.

Certain bacteria, including *B. subtilis*, form resistant spores that can revive after millions of years of dormancy. And living bacterial populations can survive for eons, too. Of course, their DNA can mutate, but the Japanese team developed a simple way to encrypt and store redundant—yet distinct—versions of the data. As the technology for replicating and sequencing DNA becomes cheaper, faster, and more accessible, bacterial

DNA might someday replace the silicon chip.

(*Biotechnology Progress*)

—S.R.

## Family Ties

As any textbook of biology (or sex education) will tell you, inbreeding is a big no-no. But at least one species of fish apparently cannot read. A team of behavioral ecologists led by Timo Thünken at the University of Bonn in Germany has discovered that members of a species of cichlid, *Pelvicachromis taeniatus*, prefer to mate with their brothers and sisters. One possible reason: closely related parents do a better job of raising their young than unrelated parents do.

*P. taeniatus* is a colorful fish, between two and three inches long, that lives in the streams of Cameroon and Nigeria. Mom and dad cooperate to repel predators that attack their eggs and young fry.

When Thünken's team gave captive fish the choice of spawning with a stranger or with a sibling, three times as many chose the sibling. That was the case even though siblings were unfamiliar with each other because they had

been separated shortly after hatching. In the resulting pairs of inbreeders, males spent more time near their eggs and young and quarreled less with their mates than did males in outbreeding pairs.

Inbreeding among animals is rare because offspring are often severely handicapped by harmful, recessive genes. Yet both inbred and outbred fry in Thünken's experiments grew and survived equally well. The species may have few harmful recessive genes, in which case the genetic cost of inbreeding may be easily outweighed by the twin benefits of passing along all the genes shared with one's mate and providing one's offspring with two caring, cooperative parents. (*Current Biology*)

—S.R.

## Water in the Bank

For wallabies in Australia's Northern Territory, putting a nose in the river often leads to a lot more than just a refreshing sip of water. In some areas, saltwater crocodiles (which can also live in brackish waters) are common, lying nearly submerged in the water to ambush the thirsty and unwary. But the agile wallaby has found a way to get a safer drink, according to a study by J. Sean Doody, an ecologist at the University of Canberra, and two colleagues. Not only do they visit the river at times of the day when the "salties" are relatively inactive; the cunning marsupials have also figured out that it's safer to dig a drinking hole in the riverbank than to sip from the river directly.

A shallow pit in the soil a yard or more away from the river



Watch a wallaby dig, mate!

quickly fills with water. By recording wallabies' behavior at the drinking holes with motion-sensitive cameras and studying footprint patterns on the riverbank, Doody found that they much preferred the holes to the river.

He also discovered that the wallabies appear to respond to variable risk: where the crocodiles were numerous, the wallabies sited their holes farther from the water's edge and dug them deeper than where the crocodiles were scarce. Wallabies, it seems, are happy to invest extra energy to avoid becoming a hungry reptile's dinner. (*Ethology*)

—Nick Atkinson





## Thin Skin

Oysters on the half shell are considered a delicacy, but what about mussels on the three-quarter shell? A new study shows that human emissions of carbon dioxide (CO<sub>2</sub>) could reduce bivalves' ability to build their shells by as much as 25 percent.

In addition to warming the Earth, excessive CO<sub>2</sub> is making the oceans more acidic, which decreases the concentration of dissolved carbonate

in seawater. Without carbonate for building their shells, numerous minute organisms—including corals and species of phytoplankton and zooplankton—are showing alarming signs of distress.

Now Frédéric Gazeau, a marine biologist at the Netherlands Institute of Ecology in Yerseke, and several colleagues have shown that the phenomenon propagates up the food chain.

In the laboratory, Gazeau exposed mussels and oysters to water with various levels of CO<sub>2</sub> for periods of two hours, measur-

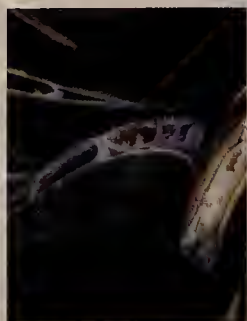
ing the water's average pH and the change in its alkalinity, which is proportional to its concentration of carbonate. From alkalinity levels he calculated the mollusks' rate of shell construction, or calcification. Sure enough, the higher the water's CO<sub>2</sub> concentration and the lower its pH, the slower the mollusks' calcification.

If atmospheric CO<sub>2</sub> reaches the levels expected by 2100, Gazeau predicts the calcification of oyster shells could decline

by 10 percent and that of mussel shells by a quarter. As the declines in calcification affect the development of juvenile shellfish, and as adults become more vulnerable to predation, both aquaculture and marine ecosystems are likely to

change. Gazeau stresses that his findings are preliminary; he measured only short-term responses to high CO<sub>2</sub> and low pH. But his next experiment will test their responses over several months. (*Geophysical Research Letters*)

—Rebecca Kessler



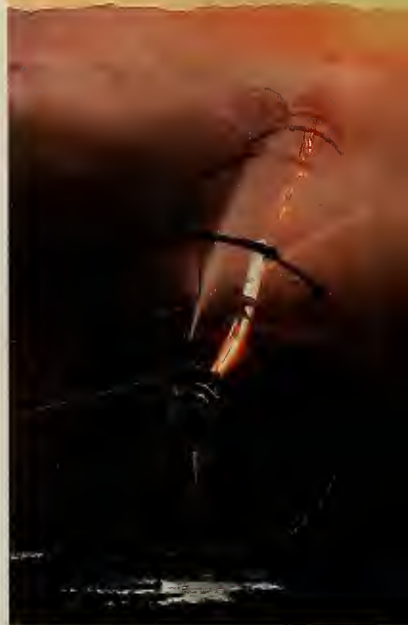
Mussels

## Cool Acres

Irrigation might be cooling local climates, and in the process, hiding the true magnitude of global warming. Many temperature-monitoring climate stations happen to lie near irrigated agricultural land; new research shows that the temperatures measured there might be skewed downward, making the actual warming much higher than estimates show.

Lara M. Kueppers, an ecosystem scientist now at the University of California, Merced, and two colleagues ran a computer model to estimate what temperatures would have been in California between 1980 and 2000 if irrigated areas had not replaced natural vegetation. For comparison, they ran another model that made the estimate on the basis of actual land-use patterns in 1990.

On average, the team found, daytime high temperatures in summer were about thirteen Fahrenheit degrees cooler in the irrigated areas than they would have been if natural vegetation still covered the land. (Irrigation made little difference in night-



time or winter temperatures.) Irrigated farmland occupies 8 percent of California's land, causing the state's overall temperature to drop by slightly less than one degree. The cooling effect of irrigation probably stems from increased evaporation from soils and plant leaves on summer days.

The effects are almost certainly not limited to California. Around the world, more than 650 million acres are irrigated, and more than half the temperature-monitoring stations in at least one important global temperature dataset also lie in such areas. (*Geophysical Research Letters*)

—S.R.

## Hot Time in the City

As the Earth warms, life in big cities is getting tougher. Abundant dark, sun-absorbent surfaces and heat emitted by cars and buildings, among other factors, push temperatures as much as twenty-two Fahrenheit degrees higher than those in the surrounding countryside. One way or another, people manage to avoid the excessive heat. But what about the rest of the urban fauna?

Michael J. Angilletta Jr., a thermal biologist at Indiana State University in Terre Haute, and a team of investigators argue that so-called urban heat islands are excellent natural laboratories for testing the possible effects of climate change on organisms. In many species, populations from warm habitats tolerate heat better and cold



Leaf-cutter ants

worse than populations from cooler climates. Angilletta and his colleagues predicted that the same would hold true for urban and rural populations of the leaf-cutter ant *Atta sexdens*.

To test the prediction, the investigators collected *A. sexdens* in the megacity of São Paulo, Brazil, and in rural areas nearby. Then they exposed the insects to a stressful

temperature of 108 degrees F. and compared the time it took the two groups to lose mobility. Finally, they chilled members of both groups for twenty minutes, then timed the ants' recovery. As predicted, the urban "Paulistanos" survived the heat 20 percent longer than their rural counterparts. But their greater heat tolerance came at no obvious expense of cold tolerance: both groups of ants recovered from "chill coma" in nearly identical times.

Angilletta and his colleagues can't tell whether the different responses of urban and rural ants come from genetic adaptations or are simply the result of physiological acclimatization. In either case, their study hints that ants, at least, might be able to beat the heat of a warming Earth. (*PLoS ONE*)

—G.F.



*special advertising section*

# *Scenic Byways*



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Oyster Bar

John Sylvester



Greenwich Beach

## PRINCE EDWARD ISLAND

Prince Edward Island is known as the birthplace of Canada and home of *Anne of Green Gables*, published almost 100 years ago. In Anne's Land, on the island's central north shore, miles of white sand beaches and fragile sand dunes are protected in Prince Edward Island National Park. Follow the Blue Heron Coastal Drive for views of red cliffs, open fields, and the rolling farmlands made famous in the novel.

The island's beaches are warm enough for summertime swimming, and a good way to explore them is by following the North Cape Coastal Drive along the western coast. Enjoy the serenity of a secluded beach or the bustle of a food festival starring the island's prized mussels, lobsters, and oysters. North Cape is the home of Canada's only national wind test site. Prince Edward Island now draws more than five per cent of its electricity from wind energy at the Atlantic Wind Test Site. View the gigantic windmills and learn all about the generation of wind energy in the newly expanded North Cape Interpretive Centre.

Start the drive in the small historic city of Summerside, with a concentration of nineteenth-century architecture and a summer-long Celtic festival. This small city is the only place in North America where you can earn a degree in bagpiping—at the College of Piping, a center of traditional Scottish music and dance. Prince Edward Island's tip-to-tip Confederation Trail passes nearby. Developed along abandoned rails, the trail crisscrosses wetlands, hardwood groves, and quaint villages and rivers, with opportunities for birdwatching along the way.

Follow Route 11 out of Summerside and head to la Région Évangéline, the heartland of Prince Edward Island's French culture. A short detour up Route 12 leads to the Acadian Museum in Miscouche, an introduction to the island's first French settlers, who arrived in 1720. Then time your arrival in Évangéline to coincide with lunch or dinner. Savor an exquisite Acadian lobster or take in some traditional Acadian fiddling and entertainment. From Woodstock, take Route 143 and turn south to O'Leary, where the Potato Museum celebrates Prince Edward Island's most famous export. The museum houses the largest collection of potato-related artifacts in the world. Continue south to Cedar Dunes Provincial Park, where the shore seems to stretch forever, particularly from the vantage point of the West Point lighthouse. Camp on the beach, follow a nature trail, head to the nearby wharf for fresh seafood. The drive west, finally leading to North Cape, is characterized by steep red cliffs, gentle beaches, and fishing boats in the distance.



Louise Vessey

Confederation Trail

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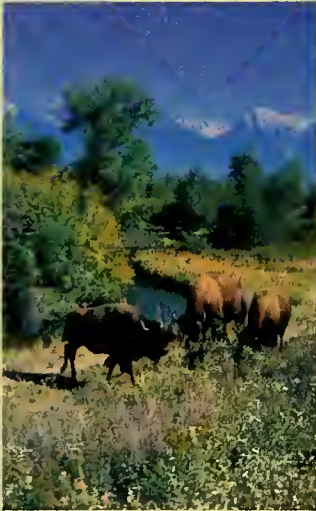
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Photos: Iowa/Montana/Danette Sexton

## MONTANA

In northwest Montana, travel along Highway 83 from Seeley Lake to Swan Lake, where hundreds of lakes dot the narrow, densely forested valleys. Squeezed between the Mission Mountains and the Swan Range, this 91-mile drive offers everything from solitary hiking to golfing to canoeing. Three miles off 83, pick up the trailhead for the easy hike to Holland Lake Falls and Old Squeezer Loop, an excellent area for birding, or follow the willow-lined Clearwater River Canoe Trail for wildlife sightings (including bald eagles) from the water.

In Glacier National Park, take the popular fifty-mile Going-to-the-Sun scenic drive up to the crest of Logan's Pass, where you will cross the Continental Divide. Pullouts along the road provide views of large glacial lakes, cedar forests, and bare alpine tundra. Amid historic lodges and breathtaking scenery, you'll spot bighorn sheep and other grazing wildlife. In Yellowstone National Park, Firehole Lake Drive is a one-way side road about three miles long. It takes you to the cone-shaped White Dome Geyser and the Great Fountain Geyser (worth seeing for its nearly hour-long eruptions, about 100-150 feet high). If you're traveling between the two parks, Highway 89 and the Kings Hill Scenic Byway, takes you through the rugged beauty of the Little Belt Mountains and winds its way past pristine mountain lakes and streams, historic mines, and abundant wildlife-viewing opportunities.

Lewis and Clark spent much of their expedition in Montana, with nearly half their campsites in the state, and the National Historic Trail connects many of the sites they encountered during their 1805-1806 journey. Trail highlights in Missouri River Country, in the state's northeast corner, include the million-acre Charles M. Russell National Wildlife Refuge, the second-largest wildlife refuge in the lower 48, and Fort Peck Lake, with 1,500 miles of shoreline. You'll see the same landscapes experienced by Lewis and Clark, with an abundance of deer, antelope, elk, and enormous flocks of songbirds and raptors. The Northeastern Plains Birding Trail guides you to the best birding in the area, with details on species and habitats. Birdwatchers can head to the lakes, reservoirs, and mountains of Montana to see millions of migrating birds.

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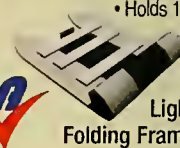
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The southern portion of Gros Morne National Park, accessed along Route 431, part of the Viking Trail, is less frequented than the rest of the park. Those missing it are bypassing the geological wonder called The Tablelands that literally stands out amid the low, rounded mountains. That's because it's flat and orange. It looks like an escapee from the Badlands, but in fact was thrust from the earth's mantle eons ago by tectonic forces. Its surface is almost devoid of plants that find its weird chemistry too toxic to colonize. But it's great for a hike.

The Road to the Isles, or Route 340, is part of the Kittiwake Coast that takes you to the shore of Iceberg Alley on the northeast coast of the Island of Newfoundland. At Long Point Lighthouse in Twillingate, which overlooks the cool North Atlantic, 10,000-year-old bergs can be seen floating by. Boat tours to see icebergs are likely to encounter whales, as well. On the way from Twillingate, stop by the Prime Berth Fishing Museum for a taste of the life of a fisherman.

Route 100, off the main highway on the Avalon Peninsula, is called the Cape Shore because it takes you to Cape St. Mary's where you can visit the most accessible seabird colony in North America. Thousands of broad-winged, golden-headed North Gannets nest here atop a sea stack separated from the cliff top by mere yards. In daylight there's constant flight and swirling sound as the adults dive into the fish-rich waters below to snap up the next meal for the bawling nestlings—soon to be fledglings—in the thousands of nests that cover the stack.

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# A Terrible Scrooge

*Nature is so cost-conscious that Darwinian principles apply even when cells are selecting the building blocks of proteins.*

By Olivia Judson

**H**oneybees. Sea urchins. Black cottonwood trees. Those are just three of the species that had their genomes published last year. It's amazing to think that a dozen years ago, the sequencing of any whole genome was a sensational event. Back then, just a few viruses and one puny bacterium had had theirs done. Now DNA sequencing is almost as automated as sausage-making, and geneticists have whole-genome sequences for a menagerie that includes dogs, rice, humans, chimpanzees, roundworms, mosquitoes, chickens, silkworms, red algae, at least four species of fruit fly, scores of fungi, hundreds of bacteria, and hordes of viruses. More exciting still, whole-genome sequences for species that don't even walk the planet any more, such as the Neanderthal, the dodo, and the woolly mammoth, will soon be available.

Each genome is a treasure trove of surprise and revelation. Sea urchins turn out to have genes for a large and complicated immune system, which may explain why some of them manage to live well beyond their hundredth birthdays. A glance at the genome of trypanosomes—the single-celled parasites that cause sleeping sickness and Chagas' disease—shows why they are so good at evading the human immune system. About a quarter of their 12,000 genes is a disguise kit, the molecular equivalent of wigs, hats, sunglasses, and false mustaches. Just when the immune system knows

what it's looking for, the trypanosomes change their appearance.

But it's not just the individual genomes that are fascinating. It's the comparisons. Without comparisons, you don't know which attributes of a sea urchin are unique, which are shared by close relatives such as starfish, and which are common to all organisms, from bacteria to people.

More important, you can't detect evolutionary patterns and trends. It was only by comparing teeth from many different animals, from horses to the fruit-eating fish of South America, that anatomists learned that diet reliably affects the evolution of tooth shape. Only by comparing the genomes of parasitic bacteria with those of their free-living

relations did biologists discover that becoming a parasite has predictable effects on genome evolution. The genomes of the parasites are smaller and more streamlined than those of their free-living relatives. Which makes sense: if you live inside another organism, you don't have to bother much about finding food.

Indeed, it was by comparing everything, from the miniature males of certain species of barnacle to the beaks of the finches living in the Galá-





pagos Islands, that Charles Darwin discovered natural selection in the first place. In each generation, some organisms have more offspring than others. Some offspring die before they make it to adulthood; others make it to adulthood but aren't very good at reproducing. Darwin reasoned that if those differences were due to certain heritable traits, those traits would be subject to natural selection. Natural selection is not the only force in evolution, but it is the most important one: it is the sculptor of beaks, and songs, and immune systems.

Just as comparative anatomy formed the basis of evolutionary thought in the nineteenth century, comparative genomics appears set to form the basis of evolutionary biology in the twenty-first. Darwin didn't know about genes, but ultimately, it is on genomes that natural selection leaves its fingerprints.

And a close look at those fingerprints shows natural selection acting in a new way. That matters, because until recently it's been an open question whether natural selection is as pervasive and powerful at shaping molecules as it is at shaping bodies.

