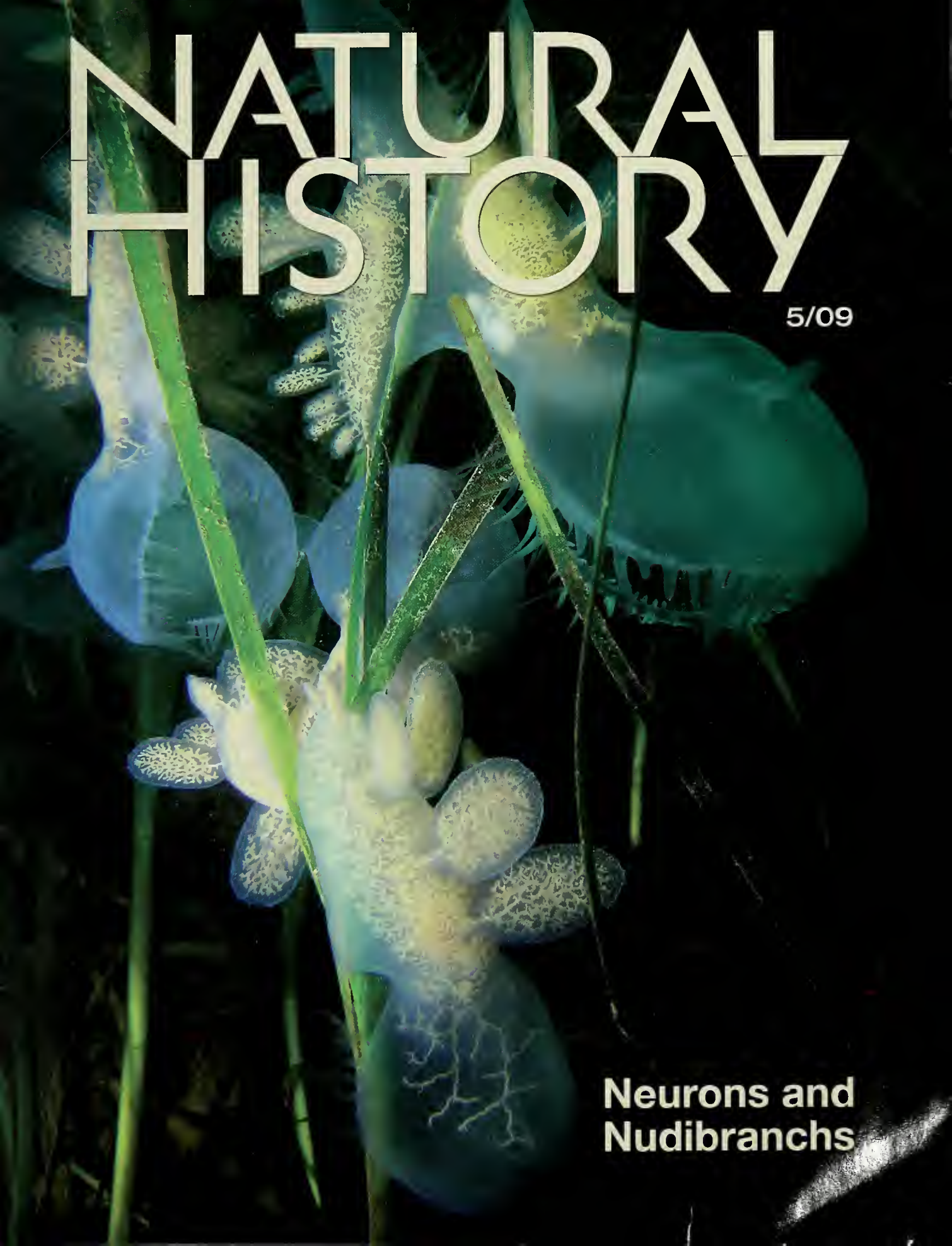
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Neurons and Nudibranchs

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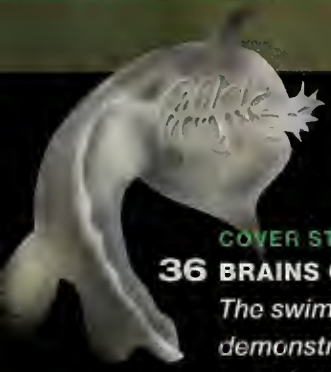

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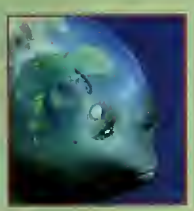

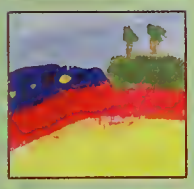

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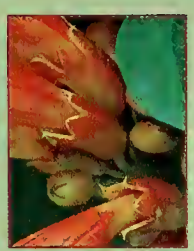

ON THE COVER: *Melibe leonia* amid eel grass in the Pacific Ocean, off the coast of Washington. *Photograph by Jan Kocian*

THE NATURAL MOMENT

DADDY'S BROOD

Photograph by Glen Threlfo

◄ *See preceding two pages*

THE NATURAL EXPLANATION BY ERIN ESPELIE

When Australian bird expert Glen Threlfo spotted a male comb-crested jacana (*Irediparra gallinacea*) preparing a nest on the pads of a lotus pond in the Northern Territory, he decided to build a "skybox" to watch the action unfold. He plopped an old wooden table in the shallow water, placed atop it a big cardboard box with a cutout viewing window, and returned to his seat periodically for the next several weeks.

After the hen laid eggs, Threlfo noticed that she flew the coop, so to speak, and "wandered around feeding, with no interest in the nest or the offspring." (On larger ponds or billabongs—seasonal water holes—a female will sometimes mate with as many as four different males and spend her time fighting intrusive females.) Instead the male took on all caretaking duties, as most jacana fathers do. He incubated the eggs for about two weeks, scooping them up under his wings and moving them if the flimsy nest sank slightly.

Upon hatching, the chicks immediately nestled under their father's wings, a refuge they continued to use for many days—for instance, whenever a hawk or raven appeared. (Note the two pairs of legs dangling from the father's wings in the photograph above.) But with every passing day they foraged farther for insects and pond veggies, navigating the lilies on their own long, unwebbed toes.

Threlfo points out that the father was able to protect the chicks from afar, too: "He makes a shrill chirping alarm, and all the chicks dive under a lily leaf and just poke their little beaks out for breathing." They only surfaced at the sight of their father's form, come to rescue them—never at the sight of a curious, looming Threlfo.

The jacana triplets live in Kakadu National Park, a cultural and natural World Heritage site in the tropics of northern Australia. Local Aboriginal leaders recently squelched the plans of a mining company to dig up the 4 billion dollars' worth of uranium deposits surrounding Kakadu. The area's 1,700 plant species, dozens of unusual mammals (some in dire straits already), and 280 species of bird—roughly one-third of Australia's bird species—will certainly benefit from such under-the-wing care.

Although **Glen Threlfo** dabbles in still photography, he specializes in filmmaking. He worked on a documentary for BBC TV on Queensland rainforest bowerbirds (shown on PBS's *NOVA* in the United States), and just recently helped to produce, with filmmaker David Warth, a wide-screen documentary called *Rainforest—the Secret of Life* for the Australian national broadcaster ABC TV. Threlfo also works as a guide for birders in Lamington National Park in Queensland, Australia.

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WORD EXCHANGE

Live and Let Live

Richard J. King's article, "To Kill a Cormorant" [3/09], brings to light the fact that man is everywhere a disturbing agent, and that human overpopulation is bringing planet Earth to its knees. Our own survival depends upon cooperation with our environment. We humans need to learn that we are not the center of the natural world.

Jim and Ginger Visconti
Monticello, Florida

Erratum

In "You Can't Hide, Glycolaldehyde" ["Samplings," 3/09], ribose was called "the backbone of RNA." In fact, ribose molecules and phosphate groups form that backbone.

NATURAL HISTORY *welcomes correspondence from readers. Letters should be sent via e-mail to* nhmag@naturalhistorymag.com *or by fax to 646-356-6511. All letters should include a daytime telephone number, and all letters may be edited for length and clarity.*

nature.net by robert anderson

WANDERLUST

So far as humans know, the world record for longest nonstop flight by a land bird is held by E7, a female bar-tailed godwit. In 2007, as a satellite tracked her, she flew 7,200 miles from Alaska to New Zealand in eight days. The Web site of the U. S. Geological Survey's Alaska Science Center (http://alaska.usgs.gov/science/biology/shorebirds/barg_updates.html) displays the bird's route. With recent improvements in technology, satellite tracking is answering many questions about animal movements across the globe. Godwits were monitored to learn how a deadly bird flu might be transmitted someday, but wildlife managers are collecting similar data from birds, sea mammals, and fish with an eye to helping far-flung species in decline. For my guide to Web sites exploring migration please visit the magazine online (www.naturalhistorymag.com).

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

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Drawing on the Wall

Modern Australia lacks big land predators, but until about 30,000 years ago, the continent was ruled by *Thylacoleo carnifex*, the marsupial "lion." Several well-preserved skeletons of the leopard-size beast have been found. Now, a newly discovered cave painting offers a glimpse of the animal's external appearance.

In June 2008, Tim Willing, a naturalist and tour guide, photographed an ancient painting on a rockshelter wall near the shore of northwestern Australia. Kim Akerman, an independent anthropologist based in Tasmania, says the painting unmistakably depicts a marsupial lion. It shows the requisite catlike muzzle, large forelimbs, and heavily clawed front paws. And it portrays the animal with a striped back, a tufted tail, and pointed ears. Those last three features aren't preserved in skeletons, but Aborigines would have known them well. Australia's first people landed on the continent at least 40,000 years ago and were contemporaries of the big predator.

Reconstruction of a marsupial "lion"; cave art suggests the animal had stripes.

Previously known rock paintings hinted at marsupial lions, but were rudimentary and could have depicted the other striped marsupial predator, the dog-size Tasmanian "tiger." That species succumbed to competition from humans in 1936, much as the marsupial lion may have done millennia before. (*Antiquity*) —*Stéphan Reebs*

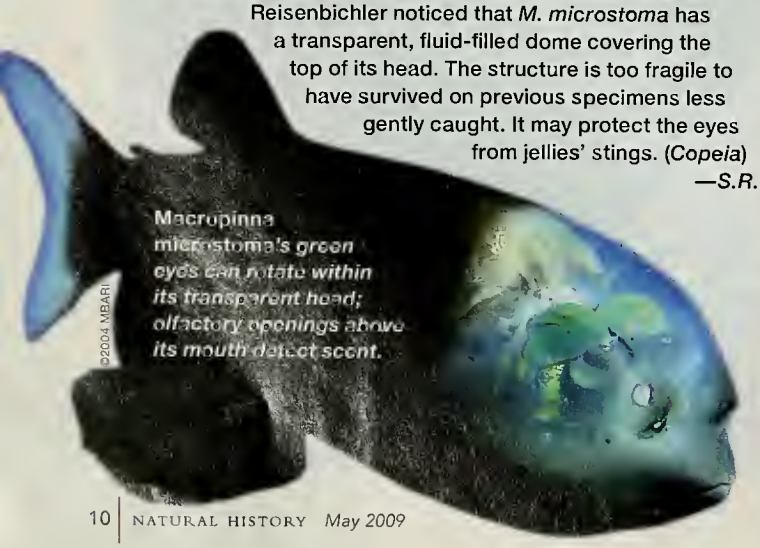
Tube Viewing

Of all the odd creatures in the sea, barreleyes are among the strangest. The deep-sea fishes have bizarre tubular eyes that point upward. The eyes are good at spotting quarry silhouetted against the dim light above, but they can't see what's right in front of the mouth. So, how do the animals feed?

Up to now, barreleyes were known only from dead specimens caught in trawl nets. That changed when Bruce H. Robison and Kim R. Reisenbichler of the Monterey Bay Aquarium Research Institute sent a remotely operated vehicle 2,000 feet undersea off California. Video observations of three barreleyes, of the species *Macropinna microstoma*, revealed that the fish could pivot their eyes forward, after all.

The ichthyologists captured one fish and carefully brought it to the surface, where it survived for a few hours in a shipboard tank. When they turned its body so the head pointed up, it swivelled its eyes to keep looking up, bringing the area in front of the mouth into its view. Barreleyes may feed just so, launching from below to steal food from the tentacles of jellyfish.

Rounding out the barreleyes' peculiarity, Robison and Reisenbichler noticed that *M. microstoma* has a transparent, fluid-filled dome covering the top of its head. The structure is too fragile to have survived on previous specimens less gently caught. It may protect the eyes from jellies' stings. (*Copeia*) —*S.R.*



Macropinna microstoma's green eyes can rotate within its transparent head; olfactory openings above its mouth detect scent.

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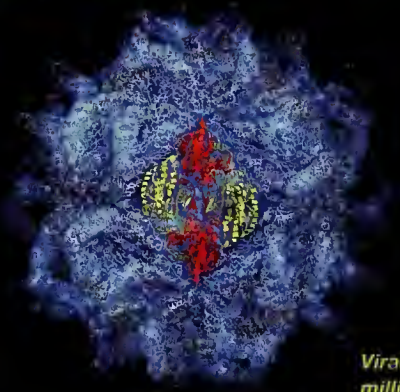
Portrait of a Virus



Viral shell 1.5 million times actual size

The colorized image above shows the outer shell, or "capsid," of *Penicillium stoloniferum* virus F (PsV-F). It was created by postdoctoral fellow Junhua Pan and his adviser, Yizhi Jane Tao of Rice University in Houston, along with eight colleagues. They used cryoelectron microscopy to image the virus, X-ray crystallography to infer its atomic structure, and advanced computing methods to re-create it in 3-D.

Viewed on a computer, the 3-D re-creation shows all 120 copies of the single protein that makes up the capsid—each copy in the right position. (Four appear above in red and yellow.) The computer can even pinpoint each of the five million or so atoms that constitute the 120 proteins.