At its most elemental level, natural selection acts on genes. And a gene is nothing more than an instruction to make a protein. Proteins are essential building blocks of the body (along with fats and sugars); they are large molecules that come in a wide range of shapes and sizes and have a variety of jobs. Some, such as hemoglobin, carry oxygen around in the blood. Others, such

as alcohol dehydrogenase, help digest alcohol. Still others form the scaffolding that helps cells stay in the right shape. If you're a finch, the protein calmodulin affects the shape of your beak. Cells make thousands of proteins—if you dry out a cell, the proteins will make up more than half the remaining mass.

But whether big or small, working in blood or beaks, each protein is just a chain of dozens or even hundreds of smaller molecules called amino acids. And each gene in DNA is an ordered list of the amino acids needed for making a particular protein.

It's no longer news that natural se-





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lection acts on protein function, that is, on how well proteins work. Mutations—changes in the DNA sequence of a gene—that improve how a protein does its job tend to spread: the owners of the mutations tend to produce more descendants. The bar-headed goose is a good example. This small, elegant goose from Central Asia has a white face and two dark bars, or stripes, on its head. But what makes the bird remarkable is that it has evolved a form of hemoglobin so sensitive to oxygen that it can breathe the thin air above the Himalayas.

Conversely, a mutation that disables a protein needed for survival may appear from time to time, but it cannot spread. If you've got a faulty collagen—the stuff of which cartilage and bones are made—you're likely to die as a baby, or even before you're born.

How well a protein does its job—its ability to carry oxygen or digest alcohol or act as scaffolding—depends to a great extent on its having a particular shape. Hemoglobin carries oxygen because the hemoglobin molecule has a little “pocket” that attracts and loosely holds oxygen molecules—a bit like one of those magnetic cups for paper clips. The shape of a protein depends on the way the string of amino acids folds up, which in turn depends on the properties of the amino acids in question. There are just twenty standard amino acids, and each is useful in particular ways, like the various shapes of Lego bricks. The amino acid glycine, for instance, is small and simple; it can serve as a hinge. Tryptophan is huge and bulky. Cysteine lends stability to a protein. And so on.

But often, only a few of the amino acids in a protein are essential to its function. At position 122, say, you must have glycine and no other—whereas the rest are interchangeable, at least to some extent. (Occasionally any of the twenty will work; more typically it'll be a choice between the two, or five, or ten that for the purposes of the protein have broadly similar properties.)

The question, then, is what determines which amino acids the cell



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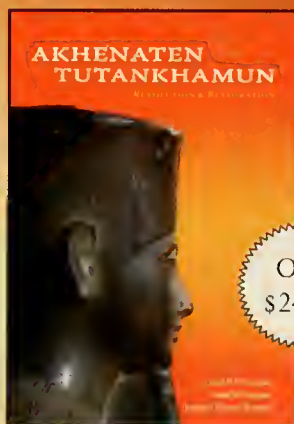
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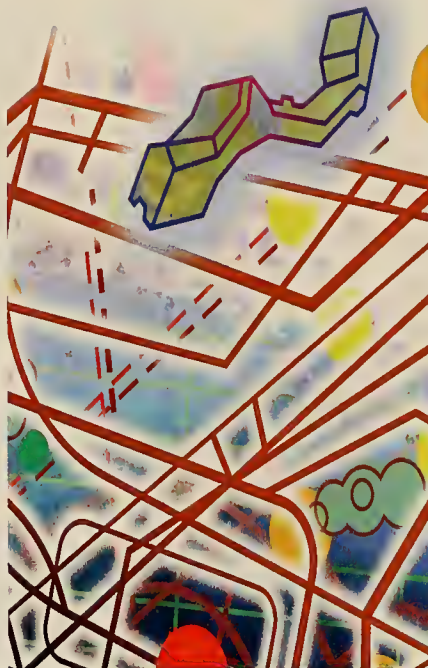


evolves to use in the less critical parts of a protein? Until recently, the choice was put down to mutation—and assumed to be more or less random. Now investigators—among them Hiroshi Akashi of Pennsylvania State University in University Park, Jonathan Swire of Imperial College London, and Takashi Gojobori of the National Institute of Genetics in Mishima, Japan—have discovered it is not random, but to a large extent predictable. And it comes down to how much proteins cost to manufacture.

To see how cost comes into the picture, think of your cells as factories, churning out proteins much as an assembly line churns out cups for paper clips. The components—in this case, the amino acids—of the final product have to be built, or acquired. That takes energy. Furthermore, not all amino acids cost the same energy to make. Bulky, complicated tryptophan is particularly expensive; small and simple glycine is notably cheap.

If cells are sensitive to cost, you would expect them to evolve to use cheap amino acids wherever possible—particularly in the proteins they mass produce, compared with the ones they make only occasionally. The reason is straightforward: if you make protein *A* thousands of times more often than you make protein *B*, a mutation that enables you to make a cheaper version of protein *A* will have a far more pronounced effect than a similar mutation in protein *B*. The organism with the cheaper (but equally effective) version of *A* will get more substantial savings on its energy bills. If reducing cost is important—if the more miserly, cost-efficient creatures are more likely to survive and reproduce—then such a mutation is more likely to spread.

Sure enough, cost matters. You can look within the genomes of organisms that have one cell—such as brewer's yeast, or that common resident of the human gut, the bacterium *Escherichia coli*. Or you can look within the genomes of animals such as fruit flies, roundworms, and people, which have lots of different



cells. But either way, you find that selection to reduce cost has been pervasive. Given a choice among several amino acids, genomes reliably evolve to use the cheapest ones. In brewer's yeast, for instance, proteins that play a role in metabolism are made in large numbers, and are cheap, whereas transcription factors (proteins that control whether or not a particular gene gets turned on or not) are made in small quantities, and are generally expensive.

That "cost accounting" explains subtle but systematic differences in the ways various organisms build their proteins. For example, the energy it takes to make a given amino acid is different for creatures, like us, that live on the Earth's surface, than it is for denizens of the sulfurous vents in the deepest seas. There, the water is infernally hot, the pressure is immense, and life and its protein-building machinery are bathed in a volcanic brew. That changes the dynamics of chemical reactions. Some amino acids that are cheap for us surface-dwellers become expensive, and vice versa.

Those discoveries are exciting, for three reasons. First, selection to reduce cost operates differently from selection on how well a protein works. Without knowing a great deal about a particular protein, it's hard to predict whether a given mutation will affect

how well it does its job. But cost selection is something that applies to every position in a protein, and in a clear way. Each amino acid has a known price tag, so you can just go down the list of amino acids that a gene specifies, and work out which mutations would lead to cost savings, and by how much. It's a weaker force: a mutation that reduces cost can spread only if it doesn't mess up how well a protein does its job. After all, it's no good making proteins cheaply if they don't work. Cost selection is therefore most pronounced in the parts of the protein that are least critical to its function.

Second, cost selection opens up a new way to understand how evolution proceeds, molecule by molecule. It shows that natural selection is as powerful and pervasive in the sculpting of proteins as it is in the sculpting of beaks. But it also shows that comparing beaks and comparing genomes are not simply questions of scale. Processes that are invisible to the beakologist nonetheless exert profound effects on the very molecules from which the beak is made.

Finally, it's not every day that a new facet of natural selection is discovered. Since the publication of Darwin's *Origin of Species*, only three or four have come to light. There's sexual selection, which explains the evolution of extravagant traits, such as peacocks' tails, that increase mating success at the expense of surviving. There's kin selection, which explains such odd phenomena as the fact that worker bees cooperate in rearing offspring that are not their own. (They do so because they share many of the same genes.) There's selection on protein function. And now, there's selection on protein cost.

When it comes to making proteins, Mother Nature, it seems, is a terrible Scrooge.

OLIVIA JUDSON, a research fellow in the Division of Biology at Imperial College London, is the author of *Dr. Tatiana's Sex Advice to All Creation: The Definitive Guide to the Evolutionary Biology of Sex* (Owl Books, 2003).



# AS HEARD ON PAUL HARVEY NEWS THE BEST AIR PURIFIER EVER Works 4 Ways to Attack Pollution from Air, Surfaces and Fabrics

**Works to eliminate odors, dust, smoke, pollen, germs, mold, bacteria, viruses, pet dander, dust mites and much more**

**Will eliminate the most noticeable indoor air pollutants in just 15 minutes  
Provides relief from allergies and sinus**

By John Whitehead, Media Services

BioTech Research has announced EdenPURE™, the ultimate air purifier.

The EdenPURE™ is the best and most advanced air purifier on the market.

It runs super quiet and requires no filter replacement.

Unlike typical air purifiers which have only 1 or 2 mechanisms of eliminating pollution, the EdenPURE™ has 4 mechanisms which eliminate pollution.

There are many different types of pollution and many of them, especially the worst, cannot be eliminated with the limited mechanisms of old-style air purifiers. The EdenPURE™ 4-mechanism system destroys all of the types of pollution.

The remarkable EdenPURE™ not only eliminates pollution from the air, but also eliminates pollution embedded in walls, ceilings, floors, carpets, furniture, clothing, and on countertops and other surfaces. It sanitizes everything in the house. The majority of air pollution comes from contaminated surfaces and fabrics.

The EdenPURE™ relieves allergies, asthma, respiratory problems, provides better sleep, more energy, and better health.

The air purification technology in the EdenPURE™ is that used by the federal government to purify air in the Space Shuttle and the International Space Station.

Old style HEPA filters mainly only remove dust and some allergens. They do not remove the most harmful pollutants such as bacteria, viruses, mold and yeast.

And if you have one of those air purifiers that has no fan, beware. More will be explained on this as you read on.

The EdenPURE™ has a super advanced fan that runs so quiet that you would have to put your ear up next to it to know that it's even running. And the EdenPURE™ is virtually maintenance free.

For more on the new EdenPURE™, here is my remarkable interview with John Whitaker, Chief of Research and Development for BioTech Research.

Q. BioTech Research has been in the air purification business for a long time and your previous air purifier model is an all-time best seller and was super effective. Why is the new EdenPURE™ air purifier so much better?

A. Yes, our previous model was an all-time best seller and in our opinion was the best air purifier on the market, which was also the opinion of

our customers.

But the EdenPURE™ is much more advanced. Our previous model used 2 very effective mechanisms to eliminate pollution, which were combinations of activated oxygen and ultraviolet light.

The EdenPURE™ utilizes 4 much more advanced electronic air purification mechanisms.

The advanced technology in the EdenPURE™ is that used in spacecrafts such as the Space Shuttle and the International Space Station.

Q. What about those air purifiers that have no fan?

A. It has been well documented in scientific tests that an air purifier without a fan cannot possibly remove pollution to any substantial level. Those types mainly remove pollution that is very close to the unit. That's fine if you're purifying the air in a broom closet, but not for a wide area. Also those units have you wiping off a plate to clean off the trapped pollution. But unless those units have ultraviolet light, that plate contains live bacteria and viruses that can be harmful.

Q. How does the EdenPURE™ eliminate pollution without requiring the air to go through the unit, and how does it eliminate pollution on surfaces and fabrics?

A. The EdenPURE™ has 4 electronic mechanisms of eliminating pollution that mimic the way it is done by nature's thunderstorm. Thunderstorms produce highly activated oxygen which destroys pollution and puts negative ions in the air that also destroy pollution and also promote better health. This super activated oxygen produced by thunderstorms is the most devastating to pollution and it is also the source of that aroma that you smell after a thunderstorm that people associate with super fresh air.

Three of the 4 electronic mechanisms in the EdenPURE™ go out and seek out pollution throughout the room, on surfaces, and in fabrics like guided missiles. The pollution cannot hide. These guided missiles also kill bacteria, viruses, yeast and mold.

The EdenPURE™ eliminates all pollution. Amongst the hundreds of pollutants EdenPURE™ eliminates besides bacteria, viruses, mold, yeast and allergens are: fungus, formaldehyde, fecal odors, perfumes, cologne, creosote from fireplaces, methylene chloride, phenols, PCB's, humic acid, DIMP's, glycerols, ketones,

## EdenPURE™ - Never breathe bad air again



The EdenPURE™ Whole House Model



The EdenPURE™ Area Model

methyl ethyl ketones, acetone from fingernail filings, styrene, nitro compounds, formic acid, benzonic, butanes, ethanes, pentanes, propanes, methanes, alcohols, cyanides, detergents, phosphates and many more too numerous to mention.

Q. Does the EdenPURE™ require filter replacement like the old-style HEPA air purifiers?

A. No. There is a small 4 inch by 8 inch pre-filter that you simply clean periodically by running water over it. This pre-filter is made of highly durable mesh that will last a lifetime.

Q. So then the EdenPURE™ sanitizes everything in the house?

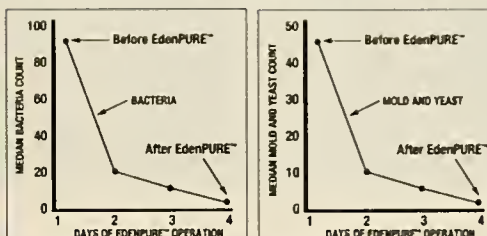
A. Yes. It sanitizes the air, walls, floors, ceiling, furniture, carpeting, countertop surfaces, sinks, bathtubs, toilets, and even sanitizes your clothes.

Q. How well does the EdenPURE™ work on eliminating odors?

A. The EdenPURE™ will eliminate all odors. It eliminates odors from cigarette smoke, urine, mildew, cooking odors, and any other odors in your home. The EdenPURE™ odor elimination is so powerful that it will eliminate the odor of a skunk in minutes.

After eliminating the odor from the air, the EdenPURE™ then goes to the source of the

## Independent Test Results



EdenPURE™ eliminates most pollution in 15 minutes. Bacteria, mold and yeast are among the most difficult pollutants to eliminate. Old style air purifiers never eliminated them. The EdenPURE™ eliminated virtually all the bacteria, mold and yeast in only 24 hours. This independent laboratory test was conducted by Dr. Dee M. Graham, one of the leading air pollution experts in the world.

## Testimonies of a few of the many EdenPURE™ satisfied customers

The EdenPURE™ is the most remarkable product that I have tried in years. All of the claims hold true. Not only did it eliminate the dust in my house, I have not had a sinus headache or scratchy throat since I began using it. The whole house smells fresh and clean. You would never be able to tell that I have two dogs and a cat. It is also nice not to have to bother changing filters. You just plug it in, turn it on and forget about it. It is truly refreshing to use a product that does everything that it is supposed to do and more.

Michelle Goldsmith

Before using the EdenPURE™ I had to take antihistamines and use allergy/sinus nasal spray. I was embarrassed because my eyes were red and I always sounded like I had a cold. I then got the EdenPURE™. I plugged in the EdenPURE™ and went about my daily duties when I suddenly noticed I wasn't coughing or wheezing or clearing my throat. This was incredible. The EdenPURE™ really works! I am so happy. My eyes are clear and I can breathe. I've tried many other air purifiers, they're all in my storage room with other failed products. The EdenPURE™ truly does what it claims to do. Diane C. Vance

The EdenPURE™ is the most remarkable product that I have tried in years. All of the claims hold true. Not only did it eliminate the dust in my house, I have not had a sinus headache or scratchy throat since I began using it. The whole house smells fresh and clean. You would never be able to tell that I have two dogs and a cat. It is also nice not to have to bother changing filters. You just plug it in, turn it on and forget about it. It is truly refreshing to use a product that does everything that it is supposed to do and more.

Michelle Goldsmith

House Model purifies air in an area up to 3,000 sq. ft. The EdenPURE™ Area Model purifies air in an area up to 1,000 sq. ft.

End of interview. For readers who want to

obtain the EdenPURE™ at this 10 day sale price please see the Special Readers Discount Coupon on this page. Those readers ordering after 10 days from the date of this publication must pay regular price.

## SPECIAL READER'S DISCOUNT COUPON

The price of the EdenPURE™ Whole House Model, which purifies air up to 3,000 sq. ft. is \$372 plus \$22 shipping for a total of \$394 delivered. The price of the EdenPURE™ Area Model, which purifies air up to 1,000 sq. ft., is \$302 plus \$12 shipping for a total of \$314 delivered. People reading this publication get a \$75 discount, free shipping and handling and pay only \$297 for the Whole House Model delivered and only \$227 for the Area Model delivered if you order within 10 days. They come in the decorator color of grey which goes with any decor. There is a strict limit of 3 units at the discount price - no exceptions please.

• To order by phone, call TOLL FREE 1-800-299-7557 Ext. EPA1607. Place your order by using your credit card. Operators are on duty 24 hours, 7 days.

• To order online, log on to [www.biotechresearch.com](http://www.biotechresearch.com)

• To order by mail, by check or credit card, fill out and mail in this coupon.

This product carries a 60-day satisfaction guarantee. If you are not totally satisfied, your purchase price will be refunded. No questions asked. There is also a one year warranty.

NAME \_\_\_\_\_

ADDRESS \_\_\_\_\_

CITY \_\_\_\_\_

STATE \_\_\_\_\_

ZIP CODE \_\_\_\_\_

Number of Whole House units you want: \_\_\_\_\_ Number of Area Model units you want: \_\_\_\_\_

Check below to get discount:

☐ I am ordering within 10 days of the date of this publication, therefore I get a \$75 discount, free shipping and handling and my price is only \$297 for the Whole House Model delivered and \$227 for the Area Model delivered.

☐ I am ordering past 10 days of the date of this publication, therefore I pay full price of \$394 for the Whole House Model and \$314 for the Area Model.

Enclosed is \$\_\_\_\_\_ in: ☐ Cash ☐ Check ☐ Money Order

(Make check payable to BioTech Research)

or charge my: ☐ VISA ☐ MasterCard ☐ Am. Exp./Optima ☐ Discover/Novus

Account No. \_\_\_\_\_ Exp. Date \_\_\_\_\_ / \_\_\_\_\_ Signature \_\_\_\_\_

MAIL TO: BioTech Research Dept. EPA1607, 7800 Whipple Ave. N.W., Canton, OH 44707





# A Spring in Its Step

*At top speed, an elephant does not run—  
by traditional standards—but it doesn't walk either.*

By Adam Summers ~ Illustrations by Tom Moore

Do elephants run, or just walk briskly? According to many biomechanists—and the judges of Olympic racewalkers—an animal is running, not walking, when at some point in each stride all of its feet—two or four of them—are off the ground at once. Of course, for anyone who has faced charging elephants, the semantics of such things don't much matter: running or walking, a herd of elephants can cause heart palpitations. But the question is still worth asking, because when it comes to the way elephants move, the traditional distinction between running and walking isn't very informative. Besides going airborne, what else might mark the transition from amble to jog?

For openers, think about what happens when you take a leisurely walk. With each step, you plant a relatively straight leg on the ground.

Then your forward motion swings your hip and your center of gravity up and over the highest point of an arc centered on your foot. So a walking leg is like an upside-down pendulum, and your hip rises to its highest point in mid-stance.

Running is almost the reverse. When all your weight is on one foot, in mid-stance, your hip dips to its lowest point in the running cycle. That difference in hip position reflects a fundamental difference in the way energy is transferred and stored. Instead of transferring forward momentum into driving an inverted pendulum, your leg, in running, acts like a coiled spring. First it compresses, storing the energy of your body's falling mass as your foot lands on the ground.

Then your leg rebounds, releasing the stored energy and propelling your body upward and onward.

You might think that by now biologists would know full well how pachyderms prance. In fact, though, there are surprisingly few believable measures of their top speed, much less clear conceptions of the gait by which they max out. In fairness, studying the motion of fast-moving elephants poses difficulties and dangers. Zoo elephants make poor study subjects, simply because they have already been selected for being unlikely to zoom around their enclosures at high speed. And there aren't many places







*Elephant legs, like primate legs, act like upside-down pendulums when their owners heave them forward in a slow walk (left). The hip (or shoulder) rises to its highest point when the foot below it is planted on the ground. As the foot pushes off, the hip or shoulder falls until the next foot is planted.*

where elephants can be safely raced for a substantial distance in a straight line. John R. Hutchinson, a biomechanist at the Royal Veterinary College in London, and his collaborators faced those challenges with a video camera, experienced mahouts, and an international array of elephants—ranging from yearlings to sixty-year-old mommas—to determine whether elephants do more than walk.

Hutchinson and his colleagues painted white dots on the hips and shoulders of both Asian (*Elephas maximus*) and African (*Loxodonta africana*) elephants, and then videotaped

them under controlled conditions in Asia, Europe, and North America. The results debunked reports that some elephants could move at an astonishing twenty-five miles an hour. The top measured speed was about fifteen miles an hour—still quite brisk, but no faster than a reasonably fit person could run in terror.

What about running? Hutchinson clearly demonstrated that at no time does the entire elephant leave the ground. The animal does get three feet off the ground at once, but an Olympic judge for racewalking would still be happy with that gait. Hutchinson points out, however, that by other definitions, Jumbo is running.

Video analysis of the white dots of paint shows that in slow gaits the elephant's hip rises after the foot is planted, just as it does in a walking person. In the fast gait, however, the hip continues falling after footfall, and rebounds before the toe comes off the ground. That is consistent with the idea that the limbs are shifting from a pendulum-dominated walking gait to a springy run [see illustrations on these two pages]. Taken as units, the fast-moving forelimbs and hind limbs each have an aerial phase, so you could say that both ends of the elephant run, but not at the same time. (Work not yet published by Hutchinson indicates

that the shoulders don't undergo the same springlike compression as the hips, though.)

You might think that the elephant's peculiar way of "running" arose solely because of its huge size. But consider the white rhinoceros, the second-largest land animal, which can weigh more than 5,000 pounds. That's half as much as an adult African elephant. Yet the rhinoceros runs exactly like a horse—a really big, nearly blind, very grumpy horse. All four of its feet leave the ground, springing the behemoth forward from step to step.

Compare that with the gait of a baby elephant. A month-old baby, with a sprightly weight of 250 pounds, is fully able to charge along as fast as its full-grown parents—often a little faster. But it never goes airborne. The anatomy of elephant legs may simply not be suited to aerialism, or perhaps the running style is hardwired into the nervous system. But whatever the case, a growing elephant does not follow a progression of running styles from zebra-style to Cape buffalo to rhinoceros: it runs to type its whole life.

ADAM SUMMERS (asummers@uci.edu) is an associate professor of bioengineering and of ecology and evolutionary biology at the University of California, Irvine.



*Faster-moving elephants change their hip movements. Instead of swinging like a pendulum, each leg acts more like a spring. In that gait, the hip dips to its lowest point when the foot is planted, then springs upward when the foot pushes off the ground. Although all four feet never leave the ground at the same time, both front and back "ends" of the elephant do.*



# Tracking the Elusive Jaguar

*When you're following one of the biggest cats in the Western Hemisphere, be aware that one might also be following you.*

By Eduardo Carrillo

On a fresh May morning sixteen years ago, I was walking with ten of my students along a beach in Costa Rica's Corcovado National Park, when we came across the tracks of a sea turtle, leading out of the water and into the thick jungle beyond. A female turtle, we assumed, had come ashore to lay her eggs the night before. But no tracks led back to the water; instead, a set of jaguar paw prints crisscrossed the turtle's flippered swipes in the sand. Sure enough, we found the turtle in the woods, partly eaten. It was a seventy-five-pound olive ridley, which the jaguar had dragged about 300 feet into the forest. After taking a few pictures to document our find, we returned to the beach. Minutes later we spotted two animals about a mile away, loping in our direction. We promptly hid behind a fallen tree. All eleven of us watched in awe as a female jaguar and her cub approached, then passed within twenty feet of us.

That lucky sighting was my first encounter with a jaguar in the wild. I wasn't looking to spot one, let alone study the big cats. In fact, few people were studying them in the early 1990s, because they are so hard to find and follow. Jaguar field biologists often go several months without catching a glimpse of

one. Yet no radio collars, no traps, no rigged cameras had been necessary for my first sighting, which profoundly marked me, both as a professional biologist and as a human being. I wanted to know more about their ecology, to study the factors that have made them endangered, and to track them in their natural setting.

It would be three years before I saw my next wild jaguar. By then, my colleague Joel C. Saenz, now at the National University of Costa Rica in Heredia, and I had resorted to pooling our own scant savings to study the jaguar and its primary prey, the white-lipped peccary (*Tayassu pecari*) in Corcovado, which has one of the highest concentrations of jaguars in Central America.





Jaguars populate a snaking strip of land from southern Arizona and New Mexico southward to northern Argentina. Hunting pressures on both jaguars and their primary prey, plus deforestation, have caused the species, *Panthera onca*, to disappear from several areas within that stretch, including the whole of El Salvador and historically extensive ranges north of the Mexican border. In fact, sightings that mark the northern limit of the jaguar's range are recent; after decades of absence from the United States, the occasional jaguar was sighted in Arizona and New Mexico, beginning in 1996. In spite of its comeback, the jaguar is still considered in great danger of extinction. Needless to say, tracking the stealthy, solitary animals remains exceedingly difficult.

Our initial objective was to gather information about the peccaries' and jaguars' movement patterns. Was Corcovado large enough to maintain long-term populations of the two species? In spite of our limited resources, we determined that jaguars feed mainly on peccaries and marine turtles. The finding was surprising, because it is clear that a jaguar could eat any animal that crosses its path, including a human being. (There are no records, however, that jaguars have ever attacked people in the wild.) On reflection, though, opting for peccaries and sea turtles makes sense for the jaguars: adults of both

kinds of prey are easy targets and weigh between eighty and ninety pounds, so they provide a good deal of energy in one fell swoop [see photographs at bottom left of next page].

We also realized that jaguars are active hunters by day as much as by night. Although they are skillful tree climbers and excellent swimmers, they travel mainly on the ground, walking along man-made trails. According to our findings, male jaguars require at least ten square miles of territory to support their energy needs; females require about four square miles. The ranges of individuals, however, can overlap.

Those early observations of ours secured funding from the Wildlife Conservation Society (WCS), the National Geographic Society, and Idea Wild. Soon we were tracking more jaguars and more of their prey. On one memorable occasion Saenz and I had followed a group of peccaries across the jungle and shot a big one with a dart, hoping to collar it. But because the tranquilizer needs about ten minutes to take effect, we had to pursue the peccaries. Off we ran, jumping through the forest, across a dry, sandy streambed, through more forest, and across







Jaguar pelts, along with those of ocelots, are stacked high in a Brazilian poacher's store. In spite of international efforts to ban the sale of jaguar skins, the black market in them continues, and some of the cat's populations are still in decline.

another streambed—where we saw our footprints in the sand. We were going in circles! But on top of our footprints were a set of paw prints from a big jaguar that had also been following the peccaries—or perhaps following us. Somehow it seemed as if the jaguars of Corcovado remained one step ahead of us. Or is that behind?

Individual jaguars' coats vary in color on their backs from stunning golden-yellow to sandy brown, dotted with black, rounded rosettes. The jaguar's belly is white with solid black spots. The top coats of the jaguars enabled us to differentiate

them, and like many field investigators, we gave our subjects names. Monster was the largest cat we saw in Corcovado, weighing in at about 220 pounds. Rosa had a spot in the shape of a rose on the left side of her body, and she searched for sea turtles on the beach at every new Moon. Negra was the curious one, eager to investigate and rub against the camera "traps" that we began setting up near the beach in 2003.

The camera traps have become essential to our research in Corcovado and Guanacaste national parks [see map on opposite page]. We place automatic cameras at sites we think are attractive to the jaguars. Each site has infrared sensors that activate the cameras when a passing animal triggers them. What we want, of course, is to capture enough of the animal on film to identify it by its coat pattern, but what we often get is a picture of its tracks or a stray tail. In any event, one of our most effective tricks for attracting jaguars to our camera stations turns out to be . . . men's cologne.

The idea came from a chat I had some years ago with a WCS colleague. Men's perfume had been useful, he told me, in attracting wild cats to scent stations elsewhere. With a little experimentation in Corcovado, we found out that jaguars cannot resist the smell of Calvin Klein cologne, specifically "Obsession." They seek out the fragrance from miles away—perhaps because of the civet scent in it. Regardless, the stuff works, and so all our stations are baited with the perfume. The photographs enable us to identify individuals by their unique pattern of spots, as well as to make general estimates of the kinds and numbers of prey that pass by the area.



Three favorite prey of the jaguar are pictured above. The white-lipped peccary (left) and sea turtle hatchlings (middle, with a jaguar print), as well as adult sea turtles, are the most hunted prey in Corcovado National Park. The squirrel monkey (right) often evades its feline nemesis, thanks in part to the vocal warnings of its fellow monkeys.



If you're lucky enough to see a wild jaguar in person, the observation is far more thrilling, and can be more informative, than a photograph. Once I went out to look for Jill (a female jaguar named in honor of my first field assistant), not long after putting a radio collar on her. I wanted to make sure her radio transmitter was working properly, and to check on her general well-being.

After about an hour of walking through the jungle with my radio antennas, I located Jill resting among the buttresses of a tree. She was only eighty feet or so from where I stood. On impulse, I decided to throw myself on the ground and try to slither toward her on the forest floor. I was making good progress on my stomach when a group of squirrel monkeys started calling from the trees above me. I recognized the particular call they were making—something like that of a barking dog—as their danger signal.

I looked up at them, but they weren't looking at me. I thought, "Hmmm, they usually make that sound when they see either a snake . . . or a feline." With that thought, I turned to my right and froze on the spot: just fifteen feet away was a male jaguar. Again a jaguar had been following my movements without my knowledge. Once this jaguar knew I had noticed him, he simply turned and walked casually into the thick woods. I was left puzzling over his behavior, but not fearful. Especially after that incident, fear was not a factor for me; the animals simply are not aggressive toward people.

In many ways, jaguars benefit from being non-confrontational. A stealthy, solitary animal can save itself the trauma of wounds from hunting prey, competing for potential mates, or fighting territorial battles. A wound in the jungle, after all, can mean a hasty death, since parasites abound.

Only in two-week-long mating encounters, and in the rearing of the young—a process that takes about eighteen months—do jaguars interact with one another. Most mothers bear two cubs, though litters of one cub or as many as four are not uncommon. In some cases a litter can include one spotted and one black cub; people once distinguished the black jaguars as "panthers." (The term is a general one, however, and it has also been applied to leopards and cougars with entirely black coats.)

Evolution has placed jaguars at the top of the food chain, but left them with one possible weakness: poor sprinting skills. Unlike the other big cats in the genus *Panthera*—including leopards, lions, and tigers—jaguars don't run much in pursuit of their prey. Instead, they track, and then pounce. Making incredibly silent approaches, the cats simply lunge from the shadows of the jungle and swiftly



Many national parks of Costa Rica (dark green) offer some protection for the country's threatened jaguars. The author has conducted extensive field studies in Corcovado National Park, in the southwest corner of the country.

bite their prey in the neck. Why run when there's nothing worth running from and nobody knows you're coming?

In spite of their lack of aggression, jaguars are coming in closer contact with people as we encroach on their habitats. In Costa Rica, farmers have recently shot jaguars when the cats strayed from within national parks and raided pig farms or cattle ranches. Yet the jaguars have good reason for fanning out to seek alternative food sources. Three of their favorite prey species, the white-lipped peccary, the collared peccary, and the paca (a large rodent related to the common agouti), are all falling victim to massive hunting for their succulent meat.

Peccary or paca poaching often takes place on the edges of protected areas, or even inside the park boundaries if rangers aren't vigilant, since that's where more animals reside. In Corcovado, for instance, the peccary population has fallen by some 60 percent since 2000 because of hunting pressure. The hunters use high-caliber automatic rifles, such as AK-47s, which can kill as many as fifty animals in a few minutes. During the same six years, jaguar numbers in Corcovado dropped from about 150 animals to a mere thirty or forty.

When jaguars lose their food supply and face starvation, they naturally seek other means of survival. Farms become targets. And once they kill a domestic cow or pig, they learn that farm animals are easy prey. So hungry jaguars, in turn, become the targets of farmers' wrath. Fortunately, funding





Adult jaguars are excellent tree climbers, often using trees as resting spots, scratching posts, or caches for their prey. The author once found a marine turtle stashed ten feet above the ground in Costa Rica's Guanacaste National Park.

in 2005 from the Moore Foundation supported the hiring of fifty-three new park rangers for conservation areas on the Osa Peninsula. Our studies show that the peccary population has recuperated since then. But it will take some years before the jaguar population begins to make a noticeable recovery in Corcovado.

Efforts to stop deforestation in some areas and to support ecological restoration in parks such as Guanacaste are also helping support the jaguar populations. Still, three Costa Rican national parks, Tortuguero, La Amistad, and Braulio Carrillo, are suffering serious losses of their jaguars.

Another threat to the cats' safety comes from the fur trade, which underwent frenzied growth in the 1960s. In Brazil alone, 15,000 jaguars were being

killed every year. The year 1973 marked a change in the trade of jaguar pelts: the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) helped to cut down on the traffic in jaguar pelts. Yet in countries such as Nicaragua, a black market for pelts still exists [see photograph at top of page 32]. There you can buy a full pelt for about \$200, not to mention other products such as belts, shoes, and wallets.

Costa Rica depends ever more heavily on tourism and wildlife conservation for its income. People are beginning to understand the importance of protecting the country's living resources. Nevertheless, a single country cannot make much headway without the support of its neighbors. Alan Rabinowitz, a WCS biologist who has worked avidly to protect jaguars in Belize, has proposed establishing a multinational "Jaguar Corridor," which would run from the southwestern U.S. through to northern Argentina. Ideally, the corridor would include enough protected areas in every country along the way to sustain a healthy, contiguous jaguar population. Barriers, both physical and political, continue to prevent that kind of linkage. One case in point is the proposed "border fence" between the U.S. and Mexico.

Whether or not a Jaguar Corridor is established, new research must focus on mapping and understanding the distribution of jaguars across the countries that make up that corridor. In Costa Rica, my colleagues and I are making progress in determining how the parks' managers can best protect jaguars and their prey. We must continue that work—much about the jaguars has yet to be discovered—but, more urgently, we need to extend our existing collaborations to other research teams. The goal must be to ensure that populations of jaguars do not continue to disappear from any of our countries. Education and bans on hunting the jaguars' prey inside protected areas will help.

Human beings have to remember that we, too, belong to nature. What we do to nature, we do to ourselves. The linkages of cause and effect are circular, just as my chase of the peccaries was. Like the jaguar in the forest, what is lurking in our shaded future may be unrecognized and unknown, but it may also be ready to cover our heavy tracks with new and unexpected ones of an entirely different cast. □

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# Pregnancy Reconceived

*What keeps a mother's immune system from treating her baby as foreign tissue? A new theory resolves the paradox.*

By Gil Mor

Why didn't your mother reject you? I don't mean psychologically, but immunologically. That may still sound like a strange question, but think about what happens when a mother conceives a child. Each baby has a mother and a father, and as a result carries a mix of genetic material from both parents. The father's genetic material is foreign to the mother. Normally when the immune system encounters something within the body that is foreign ("nonself"), it attacks and eliminates the outsider. So why doesn't the mother's immune system reject the developing embryo as a foreign body, just as it would reject a thorn, a virus, or a tissue graft from another person?

More than fifty years ago the Nobel prize-winning English transplant-immunologist Peter B. Medawar posed what has become known as the "immunological paradox of pregnancy." The fetus, Medawar argued, is like a semiforeign transplant, because half of its genes come from the father. Therefore, he concluded, the mother's immune system and the fetus must be locked in conflict. Subsequent studies showed that the immune system is indeed active at the site where the developing embryo attaches to the uterus, or "implants," at the beginning of pregnancy. Thus an aggressive maternal immune system, it seemed, would take to the ramparts against the embryo, which further implied that the embryo in turn would need to take evasive or defensive measures. Medawar's way of posing the problem still dominates current thinking about the immunology of pregnancy, though exactly how the fetal cells evade maternal surveillance is a matter of debate.