PsV-F is a double-stranded RNA virus that infects a fungus closely related to the producer of penicillin. Understanding its capsid structure in such detail may inspire new strategies to fight off infections in humans by other double-stranded RNA viruses. (*PNAS*) —*S.R.*

J. PAN & Y.J. TAO/RICE UNIVERSITY

American Red Cross

Measles remains a deadly killer that threatens children worldwide. The Measles Initiative, which has supported the vaccination of more than 500 million children in over 50 countries, is a partnership committed to reducing measles mortality.

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Burial by Hyena

LUCINDA BACKWELL

Fossil human hair magnified 300×

The oldest known human hair belonged to a 9,000-year-old mummy disinterred from an ancient Chilean cemetery. Until now: a recent discovery pushes the record back some 200,000 years. (And the newly discovered strands received a rather less dignified burial.)

While excavating in Gladysvale Cave, near Johannesburg, South Africa, a team of researchers from the University of the Witwatersrand discovered an ancient brown-hyena latrine. Upon inspection, hyena coprolites—fossilized dung—appeared to contain uncannily hair-like structures.

Lucinda Backwell, a paleontologist in the group, took a sediment block containing several coprolites back to the lab for a closer look. She and a colleague carefully removed forty of the "hairs apparent" from one of the coprolites and subjected half to scanning-electron microscopy. Sure enough, fossilized hairs they were, and five showed remarkably preserved surface scales.

Comparing the scales to those of a variety of animals—an admittedly tricky undertaking—Backwell's team concluded that human hairs were the best match. Dating of the cave's limestone layers showed that the dung had been deposited sometime between 257,000 and 195,000 years ago. During that period, both early *Homo sapiens* and a relation, *H. heidelbergensis*, roamed the South African landscape.

A couple of chilling explanations spring to mind as to how human hairs might have become lodged in hyena dung. Backwell thinks it most likely that a brown hyena scavenged an ancestral human's remains. (*Journal of Archaeological Science*)

—*Sarah Hoffman*

Half a Nap

Many diurnal birds migrate only at night, and surprisingly, they don't appear to suffer unduly from sleep loss. Restless at night during migratory season even in the lab, they still perform well on learning tests, for example. The key to their resilience may be a string of quick daytime naps, a new study suggests.

Biologist Thomas Fuchs of the University of Pittsburgh at Johnstown had already noticed that migrating Swainson's thrushes spend just 5 percent of their daylight hours—when they rest from flying—with their eyes closed. To confirm that the birds were indeed sleeping, Fuchs and three collaborators recorded the brain waves of seven captive thrushes. They found that the birds' repeated eye closures, which usually lasted twelve seconds, did coincide with true sleep.

Thrushes, like many other birds, sometimes sleep with only one eye shut. And Fuchs's recordings confirmed that when one eye is closed, only the opposite brain hemisphere is dozing. As other studies have found, half a brain and one eye are better than none at all: that so-called "unihemispheric sleep" helps birds react quickly to signs of trouble. Thus predators have less chance of catching the weary travelers napping. (*Biology Letters*)

—*S.R.*

JIM BRANDENBURG/MINDEN PICTURES

Swainson's thrush

Reach for the Sky

Anyone who has seen giant sand dunes, the tall ones stretching many hundreds, even thousands, of feet across the desert floor, has surely wondered how they get to be so big. Scientists, too, have deliberated the question for years. The sandy behemoths form in China, the Sahara, Namibia, and Iran, among other desert areas, and they come in ridge, star, or crescent shapes.

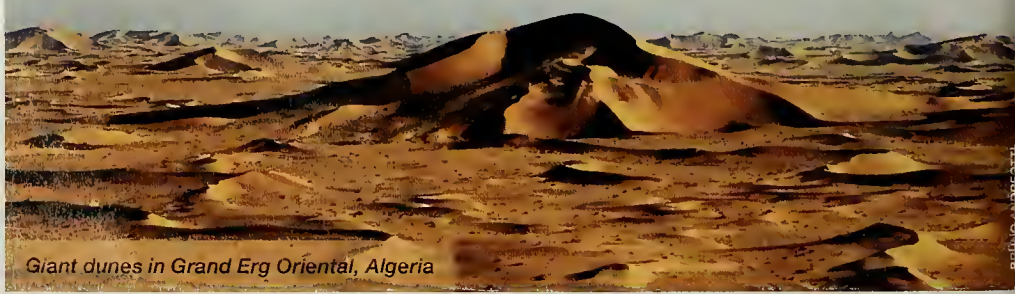
Bruno Andreotti and Philippe Claudin of the Laboratory of the Physics and Mechanics of Heterogeneous Media in Paris and colleagues now have some answers. The team studied giant-dune fields on-site, analyzed aerial and satellite photos and meteorological data, and ran aerodynamic models to investigate dune growth.

No matter the shape, giant dunes grow by the amalgamation of smaller dunes, the researchers discovered. Their ultimate size depends upon the average thickness of the lowest layer of the atmosphere, which starts at Earth's surface and within which heat recirculates. The thickness of this convective layer varies from several hundred yards near the ocean to more than a mile above inland deserts, owing to annual variations in ground temperature.

Winds flowing over dune fields are constrained within that layer. As dunes grow wider and taller, they confine the wind flow slightly more, which, in turn, arrests the dune's growth.

So, the thicker the layer, the bigger the dunes. Reaching heights of 1,600 feet or more, star dunes in the Badain Jaran Desert of north central China may be the biggest. (*Nature*)

—*Harvey Leifert*



Giant dunes in Grand Erg Oriental, Algeria

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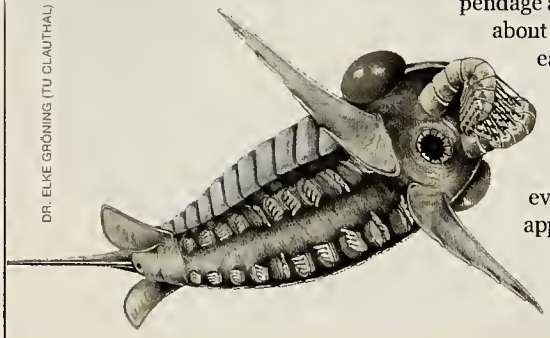
The Little Pinch

While cutting slate for roof shingles in the 1990s, a German quarry worker spotted a four-inch fossil embedded in one of the slabs. His sharp-eyed discovery has enabled paleontologists to fill a major gap in the evolution of early arthropods, says Gabriele Kühl, a Ph.D. candidate at the University of Bonn. With her professor, Jes Rust, and Derek E. G. Briggs of Yale, she analyzed the new fossil.



DR. ELKE GRÖNING (TU CLAUTHAL)

Schinderhannes bartelsi, as the team named the specimen, represents a new marine genus and species that lived in the Early Devonian epoch, some 400 million years ago. On its head, the specimen bears a pair of "great" appendages—spiny, segmented projections—that probably helped it wrangle food.

Until now, paleontologists had thought such great-appendage arthropods died out about 100 million years earlier. They're thought to share a common ancestor with scorpions and horseshoe crabs, whose pincers evolved from ancestral appendages.

From its deadly-looking appendages and large eyes, *S. bartelsi* was likely a predator with good eyesight, the team concludes. It had tail flukes and unique finlike pectoral structures that probably made it a fast, agile swimmer.

Unfortunately, the quarry that over several decades yielded *S. bartelsi* and many other Devonian fossils has been closed for economic reasons. Paleontologists must wait for new fossils to turn up elsewhere—or hope that slabs already excavated may fill some of the remaining gaps in arthropod evolution. (*Science*) —*H.L.*

Schinderhannes bartelsi: *the fossil, right, and an artist's reconstruction, below left*

Nutcracker Suite

Come lunchtime, bearded capuchin monkeys place hard nuts on one stone and crack them open with another. That skill places them in the elite tool-using set among animals. The monkeys, it now seems, are quite deliberate in their work. New research shows that they carefully select the right "hammer" for the job, and carry it to an "anvil" some distance away, a habit until now known only in chimpanzees.

A team of primatologists led by Elisabetta Visalberghi, of the Institute of Cognitive Sciences and Technologies in Rome, tested wild bearded capuchins in the Brazilian forest. Along with nuts, they offered the monkeys two or three kinds of hammer stones—hard siltstone versus brittle sandstone, or heavy versus light quartzite, for example. The capuchins almost always picked one that was heavy and hard enough for nutcracking, then carried it and the nuts to an anvil a few feet away. When the researchers slyly presented different stones made to look alike, the monkeys handled them first to judge their usefulness.

What's more, field observations suggest that to open softer food items, such as seeds or fruits, the monkeys choose lighter, easier-to-carry stones that are still hard enough to do the job. The behavior shows that capuchins can plan ahead for a task, Visalberghi and her team say.

Those feats of intelligence aren't limited to one species. Another team of biologists recently reported hammer and anvil use in yellow-breasted capuchins. (*Current Biology, Primates, American Journal of Primatology*) —*S.R.*

Bearded capuchin hammers open a nut.

ELISABETTA VISALBERGHI

THE WARMING EARTH

Ozone and the Greenhouse

Ozone-depleting chemicals are becoming scarce in Earth's atmosphere, and the ozone layer is on the mend. That's thanks to the Montreal Protocol of 1987 and its amendments, an international agreement banning ozone-munching chemicals. But global warming also influences the layer's recovery, and whether it is hurrying or hindering the process varies by location, a new study shows.

Less ozone means more ultraviolet-ray exposure and an elevated risk of skin cancer. Greenhouse gases have a cooling effect way up in the stratosphere, which helps slow the chemical reactions that destroy ozone. Lower down, of course, the gases have a warming effect. Unfortunately, that warming alters airflow patterns back up in the stratosphere, in ways that interfere with ozone recovery.

Darryn W. Waugh, an atmospheric scientist at Johns Hopkins University in Baltimore, and several colleagues ran a computer simulation that takes those contradictory influences into account. Probably because of differences in the airflow changes, the outcome varies from place to place.

The simulation predicts that at northern mid-latitudes the ozone layer will effectively heal, returning to its pre-1960 state by 2040, many decades earlier than without climate change. In the tropics, on the other hand, ozone levels will indefinitely stall 20 percent short of a full recovery. At southern mid-latitudes and the South Pole—where the infamous hole persists—recovery will be slow, but the layer should return to its pre-1960 state by the end of the century. (*Geophysical Research Letters*) —*S.R.*

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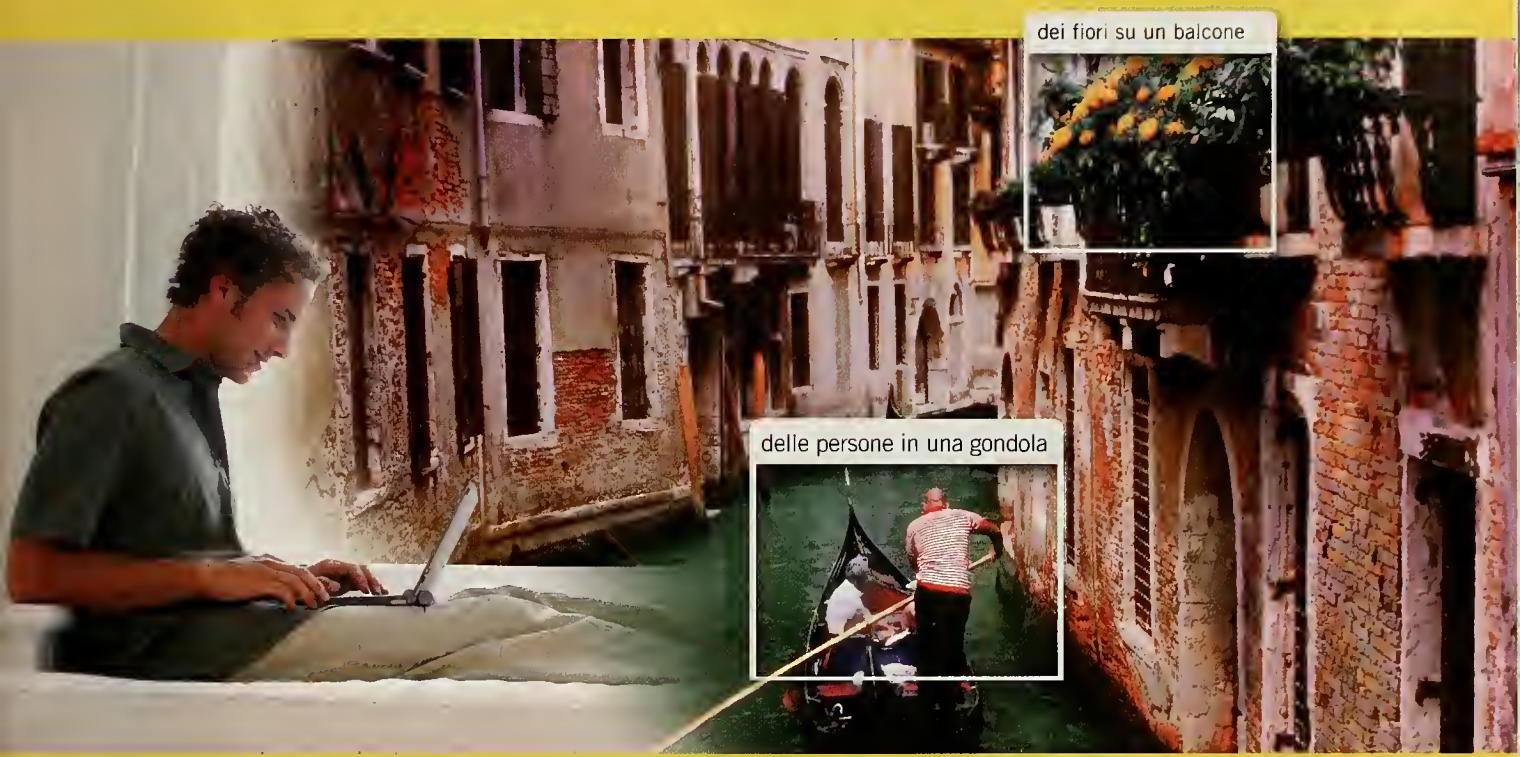

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In Science We Trust

Beliefs about the natural world that are present in infancy influence people's response to evolutionary theory.