In 2004 I was in Japan to deliver a talk on the immunology of pregnancy. In preparing for the talk, I began reviewing data showing that removing natural killer cells, a kind of immune-system cell, from certain strains of pregnant mice causes the mice to miscarry. Those findings were the exact





opposite of what you would expect, particularly from Medawar's point of view: If the immune system is a threat to the embryo, you would think that getting rid of the immune-system cells that kill an invader would help the pregnancy succeed.

That's when I had a classic "aha" moment. I realized that those results were similar to the ones that I and my colleagues had obtained a couple of years before with macrophages, another kind of immune-system cell. We had discovered that removing macrophages also harmed the pregnancy. At that time we could not explain those results, but they had been "sleeping" in the back of my mind ever since.

In the three years since my "aha" moment, I have developed a new perspective on the way the mother's immune system and the fetus interact. Although there clearly is a mechanism that prevents the mother's immune system from treating the fetus as a foreign body, I think conventional wisdom has the role of the mother's immune system completely backwards. Rather than threatening the fetus, her immune system plays a critical role in the success of pregnancy, particularly in its early stages.

To appreciate how the early fetal cells can cooperate with the immune system of the mother, recall what happens after a sperm fertilizes an egg. The fertilized egg rapidly divides to form the blastocyst, a hollow ball of cells with an inner cell mass and outer layer. The inner cell mass gives rise to the embryo, which develops

into a fetus about eight weeks after conception, when the major organs of the future baby become recognizable. The outer layer of the blastocyst becomes the so-called trophoblast. The trophoblast cells invade the lining of the uterus and thereby begin implantation.

Within a few weeks of making its home in the uterus, the trophoblast further transforms into the fetal part of the placenta, the conduit for the passage of nutrients and oxygen from mother to fetus. (Some of the mother's cells form a second part of the mature placenta.)

The immune system eliminates invaders in two ways. The first, known as the innate immune response, neutralizes invading pathogens before they can harm the body. In a wound, for example, white blood cells known as macrophages engulf invading microorganisms and also release signaling proteins called cytokines. The signals activate other parts of the immune system, such as natural killer cells, which gobble up everything foreign in their path. This response requires no prior exposure to the invader.

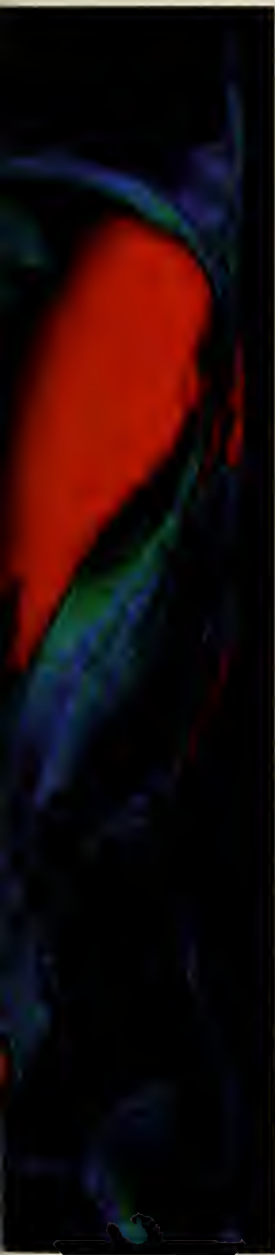
Acquired immunity is an additional, highly specific, and generally more sophisticated response. It relies on antibodies and specialized white blood cells called *B* cells and *T* cells that target particular foreign material to which the body has already been exposed. Those immune-system cells become active and multiply if they encounter molecules or parts of molecules called antigens associated with foreign organisms. The immune-system cells "remember" their encounter with those specific antigens and react to further exposures faster and more vigorously.

In 1991 Gail T. Colbern of the Medical Research Institute in San Francisco and Elliott K. Main, now at the California Pacific Medical Center in San Francisco, redefined the conceptual framework of reproductive immunology. The trophoblast cells, they realized, are the only part of the differentiating blastocyst that interacts directly with the mother's immune system. The embryo itself—and the fetus to which the embryo gives rise—has no direct contact with maternal immune cells. As a result, Colbern and Main argued, the real puzzle is not why the mother's immune system tolerates the fetus, but why it tolerates the trophoblast cells.

Several hypotheses have been put forward to explain the mother's tolerance, including:

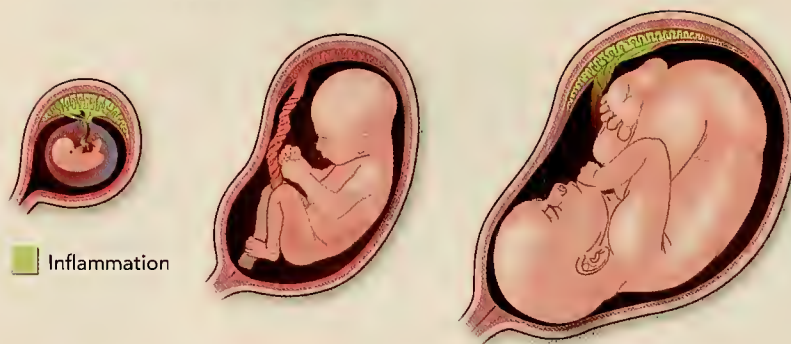
- first, that the trophoblast forms some kind of mechanical barrier;
- second, that the mother's immune system is suppressed during pregnancy;

*Colored MRI image shows a human fetus near term, its head downward against the birth canal of its mother and its umbilical cord running roughly left-to-right just above the center of the image. A fetus carries a mix of genetic material from both parents in its genome. According to the general rules of immunology, the mother's immune system should reject her fetus as foreign ("non-self") the way it would a tissue graft from another person, raising what is known as the "immunological paradox of pregnancy."*





CHRONOLOGY:  
MATERNAL IMMUNITY AND THE DEVELOPING PREGNANCY



	8-12 WEEKS	3-6 MONTHS	7-9 MONTHS
IMMUNE REACTION	Open-wound stage: embryo elicits mother's immune response (inflammation)	No inflammation: mother and fetus reach symbiosis	Another inflammation leads to labor
SYMPTOMS	Nausea, fever; contributes to "morning sickness"	None (mother feels good)	Fatigue, muscle contractions, possible fever
POSSIBLE COMPLICATIONS	Miscarriage (due to infection); No implantation (due to lack of inflammation)	Preterm labor (due to viral infection)	Preeclampsia, prolonged pregnancy, intrauterine fetal death

- third, that the mother's immune system is suppressed, but only locally, in the vicinity of the trophoblast; and
- fourth, that the balance of cytokines, the proteins that regulate the mother's immune response, shifts during pregnancy.

Although some of those hypotheses are more widely accepted than others, each still attracts its fair share of proponents. After my "aha" moment in Japan three years ago, I started thinking more critically about each of them, and noticing their flaws.

According to the first hypothesis, a mechanical barrier prevents cells from moving in either direction between mother and fetus. Thus the barrier creates a state of "immunologic ignorance": antigens inside the barrier are never detected by the immune system without. I don't find that explanation convincing, because studies indicate the placenta is not as impermeable as originally envisioned.

In 1996, for instance, investigators at Harvard and Tufts universities, and at the New England Medical Center in Boston, detected fetal cells in mothers' bodies decades after pregnancy. Furthermore, the fetal cells could infiltrate maternal tissues and differentiate into liver, blood, skin, and other cell types. Originally, it was thought that such fetal cells in the mothers caused many of the autoimmune diseases that afflict women.

But in 2002, Tufts investigators demonstrated that the fetal cells may play a critical role in repairing a mother's damaged tissue. In one case, a woman suffering from hepatitis, a serious liver disease, stopped her treatment against medical advice. Surprisingly, she recovered. Her own body could not regenerate healthy liver cells, so the investigators were baffled. When they tested a specimen of her liver, though, they discovered it incorporated thousands of male cells still left in her circulation from a pregnancy nearly two decades before her illness. Those left-over fetal cells had generated new liver cells, and thereby saved the mother's life. What a nice way for a child to repay its mother's dedication! So much for the impermeable-barrier theory.

For proponents of the second hypothesis, pregnancy involves a state of systemic immune suppression. But I find that hard to believe, too, particularly from an evolutionary point of view. When our ancestors were walking through the forest, they did not always wash their hands or clean their food before serving dinner. And they were continuously exposed to bacteria, parasites, and other microorganisms. If pregnant women were immunologically suppressed, they would have died within hours of exposure to those pathogens, and the human species would have been wiped out. Even today in many parts of the world pregnant women are constantly exposed to harsh, unsanitary conditions. A suppressed immune system would make it impossible for a mother and her fetus to survive.

In particular, if the mother's immune system were suppressed during pregnancy, every pregnant woman infected with HIV would die of AIDS, and that is not the case. In places where the disease is pandemic, such as Africa, women do not die of AIDS during pregnancy; in fact, the opposite is the case—HIV is *less* likely to develop into full-blown AIDS during pregnancy. The immune forces that the trophoblast has called to its aid keep the virus at bay.

According to the third hypothesis, local immune suppression, the mother's immune-system cells that would ordinarily attack the "foreign" cells of the trophoblast are prevented from doing so. One proposed mechanism is that the attacking



cells are simply removed by the mother's *T*-regulatory cells. A second proposed mechanism is that a protein secreted by the trophoblast cells, known as Fas ligand protein (FasL), binds to another protein on the mother's would-be attacker cells called Fas. The binding induces programmed cell death of the would-be attacker cell.

But the results of my studies have been the opposite of what one would expect if either of those mechanisms accounted for the mother's tolerance of the trophoblast. First, recall that in the studies that inspired my "aha" moment, *removing* immune-system cells (macrophages) that would be expected to attack the trophoblast caused pregnant mice to miscarry. Furthermore, subsequent studies, which we and others have confirmed, have shown that mice lacking either Fas or FasL protein can reproduce with no apparent complications of pregnancy.

The fourth hypothesis maintains that the balance of cytokines in the mother's body shifts during pregnancy, thereby changing the details of her immune response.

When a woman is not pregnant, her immune system responds to infection with an arm of the immune system

dominated by cytolytic *T* cells. These cells are mobilized to destroy the cells that have become infected. According to the cytokine-shift hypothesis, however, pregnancy changes the balance, suppressing the inflammatory response and creating, instead, an anti-inflammatory environment.

The cytokine-shift hypothesis, also known as the anti-inflammatory theory of pregnancy, was embraced enthusiastically when it was first proposed in 1993. Numerous studies measured cytokine levels in the mother's blood, in an effort to prove that pregnancy is an anti-inflammatory condition. Investigators also looked for evidence that a shift toward higher concentrations of pro-inflammatory cytokines would lead to miscarriage or to other complications of pregnancy. Some studies did indeed find a shift toward anti-inflammatory cytokines in the mother's blood, but other studies did not.

My own theory grows out of an attempt to understand those contradictory results. In my view, the contradiction is only apparent, and can be traced to an oversimplification. In the studies of inflammation, the entire pregnancy was evaluated as a single event. In reality, though, pregnancy has several chapters, each one marked by the way the mother feels. I believe that, depending on the stage, pregnancy is a pro- or anti-inflammatory condition.

In the first trimester, the mother's body treats implantation as if it were an open wound that requires a strong inflammatory response. After all, to implant itself in the wall of the uterus, the embryo has to break through the uterine lining, damage the underlying tissue, and disrupt the mother's blood vessels to secure an adequate blood supply. All those activities require an inflammatory response from the mother to secure the adequate repair of the uterus and the removal of dying cells. During this period the mother feels terrible because her entire body is struggling to adapt to the presence of the fetus. Yet without her immune reaction, the pregnancy will not "take."

The second trimester of pregnancy is, in many ways, the best time for the mother. The period is one of growth and development. Both mother and fetus reach a symbiotic stage that is anti-inflammatory: now that the "wound" is healed, the inflammation has died down. The woman no longer suffers from nausea and fever as she did in the first trimester.

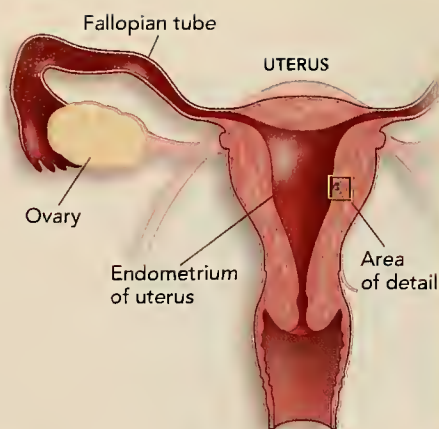
In the third trimester the fetus completes its development. All its organs become functional and ready to deal with the external world. Now the mother needs to deliver the baby. And delivery, too, is achieved through inflammation: an influx of the mother's immune-system cells into the uterus provokes the release of hormones that induce labor, or contractions of the uterus. The contractions expel, or deliver, the baby.

In analyzing the flaws in the four earlier hypotheses, I realized that reproductive immunology has always followed mainstream immunology. Beginning with Peter Medawar, immunologists have viewed the placenta—or its precursor, the trophoblast—as a "piece of skin" marked with the father's proteins. But the assumption shared by all four hypotheses—that the mother must somehow be tolerating a half-foreign graft—has never been convincingly proved. Instead, by proceeding from an unproved assumption, the hypotheses have deepened the confusion about the role of the immune system during pregnancy.

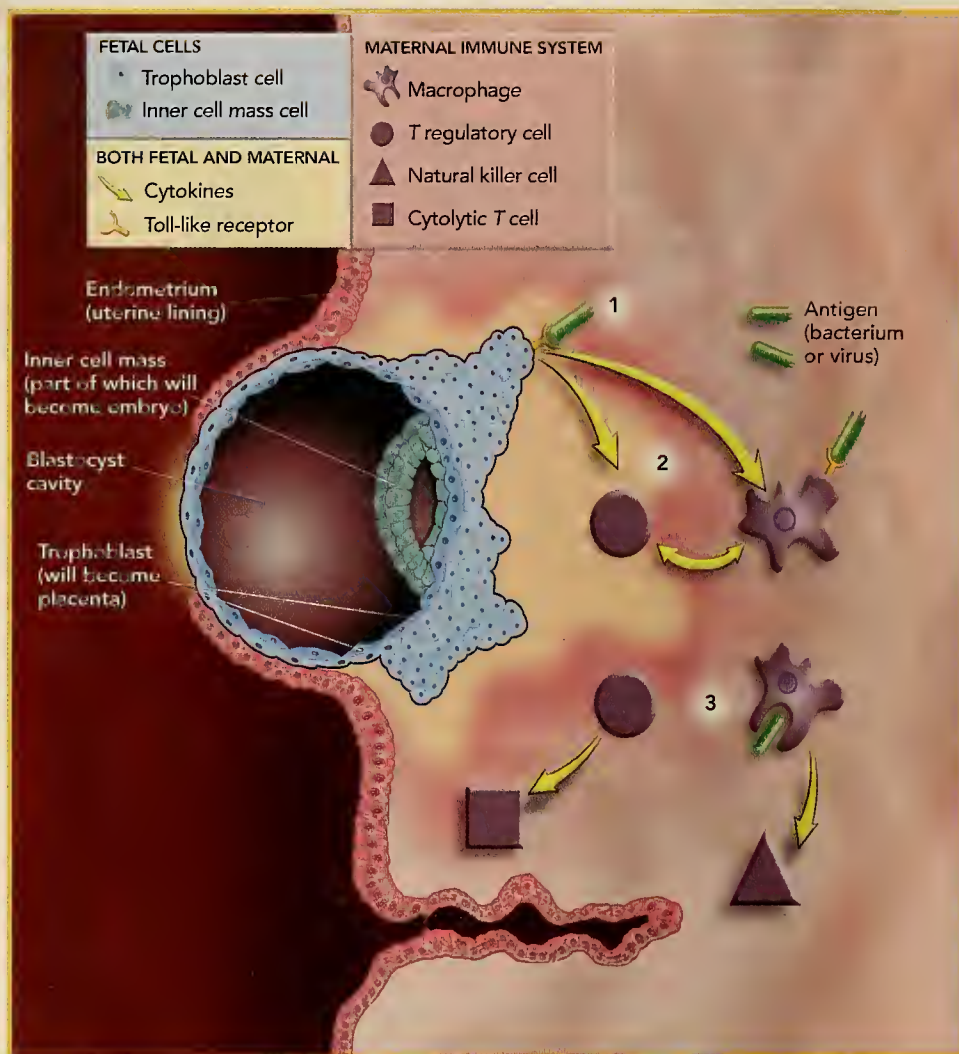
The placenta is more than just a transplanted piece of skin. From an evolutionary perspective, that is hardly surprising. Pregnancy and implantation, after all, have been taking place ever since the development of the mammalian uterus more than 180 million years ago [see "*The Birth of the Uterus*," by Vincent J. Lynch and Günter P. Wagner, December 2005/January 2006]. The real surprise would be

*Understanding how the embryo and its mother's immune system interact could help treat complications of pregnancy.*





Blastocyst (rapidly dividing fertilized egg) implants in the lining of the uterus (schematic diagram above), provoking an inflammation response from the mother. According to the author's theory, outlined in the enlarged area of the schematic diagram (right), the trophoblast (blue) coordinates the local actions of the mother's immune-system cells (purple), via signaling proteins called cytokines. Three steps of that coordinated immune response to a foreign body (antigen) are shown: (1) Toll-like receptors on trophoblast cells and on the macrophages of the mother sense the antigen. (2) The activated trophoblast cells signal the mother's macrophages and her T regulatory cells via cytokines about the nature of the threat; the macrophages and the T regulatory cells also coordinate their activities via cytokine signals. (3) The macrophages destroy the invader and signal the mother's natural killer cells to suppress their activity, while the activated T regulatory cells suppress the cytolytic T cells. The two suppressive actions prevent an attack by the mother's immune system on the trophoblast.



to find that the mother's immune system had *not* learned to recognize her own offspring.

My research suggests that the trophoblast and the mother's immune system join forces to fight their common enemies: infectious microorganisms. When the trophoblast cells "call for help," the mother's immune system responds with coordinated actions. In short, the mother's immune system becomes active in the early stages of her pregnancy to protect, not to harm, the embryo, to promote implantation and subsequent embryonic growth.

To picture how such a complex physiological partnership can function, think of the cells of the mother's immune system as musicians in an orchestra. The macrophages are one section, the T cells another, the natural killer cells a third. During pregnancy, our studies suggest, the trophoblast functions as a guest conductor. The success of the pregnancy—the musical performance—depends on how well the trophoblast communicates with each kind of cell in the immune

system, and on how well they all work together. I am trying to understand how that orchestra works at the molecular level: how the trophoblast recognizes what is nearby, and, on the basis of that information, what kinds of signals it sends that coordinate cellular activities at the implantation site.

Our recent studies demonstrate that the cells of the trophoblast share a feature with macrophages and other kinds of cells that make up the innate immune system. They all have signal receivers known as Toll-like receptors (TLRs) displayed on their cell membranes. TLRs enable trophoblast cells to sense bacteria, viruses, dead maternal cells (killed during implantation), and damaged tissue in the trophoblast environment. Before our studies, only immune cells were thought to have TLRs.

When the trophoblast, through its TLRs, senses one of those targets, it secretes a specific set of cytokines that act on each kind of immune cell present at the implantation site [see illustration above].



The cytokine signals “educate” the immune cells, conferring specific properties on them that enable them to help with implantation. For example, in response to the signals, natural killer cells help transform the mother’s blood vessels, macrophages help the blastocyst migrate to the uterine wall, and dendritic cells help in attaching the blastocyst.

A particularly important part of cytokine-mediated “education” is getting macrophages to clean up dead maternal cells. When the trophoblast invades the uterus, it sends out signals that program the death of some uterine cells, to make room for the blastocyst. The dead uterine cells need to be removed quickly or disease will result in the mother. The trophoblast cells signal the macrophages to come and clean up the dead-cell mess.

At the same time, cytokines from trophoblast cells signal *T* regulatory cells to suppress the normal actions of natural killer cells and cytolytic *T* cells. By suppressing those cells, the trophoblast avoids being attacked by the mother’s immune system. Macrophages “educated” by the trophoblast, on encountering an antigen, signal the *T* regulatory cells to suppress the natural killer cells for the same reason.

All that exquisitely synchronized activity can be derailed by viral or bacterial infection. Clinical studies have shown that infections cause as much as 40 percent of incidence of preterm labor. Furthermore, of the most severe cases of preterm delivery (pregnancies that end after less than thirty weeks of gestation), 80 percent show evidence of infection.

That raises another conundrum about immunity and pregnancy. Inflammation from infection often complicates a pregnancy, jeopardizing the well-being of the mother and her developing embryo. Nature’s solution is harsh: to save the mother, the infection not only causes inflammation, but also triggers early delivery, or miscarriage. The conundrum is that inflammation is also necessary for normal implantation. How can such diametrically opposing outcomes both originate from an inflammatory response?

To our surprise, my research group discovered that the signals triggering miscarriage may be initiated by the same guest conductor, the trophoblast. If a virus, say, is infecting the uterus, the trophoblast recognizes the virus through its TLRs, just as in normal implantation the trophoblast recognizes dead cells from the mother’s uterus. With the virus, however, the trophoblast’s response is different. Its cells signal the mother’s immune-system cells to mount an aggressive immune response. Instead of suppressing her cytolytic *T* cells and natural killer cells, she activates them. Not only do they attack the infection, but they attack the trophoblast as well.

The battered embryonic tissue is then expelled; the mother miscarries.

Even though too many bacteria in the upper reproductive tract can lead to miscarriage, some bacteria may be needed to stimulate the mother’s initial inflammatory response. The upper reproductive tract, which includes the inside of the uterus, was once thought to be a sterile environment. It is now known, however, to be continuously exposed to microorganisms. They can reach the uterus either as hitchhikers carried along by sperm or via the peristaltic waves of orgasm. We are currently exploring the possibility that bacteria play an essential role in priming the uterus for implantation.

How could they do so? During the critical time the embryo can implant, adhesion molecules on the uterine lining change their adhesive strength so that the blastocyst can become attached. Those changes of adhesiveness are thought to be induced by semen. It is possible that bacteria help spread the semen across the uterine lining, providing the pro-inflammatory stimuli needed for the blastocyst to attach. Bacteria may therefore be essential for implantation, and thus for pregnancy itself.

Our studies provide an alternative perspective on the role of the mother’s innate immune system in pregnancy. I would hope that some day my model will lead to early diagnosis and more effective treatment of obstetrical conditions in which the immune system plays a central role. In particular, understanding how the maternal immune system interacts with the trophoblast will enable medical investigators to develop new tests to monitor alterations in the normal cytokine balance that could lead to pregnancy complications. New therapies might also be developed to treat such complications of pregnancy as preeclampsia and recurrent, multiple miscarriages.

Preeclampsia accounts for 40 percent of maternal deaths in many countries of the developing world. It is known to be caused by inflammatory conditions that damage the mother’s blood vessels. Unexplained multiple miscarriages probably also result from immune-system disorders. Both those killers, and others, are likely to continue causing heartbreak and devastation until biologists can disentangle the intricate strands of the immunology of pregnancy. □

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# Hidden Tombs of Ancient Syria

*Evidence of animal and possibly human sacrifice suggests that burials at Tell Umm el-Marra were those of Bronze Age royalty.*

By Glenn M. Schwartz

Although nearly seven years have passed, I still vividly remember the events of June 10, 2000. Our archaeological team of students and specialists, about fifteen strong, had begun the third week of a two-month excavation season on the Jabbul Plain of northern Syria. We were bracing ourselves for the hot and dry summer days we could expect at our site, Tell Umm el-Marra. A *tell* (the word means “mound” in Arabic) is not a natural feature. Rather, it is an archaeological time capsule, with layers of mud bricks, stones, artifacts, and other materials that have accumulated for thousands of years as buildings were lived in, abandoned, fell into ruin, and finally served as the foundations for a new generation of buildings. At Tell Umm el-Marra the remains have accumulated to a height of twenty-seven feet across an area of fifty acres. The mound is one of scores that dot the otherwise featureless plain.

In earlier field seasons, our team had whittled away happily at parts of the mound, exploring the residue of a small city founded about 2800 B.C. But on this particular morning I was feeling disappointed. We had begun digging trenches in what we referred to as the “acropolis,” a three-and-a-half-acre area at the center of the site. A six-foot-thick wall of mud bricks built around the acropolis in about 1800 B.C. was a tantalizing sign: if ancient inhabitants had taken the trouble to build such a wall, we reasoned, it must have enclosed an important building—a palace, perhaps, or a temple. But when we had dug down to the habitation layer dating from the time

of the wall, all we found was a shapeless heap of stone cobbles and boulders.

Disappointed? Yes, but certainly not ready to quit. Could the stones and cobbles still be concealing the foundations of a palace or temple? I



*Excavation of the upper layer of Tomb 1, right, at Tell Umm el-Marra, in Syria, revealed bones of two young women and two infants, along with pottery and various ornaments. Dating from ca. 2300 b.c., the tomb was the first of several discovered within the ruins of a small Bronze Age city. Top left: Amulet in the form of a wild goat, carved in lapis lazuli, was found near the neck of one of the women; it is pictured at two times actual size. An aerial view of the site and its surroundings forms the background of these two pages.*



asked Alice Petty, a graduate student on our team, to remove the rocks in her trench—after carefully documenting them, of course—and dig deeper. As she did, she uncovered the tops of stone walls that enclosed a rectangular room about twelve feet long by eight feet wide. By the style of the pottery shards in the fill, I judged the room to date from an earlier period. Actually, though, it still didn't look very promising; I rather tepidly suggested to Petty that she keep digging and let me know if anything interesting turned up.

But as she proceeded with the work, my skepticism turned to excitement. Petty started finding unbroken vessels of pottery, which signaled that the contents of the room were unusually well-preserved. Then I heard her call me: "Glenn, there's metal here." I climbed down into the trench to take a look. Two large, lozenge-shaped metal objects were protruding from the soil. Could they be bronze spearheads? One of our colleagues, Sally Dunham, an independent

scholar with a special interest in ancient art, came to the edge of the trench to see what was going on. Why would complete vessels and metal objects be found intact inside a room? "Maybe it's a tomb," she suggested. A few strokes with my brush next to the metal objects revealed part of a long bone. I quickly called over Jill Weber, our zooarchaeologist from the University of Pennsylvania, to have a look.

"Animal or human?" I asked her.

"Human."

We summoned our human skeletal expert, Barbara Stuart of the Beirut Archaeological Center, and she began work on what we now understood to be not a room, but a tomb—and a tomb of substantial size. The bones of an adult soon began to emerge, together with objects that had been buried on or near the body. Around the skeleton's neck were beads and amulets of lapis lazuli, the much-prized blue stone from eastern Afghanistan. One of the amulets was carved in the shape of a wild goat, with its horns sweeping elegantly backward. Closer inspection of the metal lozenges, our first find, revealed that they were silver, not bronze, and pierced lengthwise, perhaps for stringing as ornaments.

The next morning Stuart began to uncover a second skeleton. At lunchtime she came into our expedition headquarters, thrilled. Next to the second skeleton she had noticed a thin, gold-colored strip in the soil. Her first thought had been, "What ninny dropped aluminum foil into my excavation?" Then she realized the strip was not modern, but an ancient object made of gold. It proved to be a headband, accompanied by gold beads and a gold bracelet.

As the days proceeded, a remarkable story began to unfold. The tomb contained three layers of skeletons, undisturbed, as were the rest of the tomb's contents, in the nearly four and a half millennia since they were buried. Ancient tombs containing gold and silver objects tend to be prime targets for robbers, both ancient and modern, and so a pristine tomb is an exhilarating find. In three subsequent excavating seasons (in 2002, 2004, and 2006) we have discovered that "our" tomb, now designated Tomb I, was not alone, but was part of a large complex devoted to the burial of high-ranking individuals in the mid- to late third millennium B.C.

We have also found clear signs of sacrifice. Next to the tombs we uncovered five







Tell Umm el-Marra lies in what is now northern Syria, not far from the region bounded by the Tigris and Euphrates rivers—often considered the cradle of civilization. The site may represent the ruins of Tuba, a city first mentioned in cuneiform texts from Ebla.

smaller enclosures of mud brick that contained the bodies of sacrificed animals and, perhaps, sacrificed infants as well. What we call Installation B, for instance, was a six-foot-square, brick-lined subterranean space containing the headless skeletons of two equids (they could be donkeys or Asiatic wild asses—or perhaps hybrids of the two). The bodies had been interred in a standing position; we found the skulls, along with a spouted jar, on a ledge overlooking the skeletons. After the equids had been positioned, smaller bodies were added to the enclosure: two sets of three puppies, as well as a human infant. The other “installations” contained similar interments of equids, sometimes decapitated, often together with human infants, spouted jars, and puppies. In short, the excavations at Tell Umm el-Marra have yielded a rich trove of material and, given the findings, have raised many questions. Our current inquiries are focusing on two issues: how did the centrally placed tombs function in the community, and why was the tomb complex abandoned and eventually covered over?

Tell Umm el-Marra was first excavated in the late 1970s and early 1980s by a Belgian team directed by the late Egyptologist Roland Tefnin. Those investigations determined the sequence of occupations at the site, which was inhabited most intensively during the third and second millennia B.C. Tefnin also uncovered a number of rooms, as well as a city gate on the northeast side.

Hans H. Curvers, an archaeologist at the University of Amsterdam, and I launched our own joint excavations in 1994. From the beginning, our goal has been to investigate the origins and early development of urban civilization in western Syria. In the standard terms of our profession, we are investigating Bronze Age times, roughly between 3000 B.C. and 1200 B.C. That period, following the widespread adoption of agriculture, is notable not only for the advent of bronze metallurgy (as its name implies), but also for the emergence of writing and, in general, an increase in social stratification. Early urban life in Mesopotamia, the region between the Tigris and Euphrates rivers that some consider the “cradle of civilization,” has been well examined, but archaeologists still have a lot to learn about developments in western Syria.

Tell Umm el-Marra, the largest site in the Jabbul Plain, probably functioned as a regional center throughout the Bronze Age [see map on this page]. It may have been the city known as Tuba, which is first mentioned in texts dating from around 2400 B.C. that were discovered in Ebla, a much larger city to the southwest. Whatever its name in ancient times, though, it was strategically positioned. To the east was a dry steppe frequented by pastoral nomads and, beyond them, the Euphrates River. To the west were rainy agricultural lands, along with the major city of Aleppo. Hence Umm el-Marra probably controlled east-west trade between Aleppo and the Euphrates, and likely served as a trading hub in its own right.

Our first few field seasons concentrated on two 400-year-long periods, the Late Bronze Age (1600–1200 B.C.) and the Middle Bronze Age (2000–1600 B.C.). Then came the unexpected discovery of our tomb, which dated from 2300 B.C., in the Early Bronze Age. The skeletons in the early tomb had been buried in three layers, inside rectangular wooden coffins. Few traces of wood remained, but the shape and material of the coffins was apparent from impressions left in the soil and other residues.



Gold pendant, shown two times actual size, was among the many ornaments discovered in the upper layer of Tomb 1.



In the topmost of the three layers were the two bodies, placed side by side, that Barbara Stuart had first exposed, females between fifteen and twenty years of age [see photograph on pages 42–43]. Each of them had the skeleton of an infant placed at the knee, and around the bodies were costly objects—beads, disks, and pendants of gold; silver bracelets; gold and silver pins used to fasten clothing; a bronze torque, or circular neck ornament; and scores of ceramic vessels.

In the second layer, below the two women, were two men, also placed side by side, and a baby at some distance away near the tomb entrance [see photograph below]. Those skeletons appeared to have been interred at the same time as the women, but in contrast with the women, the men were buried with relatively few objects—just a bronze dagger and spearhead, a silver headband, and a silver bracelet. Finally, the lowest layer held the body of a single adult, probably a woman, who had apparently been

buried earlier, because her bones had been much disturbed by the interment of the men above. A few objects, including a small silver cup and some silver pins, were found with her bones.

The remains posed an intriguing puzzle. Why were the bodies of two richly adorned women of about the same age, each with a baby, placed above two relatively “poor” men? Perhaps the women were of high rank—princesses or priestesses—and they were accompanied in death by lower-ranking men. The men might have been servants or guards who had been sacrificed to escort their mistresses into the afterlife. That kind of human sacrifice was not unknown in the period: archaeologists who excavated tombs in the royal cemetery of the city of Ur, in southern Mesopotamia, found evidence of slain attendants, and there may be another example of such sacrifice at Tell Banat, a Syrian site on the Euphrates. Or, more mundanely, perhaps the four



Middle layer of Tomb 1 contained the skeletons of two men (above) and an infant (not shown), apparently buried at the same time as the two women buried above them (see photograph on pages 42–43). Beneath the men's skeletons were earlier remains, of another adult.





Gold and silver pins for fastening clothing were recovered from Tomb 6. They are shown three-quarters actual size.

adults and three babies had succumbed all at once from natural causes, such as an epidemic.

In our excavating seasons since 2000, six more tombs have been exposed, dating from between 2500 B.C. and 2200 B.C. Most of them, unfortunately, were disturbed in antiquity. Subsequently, however, the entryways were blocked with boulders, and so the interiors have still yielded informative remains. Each tomb contained the bones of at least two people, and pottery (useful for dating) was abundant, including many intact vessels. In some cases, as in Tomb 6, we found additional artifacts, including vestiges of a wooden coffin, gold and silver pins, bronze daggers, and beads of lapis lazuli, gold, and a quartzlike, reddish-brown stone known as carnelian.

But the prize among the new tombs was Tomb 4, which had not been seriously disturbed. In our excavation we found Tomb 4 had two levels, and in the deeper (and thus older) of the two, the skeletons of two adult females and one adult male lay in repose. The women had ornaments next to their bodies, including silver pins and squares of gold with lattice designs. Pierced, pointed objects made of ivory were found with both sexes; we tentatively interpret them as hair ornaments. Two miniature tables carved from basalt, which we discovered stacked one on top of the other, may have served as surfaces for grinding cosmetics. And in the northwest corner of the tomb we were surprised to find a pair of eyes staring out at us from the soil that filled a small square shaft—eyes of stone and shell of the kind used for inlays in statuary. They may have belonged to a small statue of wood or other material that rotted away long ago.

The second, upper level of Tomb 4 also held three bodies: an adult male, an

adult female, and a child. Once again, as in Tomb 1, the woman's body was the most elaborately outfitted. It is unlikely that the costlier grave goods accorded to women signified that women held greater wealth or status than men. Texts from the same period make it clear that men wielded the greater political and economic power. Perhaps upper-class women of ancient Umm el-Marra were simply more likely to wear ostentatious jewelry than were their male counterparts—as is common in our own society. A woman's showy accoutrements

may thus have advertised the wealth or prestige of her family or her husband.

Near the woman in the upper level of Tomb 4 we also discovered seven silver vessels. They are similar in shape to metal vessels found in the royal cemetery of Ur, suggesting that the elites of Syria were imitating the styles of their Mesopotamian counterparts (and maybe vice versa). Owning luxury goods in exotic styles or from exotic places was presumably a good way to display one's high status.