By Paul Bloom

A minority of Americans subscribe to an unusual theory about the origin of people and other animals. They are often adamant about the truth of this theory, and believe that it is the only one that should be taught to children. But if you press them on the theory's details, their answers are muddled. It turns out that these people understand little of what they are defending; they are just parroting back what they have heard from others. Who are they?

They are Darwinians—people who claim to believe in evolution by natural selection.

That may be surprising. Aren't creationists, after all, the ones who are supposed to be ignorant and irrational? The word minority was a tip-off, though. In the United States there are many more creationists than Darwinians. About half of Americans polled by *Newsweek* in 2007 claimed that evolution did not occur at all—that God created humans in their present form. Most of the rest conceded that evolution might occur, but guided by the hand of God. More than twice as many Americans believe in the virgin birth of Jesus Christ as in natural selection.

Why do so many people reject evolutionary theory? Some scientists fault the educational system, and call for more and better biology classes. Others see this state of affairs as a manifestation of the powerful role of religion in American culture. But in collaboration with Deena Weisberg, a postdoctoral fellow at Rutgers University, I have drawn upon research in cognitive science to defend a different view. We suggest that the psychology of those who reject evolutionary theory is not so different from that of people who endorse it.

MIA STELLA

Conceptually correct painting of Earth and its layers from crust to inner core, made by seven-year-old Mia Stella. Usually children do not achieve a coherent understanding of a spherical Earth until they reach the age of twelve or thirteen. Younger children resist the idea because they think all people and things on the opposite side would fall off.

Consider first that all babies have certain beliefs and expectations. Babies can't tell us so, but developmental psychologists have studied what surprises and what bores a baby, based on how long the baby looks at something. They conclude that babies have a foundational understanding of the physical and social worlds. By about four months, and perhaps even earlier, babies expect objects to fall if unsupported; they know that objects continue to exist when hidden; and they demonstrate surprise if one object passes through another. They know that if you put an object behind a screen and then put another object there, when the screen drops two objects should be revealed, not one or three.

Babies can also make sense of the actions of moving social beings and respond appropriately to those actions. Yale psychology graduate student J. Kiley Hamlin, Yale psychologist Karen Wynn, and I have presented six- and ten-month-old babies with a puppet show in which one character is helped up a hill by another and pushed down by third. When the babies are then offered the opportunity to touch the two puppets, they almost always reach for the "helper," not the "hinderer." And when they watch the climber puppet "make friends" with one of the others, ten-month-olds show surprise (by staring longer) if the climber befriends its "enemy."

None of this should be unexpect-

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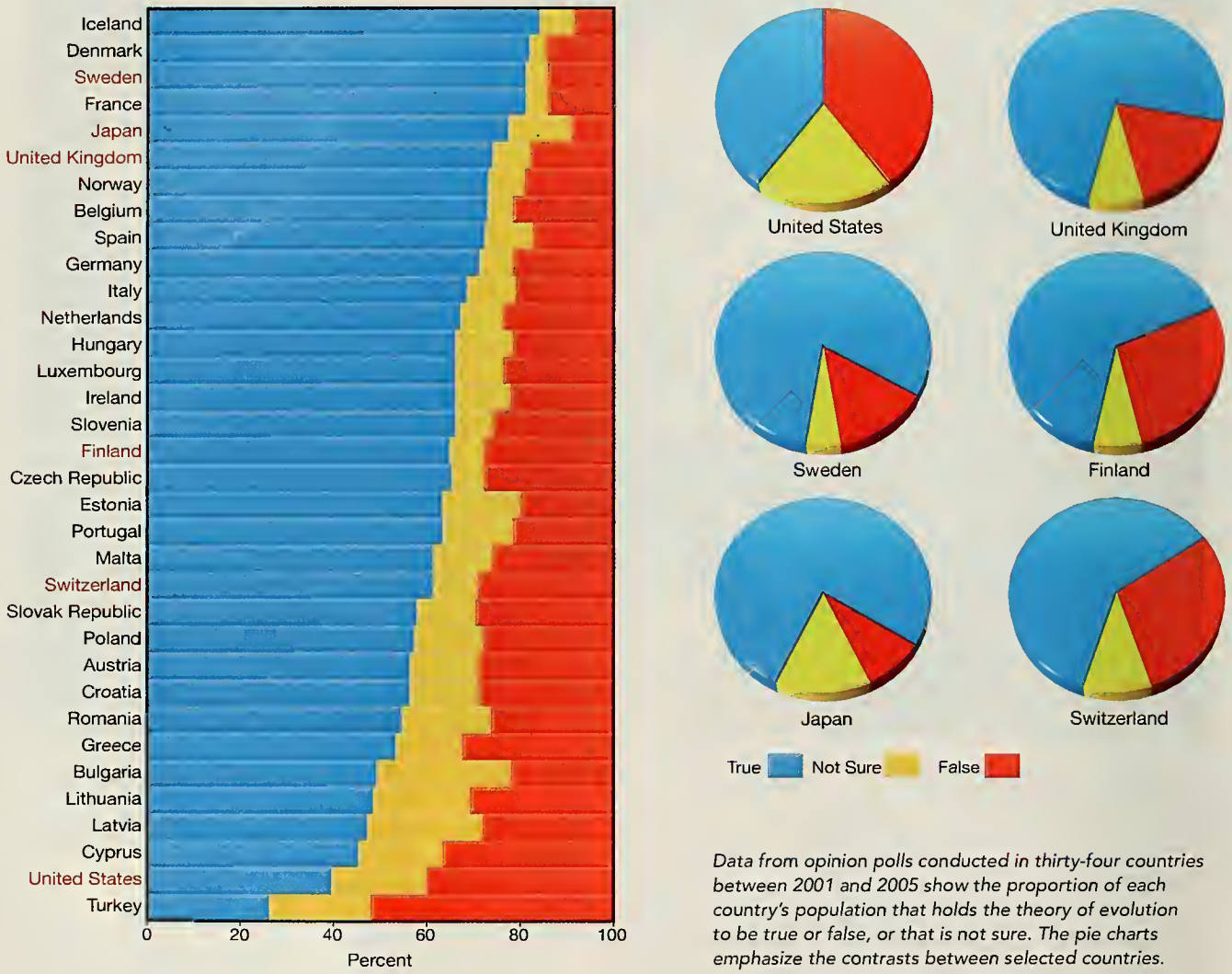


TOM MOORE

Data from opinion polls conducted in thirty-four countries between 2001 and 2005 show the proportion of each country's population that holds the theory of evolution to be true or false, or that is not sure. The pie charts emphasize the contrasts between selected countries.

ed. Such physical and social assumptions mesh nicely with the world we live in—objects do fall down, it is better to interact with someone who is a helper—and this innate knowledge gives babies a head start in interacting with and learning about objects and people. The problem is that advanced scientific theory clashes with many of these commonsense biases. Objects may seem solid, but they are mostly empty space. It seems as if objects fall downward, but they fall toward a spherical Earth.

This clash leads to problems. As psychologist Susan Carey of Harvard University puts it, the main difficulty with teaching science to children is "not what the student lacks, but what the student has, namely alternative conceptual frameworks for understanding the phenomena covered by the theories we are trying to teach."

One example is the shape of the Earth. Children's belief that unsupported objects fall downward is adaptive in the world we live in, but it makes it hard for them to see the world as a sphere—if it were a sphere, they can't help thinking, the people and things on the other side would fall off.

It is difficult for children to shake this view. It is not until the age of about twelve or thirteen that children demonstrate a coherent understanding of a spherical Earth. In some striking experiments, the psychologist Stella Vosniadou and her colleague W. F. Brewer, then of the University of Illinois at Urbana-Champaign, found that when children are taught about the Earth, they often distort the scientific understanding in systematic ways. When asked to draw the Earth or model it with clay, for instance, some children depict it as a sphere with a flattened top or as a hollow sphere that people live inside.

Something similar happens in the domain of evolution. There is by now a large body of research suggesting that humans are natural-born creationists. When we see nonrandom structure and design, we assume that it was created by an in-

telligent being. George Newman, a postdoctoral associate at Yale, along with Yale psychologist Frank C. Keil, showed three- to six-year-olds a picture of either a messy or a neat pile of toys, followed by a picture of either a teenage girl (identified as the toy owner's big sister) or an open window (letting in the wind). Children as young as three said that both the sister and the wind could have caused the disorder, but that only the sister could have caused the orderly arrangement. In another experiment, Newman and colleagues found that even one-year-old babies look longer, indicating surprise, when a computer animation shows a neat pile to be caused by a rolling ball.

This makes perfect sense; the creation of order typically requires intelligence. As the prominent Texas congressman Sam Rayburn once put it, "Any jackass can kick a barn down, but it takes a carpenter to build it." Although Darwin showed how a nonintelligent process driven by random variation and differential selection can create complex structure—design without a designer—that is an unnatural idea, and children and adults balk at it.

Psychologist Deborah Kelemen of Boston University, for instance, finds that children insist that everything has a purpose. Educated Western adults believe that human-made artifacts have purposes (cars are to drive around in) and that body parts have purposes (eyes are for seeing), but young children take this further, saying the same for animals (lions are for being in the zoo) and for natural entities (clouds are for raining).

And psychologist Margaret Evans of the University of Michigan found the most direct evidence for natural-born creationism. She carried out a series of studies in which she asked children flat out where they believe animals come from. Their favorite answer is God. That is true of children whose parents are fundamentalist Christians—no surprise—but it is also true for children whose parents accept the theory of natural selection! Evolutionary biologist Richard Dawkins was right to complain, then, that it seems "as if the human brain were specifically designed to misunderstand Darwinism."

Those built-in biases cannot be the whole explanation of adult resistance to science. Humans might start out as natural-born creationists, but some end up as Darwinians. Culture must play a role.

In one recent study of the acceptance of evolutionary theory in thirty-four countries, the United States came in second to last. The only country more Darwin-resistant was Turkey [*see chart on opposite page*].

There are also differences within societies that need to be explained. What is special about the 14 percent of Americans who, in another study, asserted that natural selection is definitely true?

Looking within the United States,

the difference between Darwinians and creationists does not reduce to smarts or education: studies of college students found no difference in how well (or poorly) they understood the theory of evolution, whether they believed it was true or not and no matter how much biology they'd studied. When researchers asked the students who endorsed Darwinian beliefs to explain the theory of natural selection, their answers were on average no more accurate than those of the students that rejected evolution. Many in each group misunderstood the theory, coming up with something closer to Lamarck's view than Darwin's.

So while an evolutionary biologist might argue that giraffes evolved long necks because the ones with longer-than-usual necks got more food from trees and hence tended to have more offspring, many students would say that it is useful to have a long neck and so (somehow) giraffes will have longer-necked children. They believe, as Lamarck did, that there is some mysterious force that causes animals to become better adapted to their environments, and they confuse this with modern evolutionary biology.

What distinguishes, then, Darwinians and creationists? A likely answer to this question emerges from the more general question of how we come to learn about the world. Some of our beliefs emerge through personal experience, which is how a person knows the taste of an apple, the color of her house, or the sound of his child's voice. Some beliefs emerge through conscious deliberation, which might apply to the views about evolution that a scientist or theologian might hold. But most of what a person knows is learned from other people, through hearsay or testimony.

It is only from other people that we even know where and when we were born, and who our parents are. If you think about it, little of your knowledge of the world actually comes from your own direct experience. As the philosopher Martin Kusch of the University of Cambridge in England points out, "Our teachers, parents and friends, as well as the media of mass communication teach us close to everything we know about history, and much about the social and natural worlds we live in." Kusch notes that if you were to strip away from your mind all knowledge acquired through testimony, very little would remain.

We are smart when it comes to social learning. Even children know enough to trust the testimony of some people more than that of others, and to trust different people on different subjects. Four- and five-year-olds, for instance, are aware that adults know things that other children do not, such as the meaning of the word *hypochondriac*. When given conflicting information about a word's meaning from a child and from an adult, they prefer to learn from the adult—unless the adult is proven to be unreliable. They also know that adults have varied areas of expertise, that doctors know about fixing broken arms and mechanics know about fixing flat tires. They prefer to learn from a knowledgeable speaker rather than from an ignorant one.

There is nothing irrational about deference to authority. Some sort of "division of cognitive labor" is essential in any complex society, where any single individual lacks the resources to evaluate all the claims that he or she hears. Scientists themselves defer all the time; any researcher has to draw upon the work of others, taking certain results and ideas on faith. And certainly nonscientists defer. I know that $E=mc^2$, and that the Earth is billions of years old, but I cannot give arguments for either of those claims. I believe them because I trust that the sources are reliable. I have faith in science.

Not everyone shares that faith. The second reason why creationism is so popular, apart from its intuitive naturalness, is that in some societies (including the United States), religious and political authorities favor it, and some people have chosen to defer to them. It is not that most creationists have assessed the scientific arguments and found them wanting. Instead, it is a matter of trust. Some people trust their pastor over their science teacher, the Pope over Richard Dawkins.