One of the most provocative questions was what to make of the skeletons of animals and infants associated with the tombs. Our conclusion was that rituals featuring animal sacrifice and perhaps even human infant sacrifice accompanied the burials of the adults in the tombs. So who were those adults? I have little doubt that they were the highest-ranking members of their community. Contemporaneous texts from Ebla reveal that high-ranking people were buried with elaborate jewelry of the kind we excavated. In fact, if Umm el-Marra was presided over by independent rulers, the tombs may qualify as royal. At the very least, the individuals buried within them were once members of powerful families.

The sacrificed donkeys or wild asses would have been objects of prestige: contemporaneous texts from Ebla and elsewhere state that such animals drew the war wagons of the elite, and that they were costly. Perhaps the sacrificed animals were intended to transport the deceased to the afterlife, or to serve them in it. Why infant sacrifice was conducted—if it was—is harder to explain. Human sacrifices often accompanied elite burials in such early urban societies as Dynasty I of Egypt, the Shang period of China, and in the Ur



Clay cylinder, perforated lengthwise and covered with what appears to be some form of writing, is one of four discovered in the upper level of Tomb 4, dating from ca. 2350 B.C. It is shown three-quarters actual size.



royal cemetery, perhaps as a display of raw power.

The tombs also probably acted as constant reminders of the importance of the deceased. After all, they were conspicuous objects in the community—centrally placed, raised up, and at least partly freestanding. The descendants of the dead, by making offerings at the tombs of those interred, may have acquired and maintained their own prestige. Ritual texts from Ebla, which describe offerings made to deceased kings by the living ruler, support that interpretation. In Mesopotamia, by contrast, royal tombs such as the ones at Ur were subterranean and well hidden, suggesting that ancestor veneration was less central, ideologically as well as spatially.

Judging from the small number of bodies in each tomb and the changing styles of pottery, we also infer that power and prestige shifted from one family dynasty to another fairly quickly, in as little as a generation or two. As I noted earlier, many of the tombs were disturbed and then had their entryways blocked with boulders. Groups that attained power may have desecrated the tomb of their predecessors, thereby destroying the link between the living community and the family that was out of favor.

It is unlikely that the perpetrators were either ordinary robbers or family members of the deceased. First, it seems unlikely that robbers would have taken the trouble to block the doorways on their departure. Second, if the tombs had been plundered by robbers, then resealed by community members who valued the interred people, an effort would have been made to tidy things up inside the tombs. But the interiors were left in disarray.

Around the end of the Early Bronze Age, about 2000 B.C., many Syrian cities shrank in size or were abandoned altogether. The reason for the apparent collapse is a subject of vigorous debate. Some point to abrupt climatic change, others to human-induced environmental degradation. We have studied both botanical and faunal remains for clues, but so far we have no satisfactory answer. What we can say is that parts of Umm el-Marra were abandoned, and many nearby settlements were deserted as well.

Then, around 1800 B.C., there was a resurgence of the community, probably related to the rise of a powerful kingdom based at Aleppo. An energetic program of public works was undertaken at Umm el-Marra, including new earth and cobble ramparts

encircling the site and a mudbrick city wall on top. In that same era, the “acropolis” was enclosed with its thick wall, and the tombs were covered over by the heap of rocks I had found so disappointing.

In the fourteenth century B.C., Umm el-Marra fell victim to an episode of substantial destruction: some buildings were burned, with some of their household implements, luxury items, and other contents still inside. The timing suggests a link with the onslaught on western Syria by King Suppiluliuma I, whose domain was centered in Boghazkoy, in present-day Turkey. By 1200 B.C.,



*Bones of an infant (lower left) and of a donkey or Asiatic wild ass (upper right) were found in a compartment near tombs 1 and 3. Both the infant and the animal may have been sacrificed, evidence of the high rank of those interred in one or the other of the tombs.*

the end of the Late Bronze Age, Umm el-Marra was abandoned, at least as a city. Although no one has yet proved that Umm el-Marra was the site of the city of Tuba, that period is also the latest in which Tuba is mentioned in ancient texts.

The mound on the Jabbul Plain was reoccupied from time to time thereafter, most substantially between about 500 and 200 B.C. Those who came that late, however, would not have known about the tombs, by then hidden and forgotten. The people buried within were left for archaeologists to discover. In a way, then, we are the first who can restore to them a small measure of the glory they once claimed. □

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Groovestem Indian plantain grows amid low hills in a remnant of Louisiana prairie.

# Uncommon Property

*In northern Louisiana, soil with an ancient link to the sea invites a unique flora.*

By Robert H. Mohlenbrock

When I visited Louisiana in late April of last year, I asked Scott D. Edwards, a plant-use specialist, what part of his state boasted the most unusual flora. Edwards, then in the U.S. Department of Agriculture's Natural Resources Conservation Service (USDA-NRCS), replied without hesitation: "The Copenhagen Hills Preserve." And so one morning he drove me and his colleague Terry G. Johnston to the preserve, not far from

the small community of Copenhagen in northern Louisiana.

As we climbed out of his pickup truck we found ourselves in a dry forest on top of a narrow ridge. To the east, a series of 300-foot hills rose one after the other before us, part of a small upland area known as the Bayou Dan Hills. The preserve, Edwards told me, extended eastward four miles along the Ouachita River. Totalling about 1,500 acres, the property was once owned in part by the

International Paper Company and in part by the late John McKeithen, governor of Louisiana from 1964 until 1972. But the steep slopes made logging difficult, and after the paper company learned of the region's botanical significance, it sold its share to the Nature Conservancy in 1999. The rest was bequeathed by the former governor, who died that same year. Because of its botanical sensitivity, the preserve is open to visitors by permission only [see "Visitor Information" on opposite page].

Hills of any kind are exceptional areas in Louisiana, which is otherwise flat. Three main hilly zones—the Kisatchie and Nacogdoches wolds (hills) and the Ouachita Hills—extend through the north of the state. They began forming tens of millions of years ago, as rivers carried silt from the north and deposited it into the

Prairie Big bluestem, Indian grass, little bluestem, side-oats grama, and switchgrass are the principal grasses. Common prairie wildflowers include black-eyed Susan, hairy laspedeza, lanceleaf tickseed, and prairie blue-eyed

grass. Rare ones for Louisiana include eared goldenrod, false boneset, groovestem Indian plantain, Nuttall's rayless goldenrod, prairie bluets, prairie parsley, prairie pleatleaf, purple coneflower, purple prairie clover, smooth oxeye,

white prairie clover, and yellow pimpernel.

Ridgetop woods Blackjack oak and post oak are the dominant trees, but pignut hickory and shagbark hickory are also common. Shorter trees include

fragrant sumac, roughleaf dogwood, and winged elm. Downy phlox is the most abundant spring-blooming wildflower; several asters and goldenrods dominate the fall landscape. Yellow jessamine is the common vine.





#### VISITOR INFORMATION

The Nature Conservancy of Louisiana  
P.O. Box 4125  
Baton Rouge, LA 70821  
225-338-1040  
318-412-0472  
[www.nature.org/wherewework/northamerica/states/louisiana/](http://www.nature.org/wherewework/northamerica/states/louisiana/)

sea. With time the layers of sediment built up and became compressed, transforming into clay, sandstone, and shale. As newer deposits were added along the coast, they weighed down those geological formations, or rock layers, tilting them down in the south. That slow tilting caused the layers farther north to rise. As streams arose, they eroded the uplifted formations, creating low hills and shallow valleys.

In the Bayou Dan Hills (which might be considered part of the Ouachita Hills), that same tilting elevated a geological formation known as the Jackson Group, which is rich in marine fossils. According to a USDA-NRCS

survey, the soil that developed from that formation includes small particles of calcium carbonate ( $\text{CaCO}_3$ ), as well as shells of mollusks, coral, and other fossils. Outcroppings of the Jackson Group formation do occur in other areas, however, so it is not the sole basis for the unusual flora in the preserve. According to Charles Guillory, a soil scientist at USDA-NRCS, an important contributing factor is that prairie habitat was widespread there in the past, creating acidic conditions that leached most of the calcium and magnesium out of the soil. In addition, he suggests, the steep slopes and the erosive action of the Ouachita River, both of which have contributed to churning and moving the soil, may also have made it unique.

From the ridgetop where we parked, my companions and I headed eastward along an abandoned dirt road, descending the first of many steep slopes we would encounter that day. Near the base of the slope was a nearly treeless expanse of land blanketed by grasses: a remnant of Louisiana prairie. The habitat has been nearly extirpated from the state. The grasses we saw were mostly spe-



Fossils found in Copenhagen Hills soil, which developed from rock layers formed under the sea

cies characteristic of prairies north and northwest of Louisiana.

The slopes above the prairie were wooded, and as we explored them and other wooded slopes, I was impressed by the great diversity of species and the presence of many plants not generally found in Louisiana. I was also surprised to find some places with upland species such as chinquapin oak and southern red oak growing side by side with bottomlanders such as Shumard oak and swamp chestnut oak.

In our one-day survey of Copenhagen Hills, the three of us recorded eighty-seven species of trees, twenty-six kinds of shrubs, and twenty species of woody vines—133 woody species in all. Numerous nonwoody species made our list as well. But there must be even more: the happy thought is that only further visits in other seasons could make our tally reasonably complete.

**ROBERT H. MOHLENBROCK** is distinguished professor emeritus of plant biology at Southern Illinois University Carbondale.



Stream flows through bottom woods between shallow slopes.

**Slope woods** boast numerous species of hickories and oaks, and several kinds of buckthorns, elms, and maples. The oaks include diverse-leaved oak (a rare hybrid of laurel oak and blackjack oak), Durand's oak, and Oglethorpe oak.

American beech, cucumber tree, flowering dogwood, nutmeg hickory, sweet gum, and tulip poplar are among the other trees. Wildflowers rare in Louisiana include spiked crested coralroot, Walter's violet, and whiteleaf leather flower.

**Bottom woods** Wetland species grow wherever a stream flows along the base of a slope. Trees include bald cypress, river birch, Shumard oak, swamp chestnut oak, swamp hickory, sycamore, and water hickory. Among

the shrubs are American snowbell, possumhaw, eastern swamp privet, and spicebush. Vines that climb high into the trees include American wisteria, climbing dogbane, ladies'-eardrops, and supplejack.



*The Invisible Sex:  
Uncovering the True Roles  
of Women in Prehistory*  
by J.M. Adovasio, Olga Soffer  
and Jake Page  
Smithsonian Books; \$26.95

Surely the title of this book is a bit hyperbolic. Judging by their place in popular culture, prehistoric females were far from invisible. After all, the best-known australopithecine is Lucy, the diminutive hominid whose 3.2-



Statuette of a sitting woman, made of polished terracotta and found near Cernavodă, Romania, dates to the end of the fourth millennium B.C.

million-year-old skeleton was uncovered in Ethiopia in 1974. And what of Ayla, the Cro-Magnon heroine of Jean M. Auel's blockbuster, *The Clan of the Cave Bear*, and its sequels?

Still, the prehistoric archaeology of *Homo sapiens*, like most academic fields, has historically been dominated by men. It's not surprising, therefore, that, in the museum dioramas, textbooks, and popular literature produced by these august gentlemen, Stone Age people are generally represented as tribes of skin-clad cavemen who hunted mammoth, bison, and giant bears and

sat around chipping spear points in their spare time. Women may not have been invisible, but traditional archaeologists did not regard them as central to Paleolithic and Neolithic culture. In the canonical story of human prehistory, men were the shamans, men invented atlatls and digging sticks, men created the exquisitely conceived paintings on the walls of hidden caves.

When women did appear front and center, they assumed an exaggerated sexual role. The famous Venus of Willendorf, a buxom statuette discovered in an Austrian riverbank in 1908, became the archaeological archetype of a Stone Age fertility goddess. Many similar figures discovered since have conventionally been described as avatars of the passive role of women: the bearers of children, the embodiment of hearth, home, and sedentary life.

Yet to J.M. Adovasio, an archaeologist, Olga Soffer, an anthropologist, and Jake Page, a science writer, the Venus statuettes symbolize, at most, the ambiguity in the evidence for women's place in prehistoric society. After all, they argue, the societal significance of many artifacts from the distant past is not immediately obvious. For all we know, the statuettes may have served as religious icons, children's playthings, or sex toys.

Thus it would be as presumptuous to attribute too much power to prehistoric women as it would be to attribute too little power to them. New Age feminists like to cite the work of the Lithuanian-American archaeologist Marija Gimbutas, who saw the Venus figures as evidence for a pervasive matriarchal society that dominated the prehistoric scene in Europe. But after years of academic debate about the evidence, the case for pacific matriarchal societies remains

as fragmentary and contradictory as the case for male-dominated packs of hunters. It's likely that Edenic clans of goddess worshippers led by Wicca priestesses are more common in California today than they ever were in Neolithic Europe.

That said, the authors offer up some less ambiguous evidence that women's roles in developing culture were at least commensurate with those of men in several important areas. Women, according to the authors, had an important part to play in the agricultural revolution. Just as important, though perhaps less well appreciated, women in both ancient and modern cultures have been the ones involved most directly in producing textiles.

Stone, of course, is more durable than cloth. But in dry caves and other places where textiles dating to the Upper Paleolithic (some 26,000 years ago) have been preserved, spun and woven artifacts outnumber stone artifacts by a ratio of twenty to one. Imprints of textiles and basketry have been found that date back tens of thousands of years. If the authors are right, the loom ought to appear along with the stone-tipped spear in those museum dioramas, and the "String Age" ought to be given equal billing with the Stone Age.

*The Sun Kings:  
The Unexpected Tragedy  
of Richard Carrington and the Tale  
of How Modern Astronomy Began*  
by Stuart Clark  
Princeton University Press;  
\$24.95

Around the time Bostonians were sitting down to Sunday dinner on August 28, 1859, all the equipment at the State Street telegraph office suddenly went dead. To the west, at the telegraph depot in Springfield, Massachusetts, a huge spark leapt from incoming wires, filling the office with acrid smoke. In Pittsburgh, Pennsylvania, telegraph operators panicked when "streams of fire" began to burst



from their receivers. As night fell, observers from Canada to the Bahamas reported intense auroral displays in the heavens, some so bright you could read newsprint out-of-doors. Compass needles swung wildly, as if the Earth itself was trembling, and nearly a week went by before the auroras disappeared and electrical communication returned to normal. Science journalist Stuart Clark calls the event "the perfect solar storm," caused by an immense ejection of electrically charged particles from the Sun. It was the most intense magnetic storm in recorded history.

Few people, however, suspected the true nature of the event at the time. A few earlier observers had reported compass disturbances that coincided with auroras. In the early 1800s the English astronomer William Herschel had noted that the price of wheat rose as the number of reported sunspots fell, suggesting that solar activity might affect climate. But the data were sketchy,

and the forces that could stir up the Earth across 93 million miles of empty space were completely mysterious.

In 1859, however, one notable observer was keeping track of the Sun's activity. Richard Christopher Carrington, a wealthy amateur and member of the Royal Astronomical Society, had been carefully sketching the Sun, as it appeared through his own specially designed telescope, on every clear day since November 1853. Captivated by the idea that fundamental solar cycles might underlie the processes of nature, Carrington hoped that by systematic long-term observation he could uncover the laws that governed solar activity.

On September 1 of that year, a few days after the great magnetic storm began, he was surprised by two brilliant, white fireballs that moved across the solar surface at a speed he later calculated to be more than 400,000 miles

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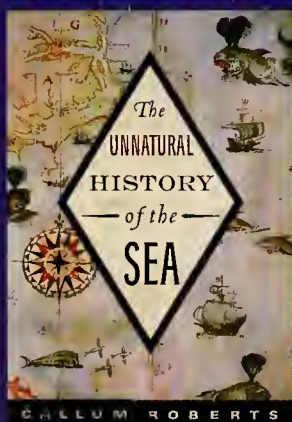
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an hour. Nothing like them had ever been seen before. In London, while traveling on business, he learned that magnetic sensors at Kew Observatory had recorded a large swing in their compasses coinciding with the fireballs on the Sun. It was the first direct evidence that solar storms generated magnetic lines of force that reached across space to Earth.

That, of course, was only the beginning of a story that continues to this day. Until the mid-1800s, astronomers had devoted themselves almost exclusively to measuring positions of objects in the sky. But the techniques of Carrington and his contemporaries gave birth to the new science of as-

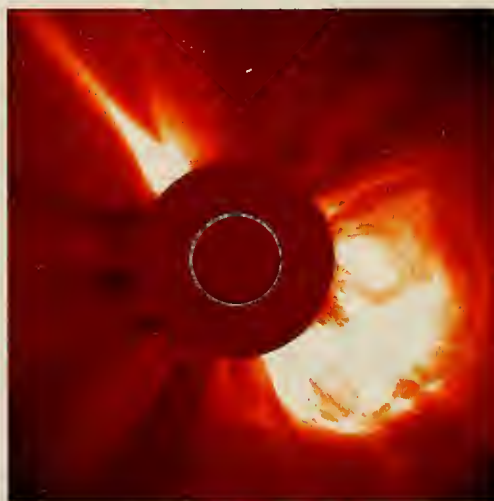
led to a Gothic imbroglio of bigamy and assault. He died too soon to appreciate how much light he had brought into the world.

*The Wild Trees:  
A Story of Passion and Daring*  
by Richard Preston  
Random House; \$25.95

North of San Francisco, not far from the California-Oregon border, lies a hidden valley where two monumental redwoods—nicknamed the East and West spires—stand side by side. If you had looked up from between their massive trunks on the morning of December 8, 2001, you would have seen two people suspended from ropes high overhead, both wearing climbing harnesses, and one a bridal veil. As an airborne minister officiated and several intrepid guests watched from adjacent treetops, Marie E. Antoine and Stephen C. Sillett exchanged their wedding vows.