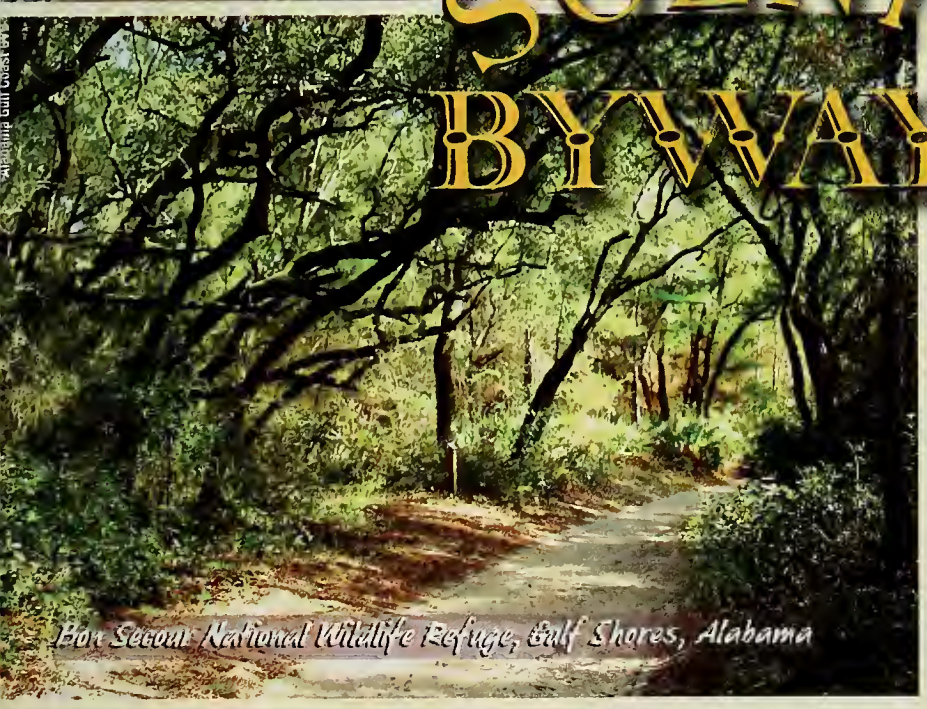
Deference has implications for science education. If it is important to have an educated public in domains such as evolution, stem-cell research, diet, and global warming, the goal should not necessarily be to teach citizens the specifics of the relevant scientific argument. Life is too short for nonspecialists to learn the relevant facts and theories in all of these domains.

Rather, it is worth making the more general point that the community of scientists really does have a legitimate claim to trustworthiness—scientific inquiry involves procedures, such as experiments and open debate, that are strikingly successful at revealing truths about the physical and biological world. The success of science is also evident from its practical applications, everything from antibiotics to airplanes.

Further, one should emphasize that when it comes to learning about nature and the cosmos, a scientific consensus, because it has been rigorously tested and questioned, carries more weight than a political or religious one. Anyone interested in diminishing the resistance to science in the United States should focus on convincing people that this characterization is true by teaching children how science works, and why.

Paul Bloom is a professor of psychology at Yale University. Bloom has written for scientific journals such as Nature *and* Science, *and for popular outlets such as the* New York Times, *the* Guardian, *and the* Atlantic. *He is the author or editor of four books, including* How Children Learn the Meanings of Words *(The MIT Press, 2000) and, most recently,* Descartes' Baby: How the Science of Child Development Explains What Makes Us Human *(Basic Books, 2004).*

SCENIC BYWAYS



Relax and Recharge Your Batteries in Arizona

Top: Enjoying the rosy sand beaches and sparkling waters of Lake Powell; below: Birding at Patagonia Lake State Park.

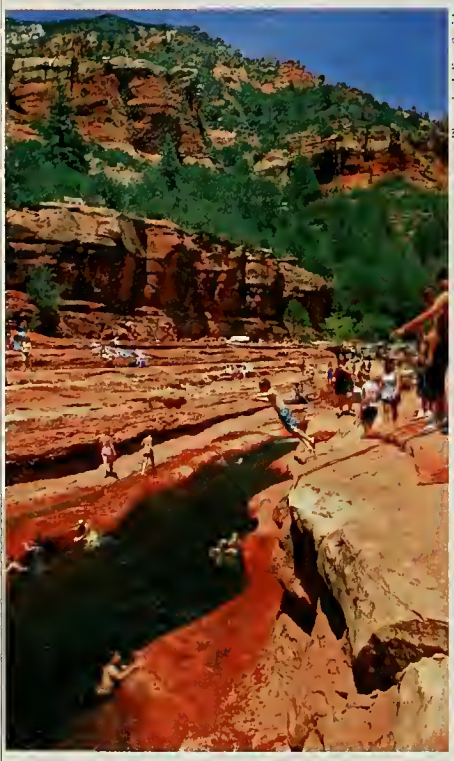


Photo by Julian Smith

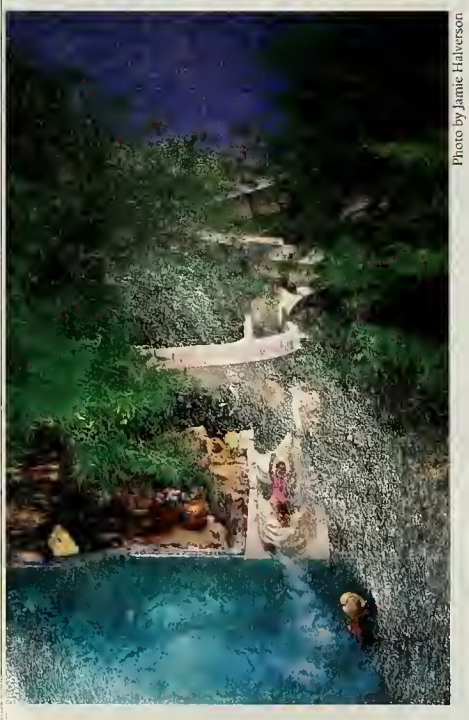


Photo by Jamie Halverson

Above left: Splashing in the natural waterslide at Slide Rock State Park; bottom left: Sliding at Sidewinder Water Park.

ARIZONANS thrive on a special way of life in the great outdoors. The state prides itself on a relaxing, open-air lifestyle that takes full advantage of sunny skies and the beauty of its landscape. Entertainment options in Arizona are as wide open as the stunning scenery: first-rate golf, world-class spas, fine outdoor dining and casual nightlife. This state of dramatic deserts and vistas also offers some very inviting ways to refresh yourself with a splash or more of water. If you're visiting Phoenix or Tucson, you'll find water parks galore. And many Arizona resorts also offer water park amenities.

If you enjoy swimming or water sports while communing with nature, you'll find some great opportunities around the state. Arizona even has its own natural waterslide. Slide Rock State Park, located in lush Oak Creek Canyon, takes its name from a 30-foot-long waterslide formed by the natural erosion of the rocks of the creek bed. Visitors can slide down this slick natural water chute or wade and sun along the creek.

How about playing in the water in one of the most beautiful places in the world? Lake Havasu, in northwestern Arizona, offers sparkling waters amid a craggy desert backdrop and 450 miles of beautiful shoreline. With Lake Havasu City as your base, you can launch your own watercraft or rent a boat or jetski for the day. Or take in the scenery with a cruise on an authentic paddlewheel boat.

You can also enjoy all manner of lake activities at Lake Powell, the second largest man-made lake in the U.S. Lake Powell is surrounded by spectacular rock canyons and unusual formations. The lake, which is 186 miles long and 400 feet deep, has nearly 2,000 miles of shoreline, with rosy sand beaches to walk along. You can explore its scenic coves by powerboat or personal watercraft or enjoy other water pastimes such as swimming, fishing, scuba diving, snorkeling, water skiing or ski tubing.

Tucked away in the rolling hills of southeastern Arizona is a hidden treasure. Patagonia Lake State Park overlooks a 265-acre man-made lake where anglers catch crappie, bass, bluegill, and catfish. Whitetail deer roam the hills, and great blue herons stalk the shoreline. The tracks of the New Mexico/Arizona railroad lie beneath the lake, and remnants of the old historic line may be found at the Nature Conservancy in Patagonia.

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ARIZONA
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Hobnob with Tucson's Astronomical Stars

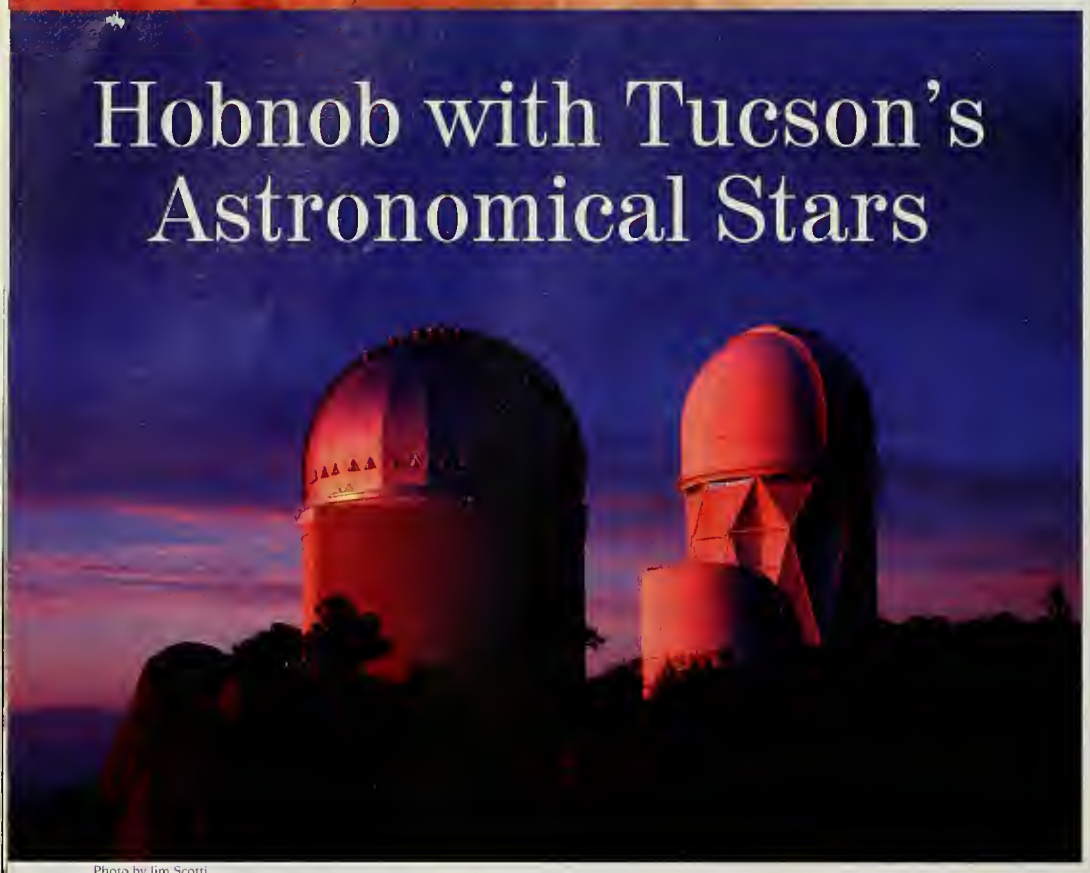


Photo by Jim Scotti

Left: Kitt Peak National Observatory, one of the world's leading observatory complexes; below: scenic mountains surrounding Tucson

TUCSON'S cloudless skies, clean air, and low humidity make it an ideal city for stargazers. Averaging 350 nights of clear skies each year, Tucson is home to some of the world's top observatories and astronomy research facilities, giving amateur astronomers unparalleled access to the stars.

On the Tohono O'odham reservation just south of the city, Kitt Peak National Observatory is part of the National Optical Astronomy Observatory (NOAO) and boasts the world's largest collection of optical telescopes. For more than a decade, Kitt Peak's Visitor Center and observatories have offered visitors a chance to view the night sky and learn about planets and distant galaxies through three powerful telescopes.

Atop 9,157-foot Mt. Lemmon, the University of Arizona's brand-new Mount Lemmon SkyCenter invites the public on an overnight adventure to glimpse the heavens through a powerful 24-inch telescope. Mt. Lemmon is also home to NASA's 40- and 60-inch Steward Observatory telescopes, which aid in detecting near-earth asteroids and minor planets in our solar system. Steward also houses an on-campus observatory in midtown Tucson, which offers public lectures and nighttime viewings.

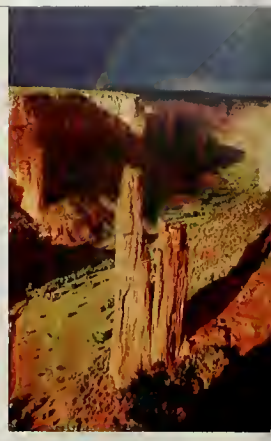
The Smithsonian Institution's Fred Whipple Observatory, located in Southern Arizona near the town of Amado, is better known by its location, Mt. Hopkins. This is the largest field installation of the Smithsonian Institution Astrophysical Observatory (SAO) outside Cambridge, MA. Since October 1968, it has been used as the site for experiments requiring extremely dark skies, dry climate, and good "optical seeing." Visitors can take a narrated shuttle ride up a 10-mile road to the working research center and observatory at the mountain top. In addition to witnessing science in action, the views from the peak can't be beat.

Astronomy enthusiasts can also get their fill of cutting-edge research and information from the University of Arizona's top-tier science and astronomy programs. UA scientists recently collaborated with NASA on an exploratory mission to Mars, and you can learn about this exciting space adventure at the UA's Science Operations Center. UA teams helped launch and successfully land the Phoenix spacecraft after a 422-million-mile trip to the red planet. The robotic lander studied soil samples in search of water and potential habitability and transmitted the data back to scientists at the university.

For more information about Southern Arizona astronomy adventures, go to **www.visitTucson.org/visitor/outdoor/astronomy.**

Photo by James Randklev

Destination Beauty



Right: Spider Rock at Canyon de Chelly National Monument; left: Navajo weaving and other crafts have become world-renowned art forms

THE NAVAJO NATION is home to wondrous scenic roads that weave a web through high desert, mountains, valleys, canyon country, lakes and one of the longest continuously inhabited landscapes of North America. The **Dinétah "Among the People" Scenic Road** is a 105-mile thread that weaves its way from I-40, near the Arizona/New Mexico border, north to Canyon de Chelly National Monument on Navajo Routes 12 and 64.

Spider Rock, inside the Monument, is a spectacular red sandstone monolith standing over 800 feet high. Spider Woman, who is said to live on Spider Rock, is among the most important and honored deities of the Diné (Navajo) people. It was she who taught the Diné ancestors of long ago the art of weaving on a loom. Through generations, weaving has evolved amongst the Diné to become a world-renowned art form.