Antoine, Sillett, and their friends are members of a subculture that finds challenge and enlightenment several hundred feet off the ground, clambering among the topmost branches of the world's tallest trees. The intrepid investigators are mapping and cataloging the biological diversity of one of the few remaining unexplored habitats on Earth: the forest canopy of the American Northwest. Antoine, who lectures at Humboldt State University in Arcata, California, is an expert on *Lobaria oregana*, or lettuce lungwort, a spongy lichen that flourishes in the high branches of old-growth Douglas-fir forest. Sillett, a biologist who is also at Humboldt State, climbed his first redwood on a lark in 1987, and is now recognized as a world expert on the ecology of the coastal-redwood canopy.

Antoine and Sillett, as respectable academics, have made high-tree climbing a source of livelihood, but most



Largest solar flare ever recorded, sixteen minutes after peak emission, November 4, 2003

trophysics, which can probe questions about the structure, function, and origin of the stars, planets, and the universe at large. Now the click of a mouse yields "Today's Space Weather" ([www.sec.noaa.gov/today.html](http://www.sec.noaa.gov/today.html)), which provides close-up images of the Sun in near-real-time, along with various up-to-date measurements of solar activity such as particle fluxes, auroras, and the strengths of magnetic fields. From Carrington's observations, Clark spins a lively account of seminal discoveries in spectroscopy, photography, and theoretical physics that led to the present-day understanding.

Carrington, alas, ended his own life after his marriage to a young woman





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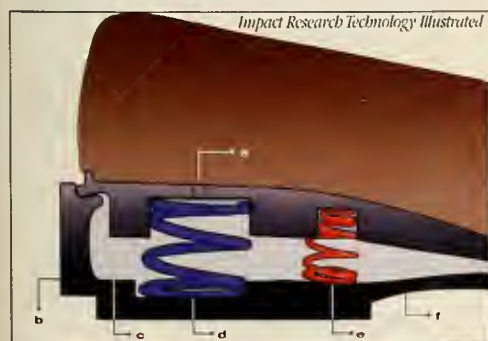
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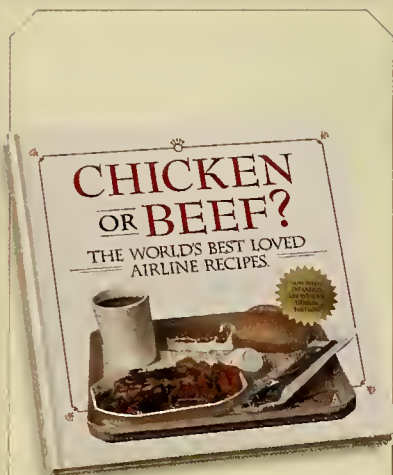


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of the canopy crew ascend just for the fun of it. Today's recreational climbers have adapted techniques first developed by tree surgeons (professionally known as arborists), cavers, and climbers to shoot ropes into the highest branches, ascend and lower with rope clamps and rappel racks, and string up networks of lines from limb to limb from which they can suspend. Like rock climbing, it's a demanding and precarious sport, but an expert tree climber can move as gracefully 200 feet up as a ballet dancer on terra firma.

Such grace, perhaps, is not surprising, since our distant primate ancestors were more at home in the trees than on the ground. What is surprising is that Richard Preston is one of the climbers himself. A best-selling author, he's known for his spellbinding accounts, both fiction and nonfiction, of deadly viruses and bioterrorism: *The Hot Zone*, *The Demon in the Freezer*, *The Cobra Event*. But in recent years, he's taken to the trees, practicing first near his home in New Jersey, and later in California and Australia (where the swamp gum, *Eucalyptus regnans*, rivals the redwoods in height). He's climbed with such veterans as Sillett and Antoine, listened to their stories of near-death falls and exhilarating aerial adventures, and applied his gift for research to learning all he can about the giants of the forest.

Natural-history buffs may be tempted to approach this retelling with a yawn. Redwoods have been the darlings of the literati since at least the days of John Muir. We all know they are huge, dignified, and ancient. But, thanks in large part to the work of high climbers, we now know much more than is evident from the ground. Preston informs us, for instance, that it takes two weeks for water to travel from the roots to the top of a redwood. He notes that redwoods also gather water



Rope climber is dwarfed by a giant redwood.

directly into their needles by absorbing water from fog. And he explains how organic material, a kind of aerial potting soil, collects in the tangles and crotches of the canopy, where climbers find colonies of worms, thickets of elderberries, huckleberries, and rhododendrons, and a lichen whose common name is fairy puke.

As far as I could tell, there is no Ebola or smallpox high in the redwoods: perhaps Preston started climbing as a respite from the terrestrial horrors he wrote about in the past. But that doesn't mean his latest effort is a let-down. *The Wild Trees* is the intelligent sort of nonfiction readers have come to expect from him, a book that elevates, entertains, and, alas, is over far too soon.

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



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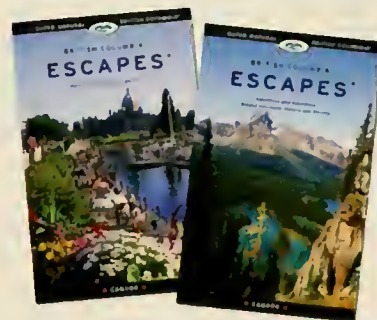


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# Life's Patterns

By Robert Anderson

Through mathematics one can enter a purely abstract world—one that I recently rediscovered while reading *The Number Devil*, by the German author Hans Magnus Enzensberger, to my children. With wonderful illustrations by Rotraut Susanne Berner, the book takes readers into the surreal dreams of a troubled math student who is visited nightly by an irritable teacher with a pointing cane, red skin, and horns. Together, student and teacher venture into territory rarely explored by the schools, which confine themselves to the materials covered by standardized tests. The Devil unveils a rich world in which the numbers form curious patterns, almost as if they were alive.

The big surprise is that even the most arcane realities of abstract mathematics often end up offering deep insights into the natural world. In 1960 the physicist Eugene P. Wigner published his classic paper, "The Unreasonable Effectiveness of Mathematics in the Natural Sciences" ([www.dartmouth.edu/~matc/MathDrama/reading/Wigner.html](http://www.dartmouth.edu/~matc/MathDrama/reading/Wigner.html)). Going beyond his title, Wigner makes the point that "the enormous usefulness of mathematics in the natural sciences is something bordering on the mysterious and that there is no rational explanation for it." Einstein's famous formula,  $E=mc^2$ , is just one example of how the natural world can be neatly reduced to equations.

There are many sites that show some of the innovative ways that mathematics can help illuminate the living world; to see my review of some of the best of them, please go to our *Natural History* Web site ([www.naturalhistorymag.com](http://www.naturalhistorymag.com)), click "Online Extras," then "Web Links," and finally "May 2007" to find "nature.net."

ROBERT ANDERSON is a freelance science writer living in Los Angeles.

Mercury reaches superior conjunction, behind and roughly in line with the Sun, on May 3rd. It passes the point of its orbit closest to the Sun (its perihelion) on the 8th, and quickly enters the evening sky. By the night of the 10th it sets fifty minutes after the Sun and shines at magnitude  $-1.5$ , just a trifle brighter than Sirius, the brightest star in the sky. The planet, in hues of topaz, can be picked up in binoculars. Look for it far to the lower right of Venus, near the west-northwest horizon; Mercury is the brightest starlike object in its part of the sky.

Mercury becomes easy to see with the naked eye after midmonth. It sets near the close of evening twilight. On the evening of the 17th Mercury is close to the horizon and about two and a half degrees to the lower left of a young crescent Moon. Although slowly fading, the little planet gains altitude rapidly day by day. By the 27th it climbs to within twenty-two degrees of Venus (your clenched fist held at arm's length is roughly ten degrees wide). Then, for about the next ten days, the two planets seem to stay almost fixed in their respective positions above the dusk horizon.

Venus is the brightest evening "star" in the west; at a dazzling magnitude of  $-4.2$ , it is bright enough to show through the blue sky soon after sunset. Appearing at its greatest height in the evening twilight for 2007, the planet stands nearly forty degrees above the western horizon at sunset. By the third week of the month it's setting in the northwest shortly before midnight local daylight time (LDT). On the evening of the 19th, Venus and the crescent Moon make a stunning celestial tableau as they descend the western sky side by side, less than a degree apart. Planetariums—and police precincts—will likely get a few calls inquiring about the "UFO" hovering next to the Moon! By month's end Venus is within several degrees of Pollux and Castor, the bright stars in the constellation Gemini, the twins. Telescopic viewers can observe Venus

becoming larger and its crescent thinner as it swings around from the far side of the Sun toward the Earth.

Mars rises within about a half hour of the first sign of morning light. Look for the orange first-magnitude object low in the east as dawn brightens. It moves eastward this month, and crosses from the dim stars in the constellation Aquarius, the water-bearer, into the similarly dull constellation Pisces, the fish, on the 9th. It also passes to the south of the Great Square of Pegasus.

Jupiter is the brilliant light pushing its way up into the southeast sky during the evenings. The giant planet rises around 10:45 P.M. LDT as May begins. By month's end it is rising around 8:30 P.M. and is already above the horizon as darkness falls, shining at magnitude  $-2.5$ . To its right or lower right is Antares, the red first-magnitude heart of the constellation Scorpius, the scorpion. The entire "fishhook" of the scorpion is extracting itself almost straight up from the horizon to Jupiter's right.

Saturn appears as a yellowish-white "star" of magnitude  $+0.4$ , about eleven degrees west (to the lower right) of Regulus, the brightest star in the constellation Leo, the lion. Saturn is more than halfway up in the southwest sky as darkness falls. It sets around 2:45 A.M. LDT on the 1st and a couple of hours earlier by month's end. At midmonth, a thirty-power telescope shows the famous ring system tilted about fifteen degrees from our line of sight.

The Moon is full on the 2nd at 6:09 A.M. Our satellite wanes to last quarter on the 10th at 12:27 A.M. and to new on the 16th at 3:27 P.M. The Moon waxes to first quarter on the 23rd at 5:03 P.M. A second full moon takes place on the 31st at 9:04 P.M. The second full moon in a calendar month is sometimes referred to as a "blue moon."

Unless otherwise noted, all times are eastern daylight time.



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# At the Museum

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## The Stuff of Dreams

Early European sailors told of sirens and sea serpents, monsters that made their way onto ancient maps at a time when terra incognita still denoted uncharted lands. Medieval tapestries recorded images of unicorns, and the literature of the Middle Ages is replete with knights in search of dragons. Today, moviegoers flock to see Gollum in *The Lord of the Rings* and children are delighted by Harry Potter's hippogriff and Disney's little mermaid, Ariel. Fact or phantasm, sometimes even a little of both, such beings are as old and enduring as imagination itself.

Here to explore the anthropological origins and cultural significance of some of the world's most enchanting mythological characters is the American Museum of Natural History's new exhibition *Mythic Creatures: Dragons, Unicorns, and Mermaids*, on view from May 26 through January 6, 2008. The exhibition can truly be called fabulous fun for the whole family. It highlights such supposed denizens of land, sea, and air as dragons, griffins, mermaids, sea serpents, and unicorns, with models that have to be seen to be believed, among them a 17-foot-long dragon; the mythical bird of prey, the roc, with a 19-foot wing span; and a kraken, the multi-armed, ship-foundering sea monster, its massive two-foot-diameter tentacles surfacing all through the hall.

Fantastic creatures have been part of human experience for thousands of years, passed down through legends and fables, ancient and contemporary art, performances, and even in the accounts of early naturalists. *Mythic Creatures* will showcase sculptures, paintings, textiles, and other cultural objects from around the world ranging from representational shadow puppets and ceremonial masks to a spectacular Japanese samurai suit of armor that bears the image of a dragon as a symbol of the wearer's power.

*Mythic Creatures* will also investigate how some fossils, through misidentification, speculation, and imagination, could have been taken as proof of the existence of legendary beasts. Visitors will learn, for example, how Scythian nomads,

East Asian dragons, like the one portrayed by this 19th-century Chinese shadow puppet, are the underwater equivalent of kings and emperors, reigning over watery realms.



D. FINNIN/AMNH

on their quest for gold in the Gobi Desert, were likely to have come across dinosaur bones that would have bolstered their belief in the existence of the gold-guarding griffin, a legendary creature with the body of a lion and head and wings of an eagle, often portrayed on heraldic shields and coats of arms.

In a reverse twist, some tales of undersea monsters may have resulted from glimpses of living sea creatures that are just as fantastic as any imaginary beast, including the giant squid and the oarfish. Even the curious manatee is said to have inspired the report by Christopher Columbus in Haiti in 1493 that mermaids were "not as pretty as they are depicted, for somehow in the face they look like men."

Mythic creatures are the product of human imagination,

and this exhibition will bring to light surprising similarities—and differences—in the ways peoples throughout time and across cultures have envisioned and represented these strange and wonderful beings, telling us as much about the people who imagined them as about the creatures themselves.

The exhibition is co-curated by Mark Norell, Curator in the Division of Paleontology; Laurel Kendall, Curator in the Division of Anthropology; and Richard Ellis, Research Associate, and is designed and produced by the American Museum of Natural History's Department of Exhibition.



D. FINNIN/AMNH

This mid-18th-century *netsuke* (an often intricately carved toggle used to fasten a small container to a kimono sash) portrays a *tengu* (a Japanese mythological bird) emerging from a giant egg.

*Mythic Creatures: Dragons, Unicorns, and Mermaids* is organized by the American Museum of Natural History, New York ([www.amnh.org](http://www.amnh.org)), in collaboration with The Field Museum, Chicago; Canadian Museum of Civilization, Gatineau; Australian National Maritime Museum, Sydney; and Fernbank Museum of Natural History, Atlanta.

*Mythic Creatures* is proudly supported by MetLife Foundation.



# Amphibious Invasion

The halls are alive with the sound of, well, chirp, trill, croak, and gribbet! That's right, back for a repeat engagement is one of the most enchanting and popular exhibitions in the Museum's recent history: *Frogs: A Chorus of Colors*, on view from May 26 through September 9.

This captivating collection of more than 200 live frogs from around the world, shown in re-created habitats, complete with rock ledges, live plants, and waterfalls, is the perfect introduction to the colorful and richly diverse world of frogs.

Among the many adorable encore favorites are the tiny golden mantella frog, which is bright red and less than an inch long, the pale green waxy monkey frog, and the Vietnamese mossy frog whose camouflage is so effective it's fun try-

ing to find one among many in a mass of moss. A dart poison frog vivarium remains a centerpiece of the exhibition, while interactive stations throughout invite visitors to hear recorded frog calls, view videos of frogs in action, and test their knowledge about frogs.

The exhibition explores the evolution

and biology of these diminutive amphibians, their importance to ecosystems, and the threats they face in the world's changing environments, and features the latest research findings on frogs, reflecting the ongoing work con-

ducted by scientists in the Museum's renowned Department of Herpetology and their colleagues around the world.

*Frogs: A Chorus of Colors* is presented with appreciation to Clyde Peeling's Reptiland. *Frogs* is made possible, in part, by the Eileen P. Bernard Exhibition Fund.



The Vietnamese mossy frog is a camouflage expert.

JOE McDONALD  
CLYDE PEELING'S REPTILAND

## DIORAMAS IN YOUR DEN

[WWW.AMNH.ORG](http://WWW.AMNH.ORG)

Longing for another look at the Cuthbert Rookery or in need of an Alaskan Brown Bear fix? The Museum's world-famous habitat dioramas and the fascinating stories behind them are at your fingertips at [www.amnh.org/dioramas](http://www.amnh.org/dioramas). You will be transported to a treasury of images and information about the explorers, naturalists, painters, sculptors, taxidermists, and conservationists who fused art and science into the three-dimensional marvels that have captivated children and adults alike for generations.

At the site, you will find 360-degree panoramic virtual tours of four favorite habitat dioramas, hall highlight videos, and a downloadable MP3 audio tour for your next visit, led by Stephen Quinn, the Museum's Exhibition Project Manager and author of *Windows on Nature: The Great Habitat Dioramas of the American Museum of Natural History*. Moreover, the site offers instant access to a unique collection of archival photos as well as profiles of the artists and taxidermists who brought the dioramas to life. Give yourself plenty of time to savor the experience—just as you would at the Museum itself.



The two-story Andros Coral Reef diorama in the Milstein Hall of Ocean Life

## PEOPLE AT THE AMNH

Jeanne Kelly

Supervisor of Fossil Preparation  
Division of Paleontology



ENRICO FIORILLI

Finding Jeanne Kelly's office within the warrens of the staff-only floors of the Museum is to be reminded that behind the public exhibition halls is a working research institution with more than 200 scientific personnel. It's also not hard to believe that the Museum houses perhaps the most important fossil collection in the world, and Jeanne ensures that the specimens are ready for study, storage, and display.

"My happiest moment is going into the collection, drawer after drawer, can after can," says Jeanne, who describes fossil prep as "a juncture between art and science."

Researchers cannot study what they cannot see, after all, and, for many of her 32 years—first as a volunteer, then part-time, then staff—Jeanne's job was to carefully chip away the matrix surrounding fossils brought from the field to the lab. Her specialty was tiny mammals, early insectivores, working under a microscope with miniature jackhammers and carbide needles to expose teeth and inner ear regions on specimens as small as one-half inch.

Between 1990 and 1996, Jeanne moved from the micro-world to the macro- for the renovation of the fossil halls on the fourth floor during which "every specimen was moved, cleaned, and remounted." She is now codirector of a similar undertaking, the transfer of the fossil mammal collection, some 400,000 specimens, as seven storage floors in the Childs Frick Building are refurbished. It's a huge job, but Jeanne is used to that from her experience in the dinosaur halls. "You don't move an *Apatosaurus* easily!"

D. FINNIN/AMNH



# Museum Events

AMERICAN MUSEUM OF NATURAL HISTORY



www.amnh.org

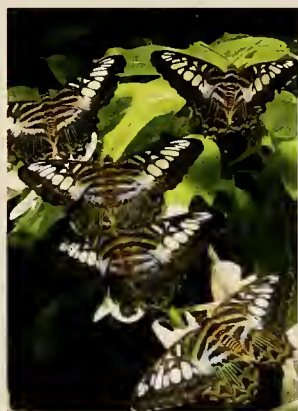
## EXHIBITIONS

### Gold

Through August 19, 2007

This glittering exhibition explores the captivating story of the world's most desired metal. Extraordinary geological specimens, cultural objects, and interactive exhibits illuminate gold's timeless allure.