When driving Dinétah Scenic Road, it soon becomes apparent how the beauty of nature influences the design and color of Navajo weaving. Navajo rugs, blankets and tapestries, yarn, tools, looms, plants for dyes, classes and weavers can all be discovered along Dinétah Scenic Road.

This same thread also weaves its way through Window Rock, Arizona, capital of the Navajo Nation. With a landmass covering over 27,000 square miles, the Navajo Nation is the largest Native American tribe in the United States. The Diné people, culture, tradition, history, recreation, scenery—it's all woven together to experience on the Navajo Nation. Visitors can discover how to weave a tapestry of memories along Dinétah Scenic Road at **www.NavajoScenicRoads.com**.

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Huachuca Mountains

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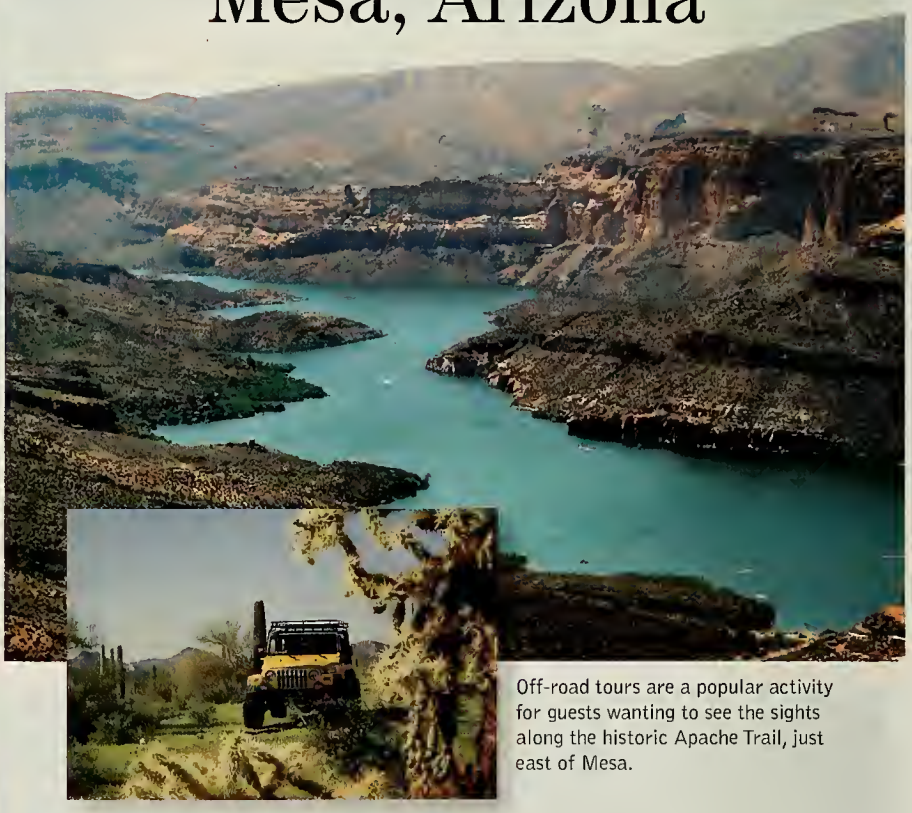
Take a picturesque bike ride on the mountain trails of the Coronado National Forest, along the rural back roads or on the miles of the City's multi-use paths.

Amaze at the smoke-and-mirrors exhibits in the U.S. Army Military Intelligence Museum on Fort Huachuca. With displays of a camera-in-a-fake-tree-branch and an original German Enigma encryption machine, the museum is a spy-lovers dream.

For those whose childhood excitement was playing cowboys and Indians, the Fort Huachuca Museum chronicles the history of the U.S. Army in the Southwest.

Go to **VisitSierraVista.com** or call the Sierra Vista, Arizona Visitor's Center at 1-800-288-3861 for more information.

Scenic Discoveries in Mesa, Arizona



Off-road tours are a popular activity for guests wanting to see the sights along the historic Apache Trail, just east of Mesa.

ONE OF THE most popular day trips for anyone visiting Mesa is up the historic **Apache Trail** through the ghostly and volcanic Superstition Mountains which rise some 2,000 feet into the desert sky and into the foothills of the Tonto Natural Forest—the fifth largest forest in the United States. Hidden in the depths of this forbidding range is the Lost Dutchman, one of the most storied "lost mines" of the West. To this day, the area continues to pay homage to its Western roots which took shape in the late 1800s. On this scenic drive guests will encounter an authentic Old West stagecoach stop, a ghost town, the famous Elvis Presley Chapel, and the majesty of a mountain lake, all nestled in the beautiful Sonoran Desert landscape that captures the true essence of Arizona.

Nature lovers can view countless species of birds, Big Horn sheep, deer and javelina roaming freely through the landscape, while adventure lovers can hike, mountain bike, waterski, kayak or wind sail. The more than 28 miles of cactus-dotted shoreline leave visitors in awe of Arizona's beauty.

For those seeking a more guided path, plan an outing with one of the many skilled desert outfitters that specialize in the area. At the end of the day, be sure to catch sunset on the wondrous rock formations that line the Apache Trail offering up a photo op like no other with deep hues of red, purple, orange and crimson illuminating this storied desert landscape.

For more on planning your visit to Mesa, Arizona call 480-827-4700 or go online at **www.VisitMesa.com** and request a complimentary Mesa Visitors Guide.

Explore Holbrook, Arizona's Frontier Gateway

HOLBROOK, ARIZONA, has been a frontier town since it was founded in 1881. It's still the real West, where tumbleweed blows into town from the desert. First on the frontier were cowboys, cattle ranchers and railroaders. The majestic 1898 Old West Courthouse, on the National Register of Historic Places, is the centerpiece of the town. You can still visit the legendary Bucket of Blood Saloon, where many a cowboy wet his whistle.

From the 1930s through the 1950s, the explorers were the travelers of fabled **Route 66**, known as the Main Street of America. And today's explorers are likely headed for the timeless mysteries and beauties of Indian Country. Holbrook is a great home base for a tour of Navajo, Hopi and Apache country.

Backtrack at the Arizona Museum of Natural History

IMAGINE A DAY trip in Arizona that can lead you all the way back to the time of the dinosaurs, then guide you through the early world of the native peoples who inhabited the state, and bring you back up to date through some of the state's most vivid historical periods. You'll find all this and more at the Arizona Museum of Natural History in the city of Mesa.

The museum's Dinosaur Hall hosts full-scale replicas of well-known dinosaurs, and its award-winning Dinosaur Mountain, with a three-story waterfall, thrills visitors with roaring animatronics dinosaurs and a simulated flash flood every 23 minutes complete with thunder and lightning. The museum's permanent Southwest Gallery explores prehistoric Hohokam culture, including replicas of Hohokam dwellings and artifacts from various stages of their history.

Visit the museum's Historic 5 C's Courtyard to learn about the importance of Arizona's 5 C's—citrus, copper, cattle, cotton and climate. The exhibit includes vibrant murals as well as living citrus trees and cotton plants. And don't miss the Arizona in the Movies collection of movie memorabilia to learn Arizona's role in the shaping of Hollywood during the heyday of Western filmmaking. And for a powerful view of the state's majesty and magic, visit the Arizona Highways' Photo Gallery.

Visit **www.AzMNH.org** or call 1-480-644-2230 for more information.

Above: St. Thomas Indian Mission is just one of the sites where you can explore Yuma's rich history; right: Yuma is the gateway to the Imperial Sand Dunes National Recreation Area, a favorite with off-roaders and moviemakers, too.

Nature, history—and the river that made them. That's what Yuma is all about.

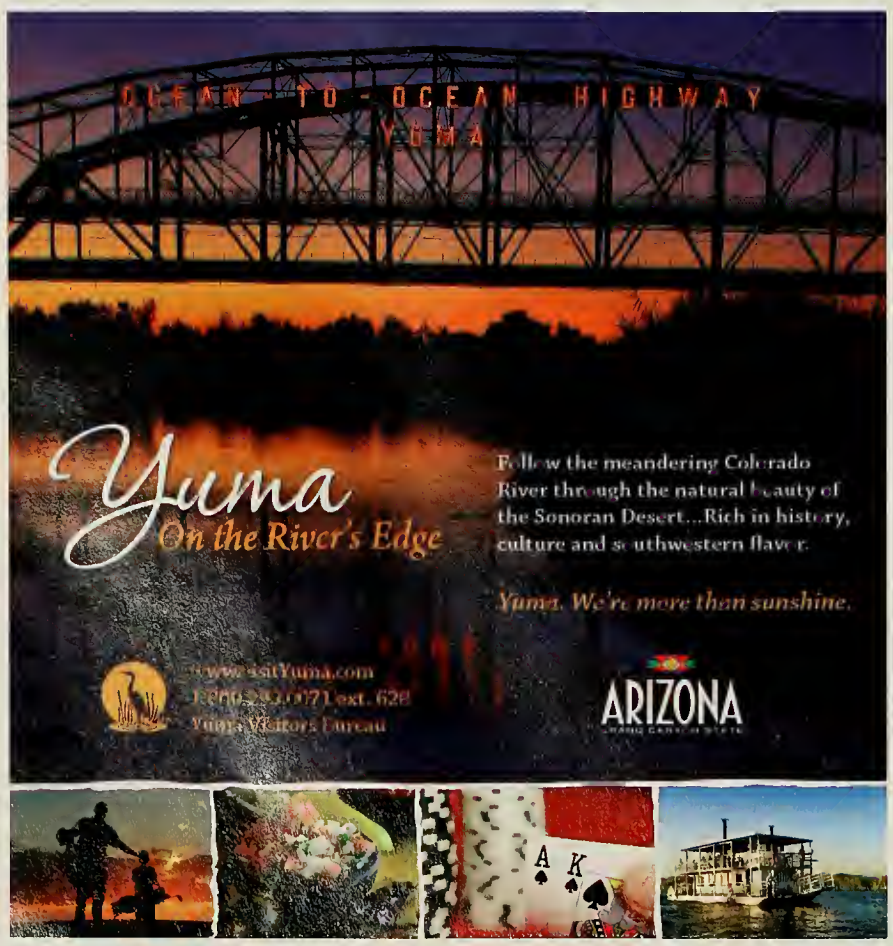
OUR GEOGRAPHY shaped the Southwest. Because the Yuma Crossing was the safest spot to ford the Colorado, all roads led here for travelers from the early Spanish explorers to Okies fleeing the Dust Bowl.

That rich heritage is showcased at two state historic parks (Yuma Territorial Prison and the Quartermaster Depot) and by local, tribal, military and private museums.

Stand at Pivot Point on the historic riverfront and listen to the "ghost train" arrive where the first train entered Arizona in 1875. Or ride miles of paved bike paths and hike the East Wetlands, one of the Southwest's largest environmental restoration projects.

If you want rugged outdoor adventure, Yuma's the perfect jumping-off spot to hundreds of square miles of wilderness in the Imperial, Kofa and Cibola national wildlife refuges, and the gateway to the Imperial Sand Dunes—a hot spot for off-roaders and movie makers alike.

And with the Colorado River running through it, Yuma offers lots of wet fun all year round, from a quiet paddle to waterskiing. Take a jet boat tour into unspoiled terrain where wildlife abounds or stake out a fishing spot along miles of backwater channels.



Browse or download our Visitors Guide at **www.visityuma.com** or call 1-800-293-0071 for more information.

Follow the River Road from Baton Rouge into Plantation Country

Houmas House Plantation and Oak Alley along the Great Mississippi River Road

BATON ROUGE is the gateway to Louisiana's fabled sugar cane country, which lies on either side of the Mississippi as it winds its way to New Orleans. Follow the **Great Mississippi River Road** to famous plantations that have been restored to their former grandeur. The very name River Road inspires a vision of white-columned mansions standing amid lush gardens and giant oaks dripping with Spanish moss.

Oak Alley has been called the Grande Dame of the Great River Road, and its quarter-mile canopy of giant live oaks forms a dramatic avenue leading to the classic Greek Revival-style antebellum home. At Laura, a Creole plantation built in 1805, you'll enter the indigenous Creole world of Louisiana. An award-winning guided tour called the *Creole Family Saga* details 250 years of true-life stories of Creole women, slaves and children.

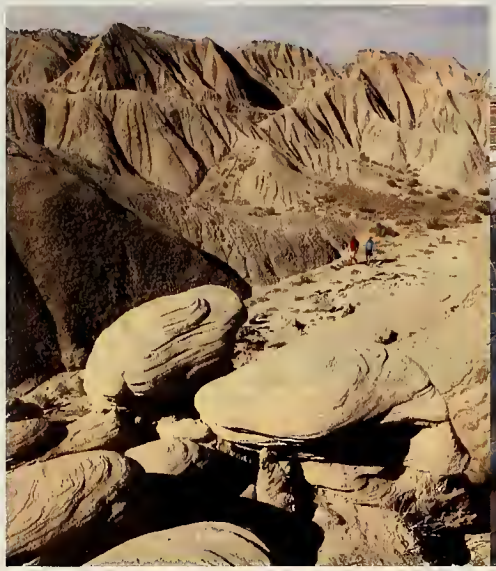
Houmas House Plantation and Gardens has reclaimed its position as the River Road's crown jewel. The original French Provincial house from the 1700s is adjoined by a carriageway to the main mansion, known during its heyday as the "Sugar Palace." Majestic Nottoway, the largest remaining antebellum mansion in the South, has also been carefully restored to its days of glory.

Be sure to stop at the River Road African American Museum, with exhibits covering 300 years of history, detailing the legacy of Africans in America. And don't forget to stop for a meal at the Cabin, which combines southern Louisiana history and authentic Cajun cuisine in the River Road tradition.

Go to **www.visitbatonrouge.com** or call 1-800-LAROUGE for more information.

Follow in the Footsteps of Explorers, Pioneers and Native American Trailblazers in Nebraska

NEBRASKA'S great novelist Willa Cather wrote of her state, "We come and go, but the land is always here." And this quintessential heartland of America is just as compelling now as it was in her day. In Nebraska, you'll find yourself following in the footsteps and wagon tracks of fabled pioneers, gold miners, explorers, and adventurers. Along the way, you'll encounter Native American cultures and geological wonders of prehistoric creatures. The state's nine historic and scenic byways reflect the dramatic range of Nebraska's history, culture and landscape.



Lunar-like formations at Toadstool Geologic Park near Crawford present a relaxing lesson on erosion.

In the Rhino Barn at Ashfall Fossil Beds State Historical Park near Royal, visitors can view fossils just as they were found.

Toadstool Geologic Park: R. Neibel, Nebraska DED; Ashfall Fossil Beds: M. Forsberg, Nebraska DED

The **Lincoln Highway Byway** traverses the state from east to west, along the route of the nation's first transcontinental highway, where you can view old Pony Express stations, sod houses, and even wagon ruts from the Oregon Trail. Stop at the Hastings Museum of Natural and Cultural History. For a quick immersion in pioneer history, follow the Heritage Highway through fertile farmland and along historic main streets. Museums along the byway showcase the area's Native American tribes and early settlers. You'll find still more history along the **Western Trails Historic and Scenic Byway**, a main thoroughfare of the great western migration in the mid-1800s that now attracts outdoor enthusiasts to fish, view bald eagles, or ride in a covered wagon around Chimney Rock. The **Gold Rush Byway**, which runs from South Dakota to Colorado, traces the route of gold miners past the landmarks of Courthouse and Jail Rocks as well as the rugged Pine Ridge.

Sandhill cranes: R. Neibel, Nebraska DED; Homestead National Monument: J. Nabb, Nebraska DED

Above left: Half a million sandhill cranes migrate along the central Platte River valley every spring; left: Homestead National Monument of America showcases pioneer history.

The **Outlaw Trail Scenic Byway** will take you to Ashfall Fossil Beds State Historical Park, where you can see Nebraska's ancient history unearthed, and to adventure on the Niobara National Scenic River, one of the nation's top paddling destinations. Travel Nebraska's heartland along the **Loup Rivers Scenic Byway**, named for the rivers that flow through rolling farmland and ranches, friendly small towns and the Sandhills. Follow the **Sandhills Journey Scenic Byway**, considered one of the country's most scenic routes, to explore this still remote and unique ecoregion. The **Bridges to Buttes Byway** will take you further into untamed Nebraska. Hike or bike into the vast prairie grasses of Oglala National Grassland or marvel at the lunar-like landscape of Toadstool Geologic Park. Or go back to the land of trappers, traders, buffalo and Native Americans along the **Lewis & Clark Scenic Byway**.

For additional information, log on to **www.VisitNebraska.gov/byways** or call 877-NEBRASKA to request a free copy of the *Nebraska Travel Guide*.

Alabama's Gulf Coast

Burrowing owl rests along the Alabama Coastal Birding Trail

Alabama Gulf Coast CVB

ALABAMA'S southern tip is one of those places where even first-time visitors find a connection and **Alabama's Coastal Connection Scenic Byway** is a treasure to those who discover it. Gulf, bays, lagoons and bayous offer scenic views and recreational opportunities for most every interest. While enjoying a stroll along the shore at sunset or a quiet sail on the back waters suits some, others may opt for more exciting recreational opportunities like the offshore fishing that is a popular pastime here.

History buffs will find plenty to explore, as well. Historic Forts Gaines and Morgan stand united around the mouth of Mobile Bay and tell the stories of battles and soldiers of earlier times. Exceptional museums chronicle the history of heritage of several communities along the coast.

The Dauphin Island Audubon Sanctuary, Bon Secour National Wildlife Refuge and Gulf State Park provide more than 12,000 acres of protected lands along the coast. Weeks Bay National Estuarine Research Reserve is one of only 29 such reserves nationally and is literally where the soil meets the sea. These vast natural assets are complimented by smaller municipal parks and trails and by the sites along the Alabama Coastal Birding Trail.

A variety of accommodations are available, making the shore accessible to those looking for a campsite, a family-friendly beach house, a luxury hotel or anything in between. Special events offer a wide range of experiences including music festivals, historic re-enactments, sporting events and celebrations of seafood, just to name a few.

Whether families on the annual vacation, couples seeking a secluded getaway, birders searching for that rare sighting, or history buffs combing the forts, all can find a connection here. Alabama's Coastal Connection has much to share and it beckons travelers to learn more about The Waters, Ways and Wildlife of Alabama's Gulf Coast.

Call 866-324-7776 or visit **AlabamasNaturalCoast.org** for more information.

From Beaches and Birds to Chateau Country in Delaware

YOU COULD travel the length of Delaware in a mere two hours. But its three counties are nearly as diverse as three different countries. You'd barely scratch the surface if you spent a night in each. And you'll find that this little state with moderate temperatures and pleasant breezes has more than a country's worth of natural, historic and cultural attractions to keep you there. Linger on its beaches; stop at roadside farm stands; explore wildlife refuges; have a night out under city or casino lights; and tour the famous du Pont estates.

A journey through the genteel **Brandywine Valley Scenic Byway** will take you into the rolling hills of the countryside known as Chateau Country, replete with historic sites, magnificent estates, and glorious gardens. Or take the **Red Clay Valley Scenic Byway** to the Mt. Cuba Center dedicated to the conservation of Appalachian Piedmont plants and the Ashland Nature Center, with its Butterfly House and nature trails winding through meadows and marshes.

Delaware's Coastal Heritage Scenic Byway (Route 9), from historic New Castle almost to Dover, traverses 50 miles of the state's carefully preserved shore, unparalleled on the East Coast. You'll pass villages and working farms, and you'll find some great birding along the way. The route's generous stretches of unspoiled marshland include the Thousand Acre Marsh, the largest freshwater tidal wetland in northern Delaware. You'll find easy access to the Bombay Hook National Wildlife Refuge, with its handy observation towers, and to the adjacent Little Creek Wildlife Area.

Rolling hills of the Brandywine Valley Scenic Byway

Start the exploration at **www.visitdelaware.com.**

Brains of Bea

The swimming styles of sea slugs demonstrate how malleable neural circuitry can be.

BY PAUL S. KATZ AND
JAMES M. NEWCOMB

uties

Melibe leonina, a hermaphroditic shell-less mollusk, is one of some 3,000 nudibranch species, and one of only 2 to 3 percent that can swim. The authors explore the structure and evolution of the neural circuits that enable the animal to do so.

Attack of the Killer Sea Star!

The camera pans across an underwater setting, the Puget Sound mud flats. Enter a sunflower sea star, menacingly waving all twenty-four arms, studded with 15,000 sucker-tipped tube feet. Our humble hero-heroine, the hermaphroditic sea slug *Tritonia diomedea*, seems to stand no chance: it moves at one-fifth the speed of the sea star, gliding so slowly along the seafloor that we must use time-lapse photography to catch it mid-creep. One tube foot makes contact with the sea slug! Is the end near?! Sensing a kill, the sea star lurches forward to get its mouth positioned over the slug so that it can evert its stomach, digest the sea slug, and suck in its snack. Apparently doomed, the sea slug starts to thrash. First, it flattens its body horizontally. Then it jackknifes, making its mouth touch the underside of its tail. Next, a backbend: the top of its head touches the dorsal side of its tail. Death throes? No—*Tritonia*, it turns out, can swim! Sort of. Although direction can't be controlled, the rhythmic flexions (seven or eight over a minute) somersault the sea slug up off the mud and into the safety of a passing ocean current. Finally, under the closing credits, the sea slug lets itself sink down through the silty water and into the mud, where it goes back to its usual slow, creeping ways.

Of the thousands of species of sea slugs that grace the Earth's oceans, fewer than a hundred can swim in some fashion. Some do it by flapping flipperlike appendages, others use whiplike stroking movements, and still others make wavelike undulations of their bodies. We study the neurons controlling the swimming behaviors of two particular species of swimming slugs, *Tritonia diomedea* and *Melibe leonina*. Those species intrigued us because they have similar neurons and neurotransmitters in control of swimming behaviors, yet their swimming styles differ radically. *Tritonia* swims convulsively and only in emergency situations, whereas *Melibe* shimmies like a fish and can do so for over an hour, with some control of its direction. Why do animals with similar brains behave so differently?

Sea slugs, by which we refer to the group of gastropod mollusks called opisthobranchs, glide and glom on surfaces and in climates as distinct as Caribbean coral reefs and the Arctic seafloor. *Tritonia* and *Melibe* belong to the nudibranchs, a subset of opisthobranchs many of which notably possess "naked gills" that frill their shell-less bodies. These hermaphrodites thrive in waters shallow and deep. Many are brightly colored and beautiful, advertising to potential predators that they are toxic or bad-tasting. But brains, not beauty, attracted us to the wonderful, weird world of nudibranchs—more precisely, the simplicity of their neural circuitry.

Whereas human brains contain about 100 billion neurons, each interlinked by 10,000 or more synapses, resulting in more than 100 trillion connections, sea slugs have

fewer than 10,000 neurons, with presumably far fewer connections. That manageable number of neurons makes the nature of those connections much easier to decipher, which is why neuroscientists have been examining the brains of sea slugs for almost half a century.

Many sea slug neurons are unique in that each has its own anatomy and connectivity. In animals more complex than a roundworm, it is very unusual to have recognizably distinct individual cells; you can't tell one liver cell from the next. In our massive multibillion-neuron brains, the best we can do is to recognize general classes of neurons found in the same brain region. (The cortex, for instance, comprises 30 billion neurons of 200 different types.) But in sea slugs, we can identify and study the same neuron in different individual animals.

Better yet for scientists, those neurons are gigantic, relatively speaking. In the California sea hare, for instance, one neuron—named R2—has a cell body visible to the naked eye, with a diameter of as much as a millimeter, which makes it the largest nonreproductive cell body in the animal kingdom. Although R2 is exceptionally large, even the average neuron body in many sea slug species is as wide as a human hair is thick. Researchers have thus been able to impale the cells with microelectrodes, record electrical activity, and produce "wiring" diagrams that indicate how groups of sea slug neurons are connected.

Illustration sequence shows how Tritonia diomedea swims by convulsing its whole body with dorsal-ventral flexions, performing a series of jackknives and backbends. Tritonia only swims in emergencies, such as to escape a predatory sea star (bottom left).

In the 1960s, neurobiologist A.O. Dennis Willows at the University of Washington's Friday Harbor Laboratory discovered that individual neurons in *Tritonia* play distinct roles in particular behaviors, such as bending, withdrawing, or swimming. When an animal makes such a movement, he found, single neurons emit reproducible patterns of electrical impulses. Furthermore, he showed that electrically stimulating those neurons can reliably elicit those behaviors. Think about that: it is truly remarkable that in a brain of 10,000 neurons, a single neuron can play such an important role in triggering a movement involving many different muscles acting together in a coordinated fashion.

Tritonia moves by crawling when it is heading toward a mate or the orange sea pen on which it dines. Yet saying that *Tritonia* "crawls" is not quite accurate, because it does not make any muscular contractions to move forward. Instead, the slug seems to magically glide along. The secret to its movement is cilia, those microscopic hairlike organelles that fringe paramecia to help them wiggle through water.

Like many kinds of small land snails, *Tritonia* secretes mucus onto a surface (the seafloor) and then moves forward on waves of beating cilia on the bottom of its foot (the so-called "foot" is the underside of its entire body behind its head). The cilia are only about twenty microns long (or 0.02 millimeters), whereas the animal can grow to almost a foot in length. This is a strange and not particularly efficient way to get around, equivalent to driving a car on wheels with a diameter of less than half a millimeter. Not surprisingly, *Tritonia*'s crawling speed is slow, averaging about twenty feet per hour. Relative to body size, that translates to walking at about 170 feet per hour. At that rate, it would take almost a day and a half to walk a single mile.

How fast the sea slug creeps is determined by the rate at which the cilia beat, which is controlled by a pair of particularly large neurons. When they fire electrical impulses, the neurons release chemicals known as neurotransmitters, which excite the ciliated cells of the foot, causing the cilia to beat faster. Willows's lab has identified unique peptide neurotransmitters that increase ciliary beating. (Peptides are short strings of amino acids that can be secreted by neurons and other cells.) The greater the frequency of impulse firing, the greater the quantity of peptides released, and the faster *Tritonia* moves.

Unlike its usual ciliary crawling, *Tritonia*'s swimming

Melibe leonina, *like* Tritonia, *flexes its whole body when it swims, but it does so laterally rather than dorsoventrally, using different muscles. Unlike* Tritonia, *Melibe can shimmy for an hour or more, with some directional control.*

MELISA F. EVENHUIS

convulsions are produced by contraction of body-wall muscles. During a swim, muscle contractions of the dorsal and ventral body walls alternate to make the animal thrash up and down. Thanks to the work of several researchers, we know much of the neural circuitry that controls that behavior, from the sensory neurons that register a threat to the motor neurons that relay the pattern of activity to the muscles. In particular, the late neurobiologist Peter A. Getting at the University of Iowa identified a group of three kinds of neurons as forming what is known as a Central Pattern Generator, or CPG. A CPG generates a rhythmic pattern of electrical impulses that drives repetitive movements—like the chip in an Energizer Bunny®.

A CPG in human brainstems controls breathing; a CPG in the spinal cord controls walking. Rather than a simple trio of cells, however, the CPGs in mammalian nervous systems consist of millions of neurons, and are thus hard to decipher. Studying CPGs in invertebrates has yielded insight into how rhythmic behaviors in many species are produced.

In our lab, we wanted to elucidate how the neurons that make up *Tritonia*'s "swim CPG" interact. Our interest arose in large part because the swim CPG involves the so-called Dorsal Swim Interneuron (DSI), which releases the neurotransmitter serotonin. In humans, serotonin plays an important part in a number of disorders such as clinical depression, obsessive-compulsive disorder, and obesity. And while no one knows exactly why various antidepressants work—or why they sometimes don't—many function by blocking serotonin reuptake into neurons. *Tritonia,* with its large, serotonin-containing DSI neurons and known neural connections, offered a tremendous opportunity to study how serotonin functions.