Gold is organized by the American Museum of Natural History, New York (www.amnh.org), in cooperation with The Houston Museum of Natural Science. This exhibition is proudly supported by The Tiffany & Co. Foundation, with additional support from American Express® Gold Card.



H. DAVIES/AMNH

Clipper butterflies

### The Butterfly Conservatory

Through May 28, 2007

Visitors mingle with live, free-flying butterflies in a tropical environment.

### Undersea Oasis:

#### Coral Reef Communities

Through January 13, 2008

Brilliant color photographs capture the dazzling invertebrate life that flourishes on coral reefs.

### Beyond

Through April 6, 2008

Exquisite images from unmanned space probes take visitors on a journey through

the alien and varied terrain of our planetary neighbors.

The presentation of both *Undersea Oasis* and *Beyond* at the American Museum of Natural History is made possible by the generosity of the Arthur Ross Foundation.

## GLOBAL WEEKENDS

Explore the cultures of the world with live musical performances, films, discussions, and more.

### Asian American Heritage

Saturday, 5/12

2:00 p.m. The Triangle Project's *Journey of the Dandelion* explores peace and unity through drumming, singing, and movement.

4:00 p.m. KaWaDa Ensemble, a trio of Japanese and Mongolian musicians, performs *As the Wind Blows*, created specifically for this event.

This program is cosponsored with the Asian American Arts Alliance.

### In Celebration of Indigenous Peoples

Saturday, 5/19, 1:00–4:30 p.m.

Live Native American musical performances and discussions with representatives from the United Nations and indigenous peoples.

Global Weekends are made possible, in part, by The Coca-Cola Company, the City of New York, the New York City Council, and the New York City Department of Cultural Affairs.

Additional support has been provided by the May and Samuel Rudin Family Foundation, Inc., the Tolan Family, and the family of Frederick H. Leonhardt.

## LECTURES

### Sea Dragons

Tuesday, 5/8, 7:00 p.m.

Richard Ellis discusses the lives, deaths, reproductive habits, and hunting strategies of giant prehistoric marine



ED COHEN

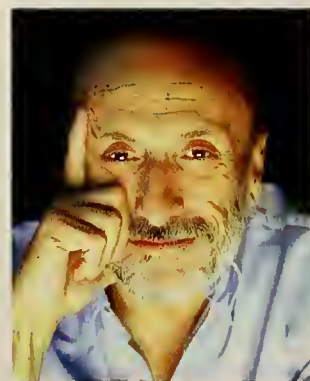
Yoko Fujimoto, Nobuko Miyamoto, and P.J. Hirabayashi are the Triangle Project.

reptiles such as *Ichthyosaurus*, *Mosasaurus*, and *Plesiosaurus*.

### Slow Food Nation

Tuesday, 5/15, 7:00 p.m.

Carlo Petrini, founder of the Slow Food organization, explains how we can improve our health and the health of the planet and offers models for reforming the way food is grown, prepared, and eaten.



SLOW FOOD/ALBERTO PEROLI

Carlo Petrini, originator of the Slow Food movement

### ADVENTURES IN THE GLOBAL KITCHEN

LECTURES AND TASTINGS

#### Bees and Their Honey

Tuesday, 5/8, 7:00 p.m.

Honey has been used for thousands of years for everything from flavoring food and beverages to curing illnesses.

Research entomologist Diana Sammataro discusses the history of the cultivation and uses of honey, and presents different varieties to taste.

### Exquisite Mushrooms

Tuesday, 5/15, 7:00 p.m.

Mushrooms can be tasty, medicinal, or even deadly. Focusing on the tasty varieties, author Gary Lincoff and chef Amy Farges will transform the way you view the not-so-lowly fungi.



ROSE CENTER FOR EARTH AND SPACE

Sets at 6:00 and 7:30 p.m.

Friday, May 4

Michele Rosewoman and Quintessence



### All about Wine

Tuesday, 5/29, 7:00 p.m.

Vintner and wine judge Louisa Thomas Hargrave discusses the history of winemaking and current trends in production and consumption.



### WORKSHOP

#### Making Gold-Wire Jewelry

Sunday, 5/20,

10:00 a.m.–4:00 p.m.

Gold wire has been used in jewelry making since antiquity. Honey Jeanne Laber and Marsha Davis guide students through basic gold-wire

techniques used in creating earrings, pendants, bracelets, and necklaces.

### FAMILY AND CHILDREN'S PROGRAMS

#### NEW! Alien Workshop

Sunday, 5/20, 11:00 a.m.–

12:30 p.m. (Ages 4–5,

each child with one adult) and

1:30–3:00 p.m. (Ages 6–7,

each child with one adult)

Can life exist on other planets?

Children participate in experiments that might help answer that question and take home their own "alien."

#### AstroFavorites: The Earth and Space Collection

Thursdays, 5/10, 17, and 24

4:00–5:30 p.m. (Ages 4–6,

each child with one adult)

A discounted series of astronomy workshops: Earthly Adventures, Solar System Adventures, and The Sun and Its Energy on three consecutive Thursdays.

### INFORMATION

Call 212-769-5100 or visit [www.amnh.org](http://www.amnh.org).

### TICKETS AND REGISTRATION

Call 212-769-5200, Monday–Friday, 9:00 a.m.–5:00 p.m.,

or visit [www.amnh.org](http://www.amnh.org). A service charge may apply.

All programs are subject to change.

**AMNH eNotes** delivers the latest information on Museum programs and events to you monthly via email. Visit [www.amnh.org](http://www.amnh.org) to sign up today!

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The Hayden Planetarium

### HAYDEN PLANETARIUM PROGRAMS

#### TUESDAYS IN THE DOME Virtual Universe

#### Out of This Galaxy

Tuesday, 5/1, 6:30–7:30 p.m.

#### Celestial Highlights

#### Parade of Planets

Tuesday, 5/29, 6:30–7:30 p.m.

### HAYDEN PLANETARIUM SHOWS

#### Cosmic Collisions

Journey into deep space—well beyond the calm face of the night sky—to explore cosmic collisions, hypersonic impacts that drive the dynamic forma-

tion of our universe. Narrated by Robert Redford.

*Cosmic Collisions* was developed in collaboration with the Denver Museum of Nature & Science; GOTO, Inc., Tokyo, Japan; and the Shanghai Science and Technology Museum. Made possible through the generous support of CIT. *Cosmic Collisions* was created by the American Museum of Natural History with the major support and partnership of the National Aeronautics and Space Administration's Science Mission Directorate, Heliophysics Division.

#### SonicVision

Fridays and Saturdays,

7:30 and 8:30 p.m.

Hypnotic visuals and rhythms take viewers on a ride through fantastical dreamspace.

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## ENDPAPER

# Where Eagles Swim

By Annie Prevost

**E**normous, swiftly moving dark wings first catch my eye, then a white head and a tail, as I walk along Mineral Point on San Juan Island, Washington. Bald eagle—the thought flashes through my brain—diving like a missile after a seagull. I am riveted by the pair. The eagle misses, rises, turns sharply, and plunges again; the hapless gull doesn't stand a chance. Into the ocean they both tumble. Repeatedly the eagle goes underwater as the gull fights for its life. Other agitated seagulls dive-bomb the eagle, and a lone crow joins the fray.

Soon enough, the struggle ceases. Then slowly, with great effort, the eagle begins flapping its six-foot-wide wings through the water, not heading skyward, but swimming, towing its quarry toward shore. When soaring in the sky, an eagle is the crowning symbol of effortless power and speed. The swim I am watching, though, is flight in slow motion—ponderous, laborious, anything but effortless.

Now the eagle appears to be barely moving. To reach the shore it must swim the length of two football fields placed end to end. With the gull clutched in its talons, it moves as though it's dragging a sea anchor. Won't fatigue and hypothermia set in? And won't the long swim consume as many calories as the seagull will provide? Yet the eagle perseveres. The other birds disperse, and I won-

der whether I will have to watch all afternoon to see the eagle finish its swim to shore.

**T**wo years earlier, I watched a similar scene unfold from my mother's waterfront condo in West Vancouver, British Columbia. That day, too, an unusual motion in the water caught my eye. Grabbing binoculars, I saw an eagle floundering and thrashing at the surface. Not yet knowing that eagles could swim, I thought the bird was drowning. Then I saw that it was trying to lift a large white object, what I guessed to be a dead seagull. Soon the eagle gave up and with a mighty flap rose from the water with empty talons. But before I could put down the binoculars, it swooped back to the water's surface with enough momentum to grab its catch and fly off in triumph.

I've since learned that eagles have a hard time raising their wings once they're in the water. That's why, instead of attempting a liftoff, they swim considerable distances to shore. Perhaps they'd rather face a long

swim than abandon their catch.

When I look again at my San Juan eagle, I'm surprised to see how much progress it has made in ten minutes of swimming. Even without binoculars I can see its erect white head and white tail fanned out over the ocean surface, as it steadily muscles those great wings through the water. It swims with both wings in sync, a butterfly stroke without the benefit of a leg-driven dolphin kick.

About fifty feet from shore the eagle suddenly takes flight, rising into the air while the seagull floats limply in the water. But not for long. I should have guessed from my earlier sighting: the eagle circles, swoops down, and hooks the prey. Then, like an overloaded bomber, it flaps heavily away, the gull dangling from its talons like a sack of flour. The eagle, I would guess, has been in the water between fifteen and twenty minutes.

I move for a better view, in the hope of seeing it land. Across a small bay atop some steep rocks I spot the familiar dark brown and white form. I strain to see the white head moving up and down as it feeds. And I imagine I can just make out the gull's white feathers fluttering down the rocks. If only I had my binoculars.

*ANNIE PREVOST is a writer and a keen observer of the natural world who lives in northwest Washington.*



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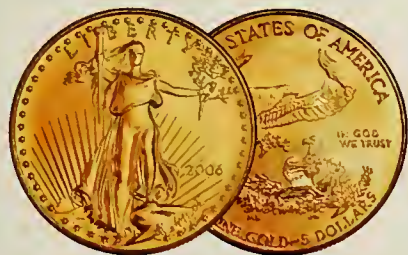
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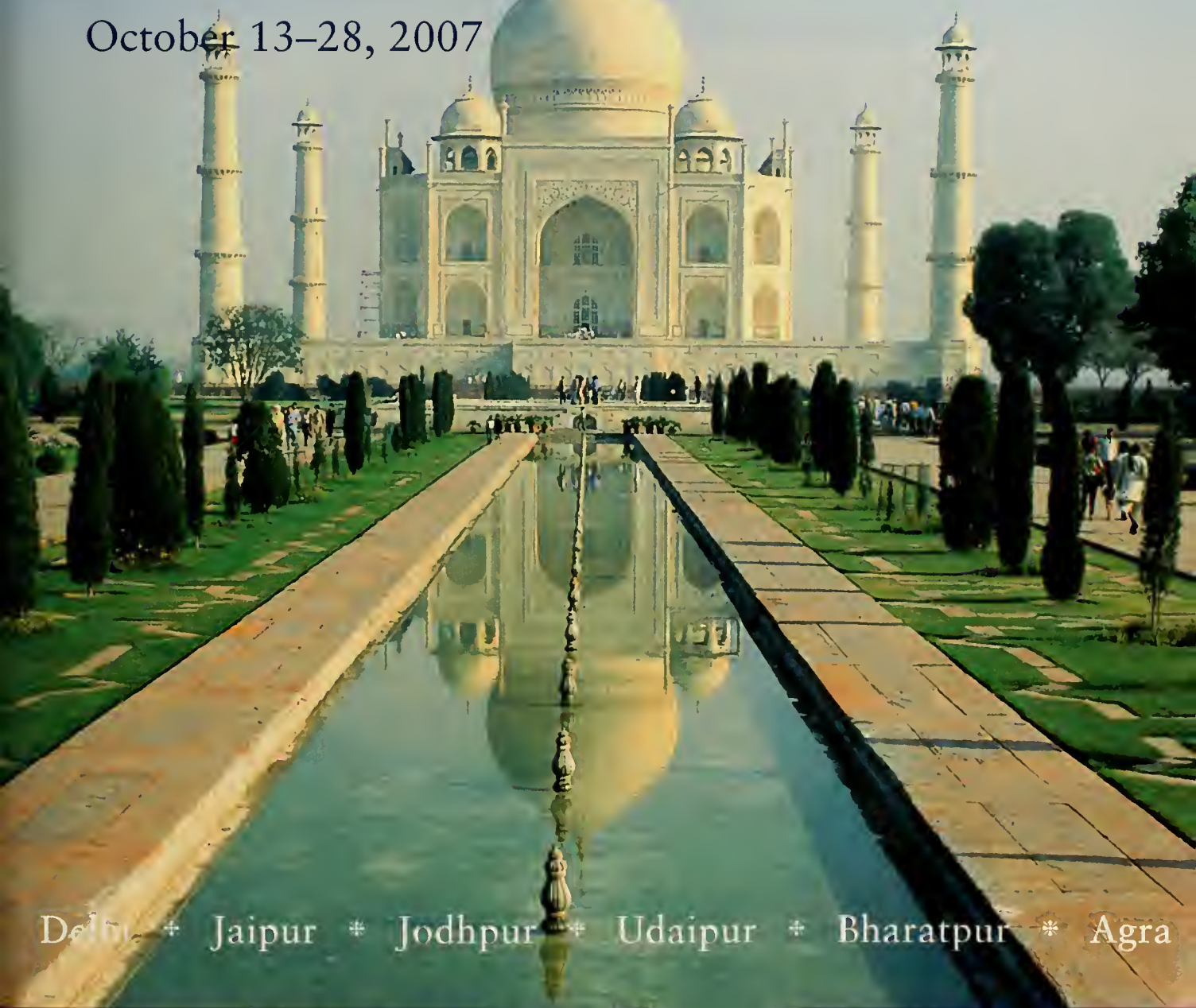


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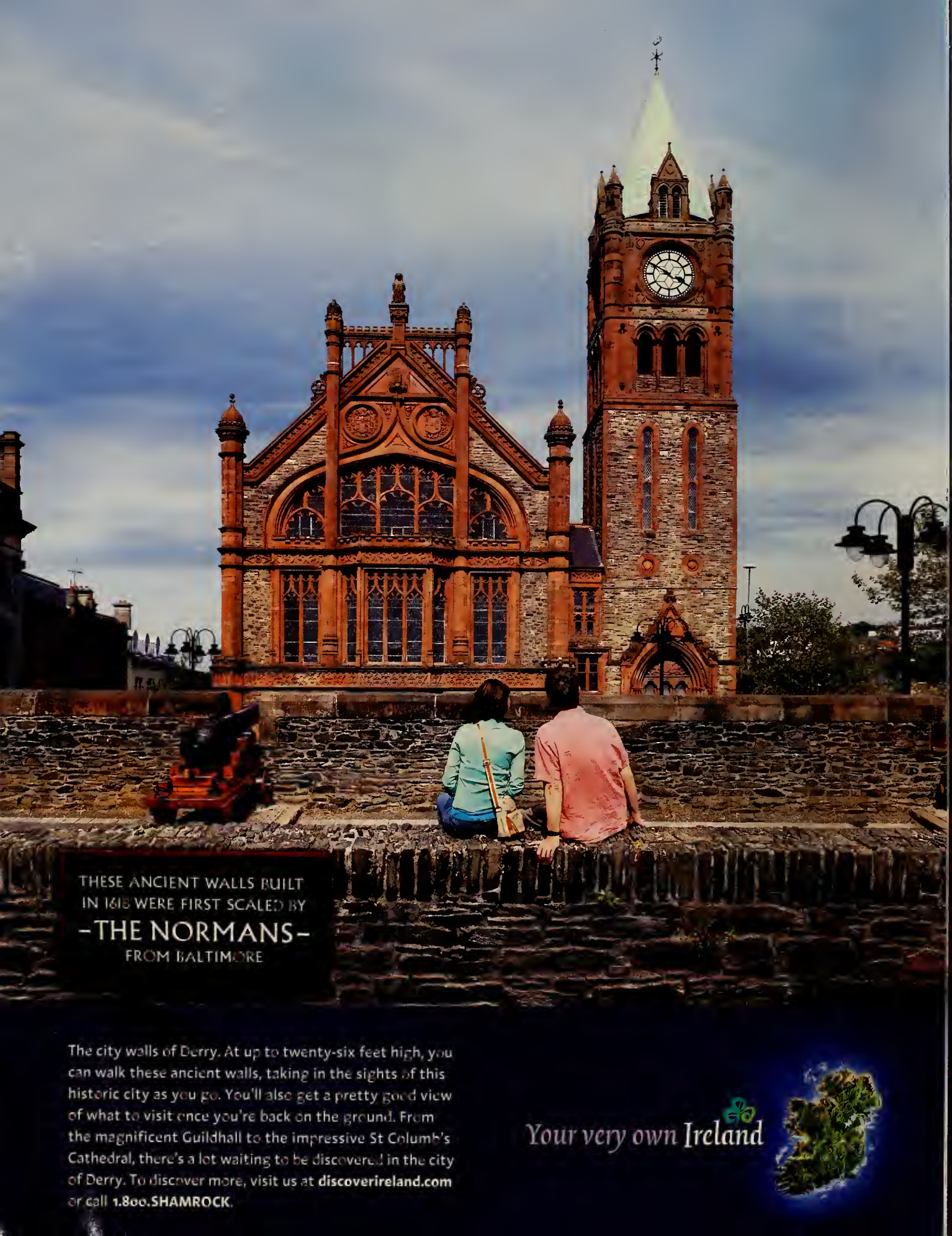


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