We began by investigating the role of DSIs in initiating and maintaining the swimming behavior. We and others found that stopping the neurons from sending signals prevented the animal from swimming. Nor could it swim when administered a drug that blocks serotonin receptors. Conversely, when a *Tritonia* was injected with serotonin, it swam without stimulus from a sea star or other predator. Serotonin also caused an isolated brain—one resting alone in a Petri dish—to produce the pattern of electrical activity that underlies swimming. Those results demonstrate the essential role of DSIs and their neurotransmitter serotonin in generating *Tritonia*'s swimming motor pattern.

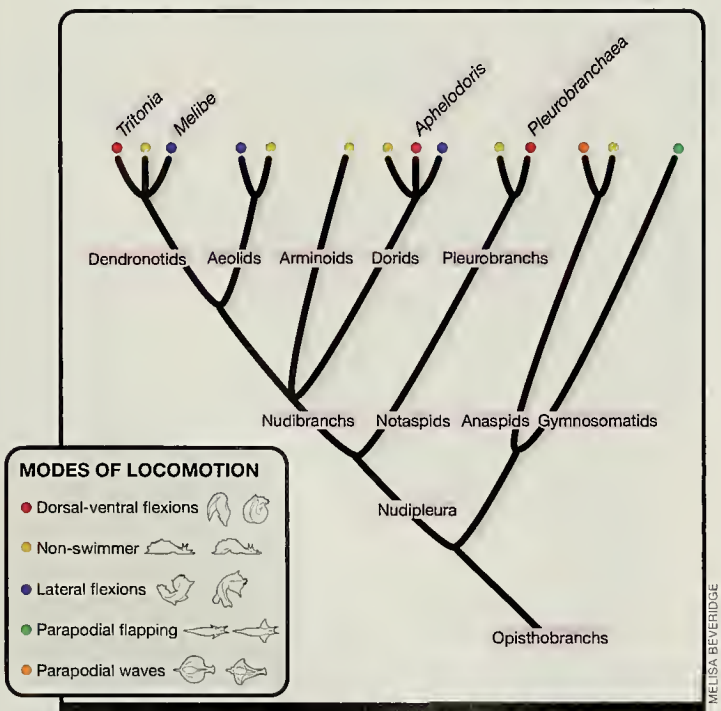
Next we wanted to see if serotonin neurons like the DSIs also generated rhythmic movements in other sea slugs. So we looked at other nudibranchs, such as *Tochuina tetraquetra, Dendronotus iris,* and *Triopha catalinae,* to see if they contained the same set of swimming neurons, even though many of the species we looked at cannot swim, or if they can, do so in a manner different from that of *Tritonia.* In the ten species that we examined, in all four major nudibranch lineages, we found serotonin-containing neurons with similar anatomical features. Those neurons are most likely *homologous*—that is, their presence in diverse sea slug species strongly suggests that a common ancestor of the animals had the same neurons.

What are swimming neurons doing in nonswimming sea slugs? We knew that even in *Tritonia* the DSIs play other roles: when the animal is not swimming, activating the DSIs speeds up the rate of crawling. Neurobiologist William N. Frost and colleagues at the Chicago Medical School have shown how that happens. The DSIs make connections with the very peptide-containing neurons that increase the rate of cilia beating on the foot. But did the nonswimming species have the neurons wired to increase cilia speed? Yes, we discovered they do have those connections, meaning that the neural setup has been conserved across species. But we did not know what differences in DSI wiring allow *Tritonia* to swim while

other nudibranchs cannot.

To find out, we looked at a sea slug that does swim, but in a manner different from *Tritonia*. The lion nudibranch, *Melibe leonina*, also called the hooded nudibranch, is found in the Puget Sound region as well, but prefers shallower water, where it clings to eelgrass rather than crawling on the bottom in the silt as *Tritonia* does. *Melibe* uses its large oral hood, which resembles a Venus flytrap, to catch small plankton such as crustacean larvae that float by. When dislodged from a blade of eelgrass, *Melibe* will swim until it reaches another surface to cling to.

As described earlier, *Melibe*'s swimming style differs significantly from *Tritonia*'s in degree of control, length of time, and reason for initiation (*Melibe* sometimes swims spontaneously, not only during emergency maneuvers). The most important difference, from our perspective, is that *Tritonia* flexes dorsally and ventrally, while *Melibe* flexes its body laterally, from side to side [*see illustrations on pages 38-39*]. That means that although both sea slugs flex their entire bodies to swim, different sets of muscles power those movements.



MELISA BEVERIDGE

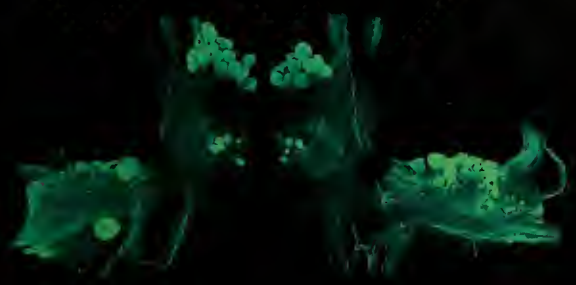
Chart showing the presumed evolutionary relations among selected branches in the family tree of sea slugs: similar swimming behavior in the nudibranch Tritonia and the notaspid Pleurobranchaea—both relying on dorsoventral flexions—arose independently from common ancestral neural circuitry. Only some dendronotids, dorids, and pleurobranchs can swim in that way. Other sea slugs either flex laterally, rely on parapodial movements, or don't swim at all.

Perhaps not surprisingly, the underlying neural circuitry in the two species is also dissimilar. Neurobiologist Stuart H. Thompson at Stanford University's Hopkins Marine Station and neurobiologist Winsor H. Watson III at the University of New Hampshire have identified the neurons in the *Melibe* brain that form the CPG for lateral-flexion swimming: they are located in different parts of the brain and possess anatomical features different from those that form the swim CPG in *Tritonia*. Therefore, the neural swim circuits in *Melibe* and *Tritonia* probably are not homologous; that is, they do not derive from the same neurons and circuits in a common ancestor.

Yet the brains of those animals do contain homologous neurons: the *Melibe* brain has homologues of the *Tritonia* DSIs mentioned earlier as occurring in nonswimming relatives. Again the question arises: what are Dorsal Swim Interneurons doing in an animal that does not swim with dorsal-ventral body flexions? In contrast to *Tritonia*, for which those neurons play a necessary role in swimming, we found that although the DSI homologues can trigger *Melibe*'s swimming, they are not needed for the swimming behavior to occur. That suggests that something about the neuronal wiring or properties of these homologous neurons is causing them to behave differently in the two species.

Serotonin, the neurotransmitter of DSIs in *Tritonia* and of their homologues in *Melibe*, also functions differently in the two species. Drugs that block serotonin receptors do not prevent swimming in *Melibe* as they do in *Tritonia*, but serotonin does facilitate the swimming behavior. Thus, serotonin seems to be an optional means for eliciting the swimming behavior in *Melibe*. That finding implies an important lesson: the role of a neurotransmitter varies depending on the role of the neurons in their neural circuit; neurotransmitters don't play the same role in every species.

Our work with *Tritonia*'s CPG is also revealing more and more about the complex ways serotonin works. In the process of generating and modulating the slug's rhythmic swimming behavior, it acts to make a weak synaptic connection stronger, but a strong synaptic connection weaker. This discovery has implications for understanding how serotonin—and other important, related neurotransmitters—might function in more complex brains such as our own. It's common for scientists and the public to refer to "serotonin levels." There are even self-help guides



Microscope images of the brains of Tritonia diomedea (far left) and Melibe leonina (near left): the lighter green circular shapes in the center of each image are cell bodies of neurons involved in controlling the movements of swimming. Differences and similarities in these sea slugs' nervous systems reflect how evolution has arranged the same set of neurons, inherited from a common ancestor, into differently organized networks.

©PAUL S. KATZ

which advise "adjusting serotonin levels" on one's own to solve emotional problems. It's true that serotonin plays a role in depression; that's why selective serotonin reuptake inhibitors like Prozac can be effective. But it is a drastic oversimplification to conclude that changes in serotonin levels equal changes in depression. Our work shows that serotonin does not act like a simple volume control knob, turning up or down ongoing activity; rather, it can act like a component of a more sophisticated logic circuit.

The finding that the brains of *Tritonia* and *Melibe* were so different surprised us in the light of work from the lab of neurobiologist Rhanor Gillette at the University of Illinois on another sea slug, *Pleurobranchaea californica*. Both *Tritonia* and *Melibe* are in the order Nudibranchia, but *P. californica* is in the sister taxon Notaspidea [*see diagram on opposite page*]. Yet *Pleurobranchaea* swims in a manner similar to *Tritonia*. Furthermore, when Gillette's lab investigated the neural basis for this swimming behavior, they found that neurons homologous to the *Tritonia* DSIs play a similar role in *Pleurobranchaea*. Does that mean that their common ancestor swam like *Tritonia*? If so, it would mean that the lineage that led to *Melibe* lost the ability to swim with dorsal-ventral flexions and evolved the ability to swim with side-to-side flexions.

We looked for more examples of the two types of swimming behavior and found other examples of species that could swim with side-to-side flexions in two other nudibranch lineages (Aelidoidea and Doridoidea). But only Doridoidea contained species that could swim with dorsal-ventral flexions. Therefore, we hypothesize that the DSI-like neurons were present in an ancient ancestor and became incorporated into swimming circuits more than once (in *Tritonia* and *Pleurobranchaea*). We plan to investigate the neural basis of swimming in other sea slug lineages to more clearly address how those behaviors may have arisen.

How is this pertinent to animals with more complex nervous systems? Consider the evolution of gaits in mammals. All mammals possess a spinal cord that consists of the same types of neurons. But in different animals, these neurons produce very different gaits. Most four-legged mammals trot when they walk at a brisk pace, with the left front leg and right hind leg moving forward at the same time. But some mammals, such as camels, certain breeds of horses, and some dogs, move in a different way: they *pace*, with the two legs on the same side moving forward together. That means pacing is a heritable feature that appeared independently in dogs, horses, and camels. We don't know which changes in the spinal circuits caused these different types of movements to be produced, but the point is that the same sets of neurons independently evolved more than once to produce similar locomotion.

Extrapolating from our work to other taxa is unwieldy because there is no part of a molluscan brain homologous to any part of a vertebrate brain. Some claim that parts of arthropod brains are homologous to vertebrate brains. If that's true, some complex properties may have re-evolved: there may be so-called "deep homology" in the nervous system that has allowed certain features to reappear over and over again, such as genes that form eyes—in insects and humans. In any case, understanding the basic differences in circuitry layouts of sea slugs might help to unravel more complex wirings.

What we have found startling is the great flexibility in the rather simple circuitry of sea slug brains. Homologous neurons have evolved in some cases to serve the same function in different species; in other cases the functions vary to produce different behaviors. While our work on slug brains may not explain what it is in our brains that makes us scream, shiver, or laugh at a horror film, it's a "creepy" start.

Paul S. Katz became interested in comparative approaches to neural circuits as a graduate student at Cornell University. He is co-director of the Neural Systems and Behavior Course at the Marine Biological Laboratory in Woods Hole, Massachusetts, a professor in the Neuroscience Institute at Georgia State University in Atlanta, and president-elect of the International Society for Neuroethology.

James M. Newcomb is an assistant professor of biology and health science at New England College in New Hampshire. He earned his PhD in biology at Georgia State University. Much of his research has explored the neural control of swimming nudibranchs.

Web links related to this article can be found at www.naturalhistorymag.com

Rational Fear

There are parts of Africa where humans are just another meal, where walking alone down an unlit path can bring on an overwhelming sensation of helplessness, and where a fear of the dark or of monsters under one's bed is anything but superstitious. Bantu farmers in southern Tanzania and northern Mozambique rank among the poorest in eastern Africa. They grow rice, maize, and cassava in small plots, which they hoe by hand, and live in nearby huts with thatched roofs and mud-caulked walls of interwoven sticks. Most are Muslim, and few are educated beyond primary school. Birthrates are high. Children are everywhere, walking to and from school, playing outside. Women fetch water from wells, streams, or ponds a few miles from home. No one has indoor plumbing; outhouses are at least fifty feet from the back door. Every evening people dine outside in the hot, humid air. Some have kerosene lamps, but no one owns a flashlight. Twilight is brief and the nights are always about twelve hours long. On a cloudy night, the darkness is absolute.

In a bad year, lions attack as many as 140 Tanzanians; unreported cases may double that number. During quiet intervals, lions still attack ten to thirty people a year, and the numbers often flare up again. The majority of lion attacks are fatal, and the victims are eaten. Lions' patterns of predation on *Homo sapiens* are similar to those on wildebeest, zebra, or gazelle: they prefer to catch people who are away from others in the dark. Some cases are particularly horrifying: lions dig through thatched roofs and drag elderly people out of bed; they pluck small children from the breasts of their nursing mothers or the arms of their grandmothers; one woman lost her husband and parents in two separate attacks several months apart.

The threat of man-eating predators has molded our evolution, and has provided fodder for folklore and travelers' tales. But there have been many more rumors

A pride of lions, photographed without flash, waits and listens for potential prey in Tanzania's Serengeti National Park (the starry nightscape was also photographed on the Serengeti plain, but separately). Top image: An infrared camera picks up the body heat of a pair of lions on the move at night.

As human populations expand and lions' prey dwindles in eastern Africa, the poorest people—and hungriest lions—pay the price.

BY CRAIG PACKER

and myths about man-eaters than hard facts. Two of my students, Dennis Ikanda and Hadas Kushnir, and I have conducted detailed studies of man-eating lions in the coastal scrublands of southern Tanzania for the past six years. Ikanda and Kushnir have visited the survivors and the victims' families to find out what happened in more than 300 lion attacks. Who was taken? What were they doing? Where and when did the attack take place? We hope these data will help authorities devise ways to protect local people from lion attacks and reduce the need for retaliation.

Although the problem has intensified in recent years, lions have eaten people in these areas for as long as anyone can remember. In the past century, lion populations throughout Africa have plummeted to less than 50,000 individuals in total. The big cats have largely been eradicated outside the national parks and game reserves in almost every other part of Africa, but the coastal scrublands stretching from Dar es Salaam down

Bushpig, a nocturnal animal that frequents agricultural areas, is a favorite prey of lions.

to the Mozambican town of Pemba host the last great population of lions that live among people—and outside any sort of protected area.

And here be Man Eaters.

IN THE GROTTE CHAUVET OF SOUTHERN FRANCE, 32,000-year-old cave paintings detail the angle of lions' ears, their whisker spots, and their facial expressions while snarling. Since the artist(s) lacked spotting scopes, binoculars, and telephoto lenses, they must have observed lions at reasonably close range—and lived long enough to record their observations. Large, maneless cave lions (*Panthera atrox*) once ranged throughout the Northern Hemisphere, and archaeological evidence suggests that early humans were scavengers for hundreds of thousands of years before they began hunting for themselves. Thus, early humans must have relied on lions and other large predators as a major source of animal protein—chasing the carnivores away from their kills and feasting on the remains. Similarly, modern Bushmen, such as the Hadza of Tanzania, are rarely troubled by the sight of a lion; in fact, some believe that they can make "medicine" of saliva and a chewed-up seed to keep lions at bay.

Modern pastoralists have a more complex relationship with lions. The Maasai, for example, retaliate against lions that kill their cattle, and they are also motivated to kill lions in a ritual hunt known as *ala-mayo*, in which young warriors prove their courage by spearing a lion and taking its tail. Dennis Ikanda and another of my students, Bernard Kissui, have studied the relationship between lions and Maasai in northern Tanzania, and they found that lions almost never seek Maasai as prey. Rather, lions only attack the warriors in self-defense or injure herders during cattle raids. Working in the Ngorongoro Conservation Area, Ikanda found that while lions are especially likely to attack livestock herds tended entirely by children—yes, children, often only six or seven years old—a hungry lion will push a child aside to get to a goat or cow. Kissui has found that the "exchange rate" around Tarangire National Park is approximately one lion killed for every dead cow. Consequently, lions in the land of the Maasai are strikingly nonthreatening to humans, slinking off whenever tourists or other harmless bipeds emerge from their vehicles.

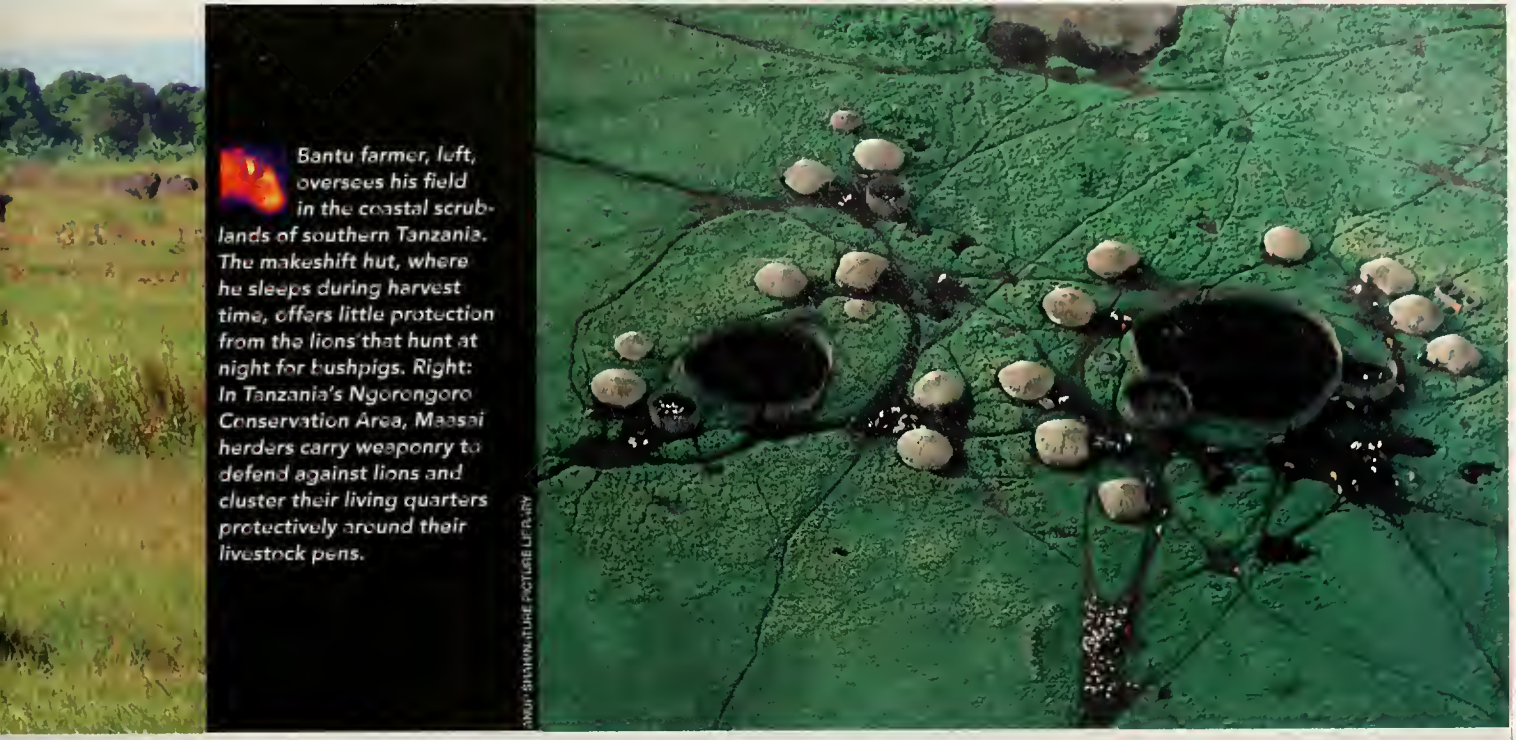
Unlike the Maasai with their warrior traditions, rural farmers in southern Tanzania and northern Mozambique have less direct experience of wild animal behavior and fewer, if any, weapons to protect themselves. And, of course, agriculturalists transform land from its native state to grow crops, reducing the carrying capacity for the lions' natural prey and replacing herbivore biomass with more and more people. The human population in southern Tanzania and northern Mozambique has nearly doubled in the past twenty years.

BERNARD KISSUI

But agriculturalists do not live in a vacuum—their crops invite various unwanted species, such as monkeys and birds. Daytime pests require daytime vigilance and extra time in the fields. But it is a nocturnal species that provides the necessary link between lions and people to create the optimal circumstances for an outbreak of man-eating: bushpigs (*Potamochoerus larvatus*) [*see photograph on previous page*].

JOE LEMONNIER

Typical lion prey such as buffalo, wildebeest, and zebra cannot survive the transformation of savanna grasslands to cropland. Highly disturbed habitats, on the other hand, are ideal for bushpigs. Those nocturnal omnivores remain hidden in thick vegetation during the day and emerge as voracious crop pests during the night. Pigs also breed easily and are virtually impossible to eradicate. In northern Tanzania, some areas are predominantly Christian; farmers there dig trenches around their fields, too wide for the pigs' short legs to clear, and then feast on anything that falls in. In largely Muslim southern Tanzania and



Bantu farmer, left, oversees his field in the coastal scrublands of southern Tanzania. The makeshift hut, where he sleeps during harvest time, offers little protection from the lions that hunt at night for bushpigs. Right: In Tanzania's Ngorongoro Conservation Area, Maasai herders carry weaponry to defend against lions and cluster their living quarters protectively around their livestock pens.

PETER JOHNSON/CORBIS

northern Mozambique, however, most people will not eat pork; some Muslims hesitate even to touch a pig. So the main strategy for pig control there is to build a simple covered platform, or *dungu*, where the farmer can sleep in the field, listen for disturbances during the night, and chase away any pigs with loud noises, sticks, and stones.

Loud noises and sticks and stones are not much defense against the lions, which specialize in bushpigs, the greatest biomass of their prey in the coastal agricultural region. Villagers say that the loud squeal of a dying pig is a sure sign of lions, and any Christians in the area will eagerly chase off the lions for a free meal of wild pork. So the pigs, being maintenance food for lions, act as magnets that draw predators all the way into the fields and villages. We have found that the most common context of lion attack is when the victim sleeps in a *dungu*—and lions following bushpigs into the fields have stumbled across easier prey.

Regardless of their initial experience with human flesh, once lions learn that people can be eaten, some become repeat offenders. Some habitual man-eaters are males, some are females, some are old, and some are young. Sometimes whole prides partake.

AN OUTBREAK OF MAN-EATING LIONS MAY LAST for two to three years, or until the repeat offenders and their offspring are killed. In the meantime, more than forty people may fall victim in a roughly forty-square-mile area. The worst outbreak of man-eating lions in history was in the Njombe district of southern Tanzania, where as many as 1,500 people were killed between 1932 and 1947 [*see map on opposite page*]. The outbreak was apparently precipitated by a game-control program on the border with Malawi and Zambia, intended to prevent the spread of rinderpest (a livestock disease) between eastern and southern Africa. George Rushby, a British game warden, was sent by the colonial authorities to eradicate the man-eaters, and he expressed surprise that there could be so many lions in the area, since there seemed to be so little lion prey and so many bushpigs!

In a statistical analysis, my students and I found that the districts of Tanzania with the highest number of lion attacks on humans in the twenty-first century also had the lowest abundance of "normal lion prey" and the greatest abundance of bushpigs. Areas surrounding the famous national parks in northern Tanzania (Serengeti, Tarangire, and Manyara) have abundant wildebeest, zebra, and buffalo and very few bushpigs—so tourists have little to fear!

Fear among locals, however, has been a significant impediment to dealing with man-eaters. The belief is pervasive among local people that these are not animals at all, but malevolent magic spirits. Sometimes the first victim's family won't even tell their neighbors about the attack, fearing that the death was retribution for some heinous crime committed by their dead relative. People's perceptions of magic are deep and abiding. In some cases, villagers rely on the local medicine man to tell them if it is a spirit lion or a real lion. Local villagers will tell you that they don't mind real lions—it is the spirit lions that terrify them. But over the course of any persistent outbreak, the medicine man eventually changes his mind and declares the offending lions to be real—and control strategies are finally implemented.

The belief in spirit lions can tear apart the fabric of local society. In northern Mozambique, outbreaks of man-eat-

Harunnah Lyimo, one of the author's students (right foreground), interviews locals in Simana, Tanzania, to profile the risk factors associated with lion attacks.

ing lions have led to public lynchings of villagers who were accused of unleashing evil spirits. Elsewhere in Mozambique, the number of official reports of man-eating lions fell to zero during the tenure of a particularly powerful and famous medicine man. After his death, cases were no longer exclusively attributed to spirits, and the number of reports returned to normal.

Further reinforcing the belief that the killers are supernatural, the movements of man-eating lions can be highly erratic and unexpected. One famous man-eater in southern Tanzania was called Simba Karatasi, literally "paper lion," because he seemed to move about as randomly as a piece of paper blown by the wind. Lions rely on stealth and surprise when capturing their prey: they cannot outrun their usual quarry of wildebeest or zebra, so they often stalk them to within several feet before a final charge. Since lions are primarily nocturnal, most of their long-range movements are under cover of darkness, and even in undisturbed areas like the Serengeti, lions may move two miles in a single night looking for unsuspecting prey. Where prey is scarce, they can move as much as twelve and a half miles overnight. And since many man-eaters survive mostly on bushpigs, they may only feed on human flesh every fourth or fifth meal. So it is no surprise that people think they are appearing out of nowhere.

THE MYTH OF THE GREAT

White Hunter has resonated for well over a century in Europe and North America. David Livingstone, the famous explorer and missionary, traveled through eastern and southern Africa seeking to eradicate the slave trade and to spread Christianity throughout Africa. Livingstone largely supported himself through his writings, and his books contained florid accounts of the man-eating lions he killed in what is now Zambia (then Northern Rhodesia) and Zimbabwe (then Southern Rhodesia). In the 1890s, about two decades after Livingstone's death, Colonel J.H. Patterson was sent to Tsavo, Kenya, by the colonial authorities to deal with an outbreak of man-eaters during the construction of a railway from Mombasa to Kampala. The lions proved to be difficult quarry, and his subsequent book, *The Man-Eaters of Tsavo*, spawned no fewer than three Hollywood films: *Bwana Devil* (1952), *Killers of Kilimanjaro* (1959), and *The Ghost and the Darkness* (1996) [*see "Man-Eaters of Tsavo," November 1998*].

Mother and two of her children relax outside their home in Nampunga, Tanzania—without any barrier against intrusive wildlife. Arabic prayers cover their blackboard.

Indeed, popular culture has been quite obsessed with the notion that white men are somehow the only reliable agents for protecting helpless villagers. Certainly *The Man-Eaters of Tsavo* had a disproportionate impact on this perception, with Colonel Patterson being the only man who could rescue the railway crew. Yet at least twenty-eight of the Tsavo victims were laborers from India who had likely never owned a weapon in their lives and might have fared better if they had been as well armed as Patterson. In the 1932 outbreak, George Rushby relied on his Tanzanian assistants as well as his experience as a hunter to finally end the terror in Njombe.

The falsehood at the heart of the Great White Hunter myth is the notion that African villagers will forever remain helpless and that only outside expertise can protect them against the forces of nature. It is certainly true that when you are very,

very poor and cannot afford anything more than the clothes on your back, there is no way that you can buy your own guns to shoot the marauding lions or erect fences to keep the pigs out of your fields or even provide adequate lighting around your house at night. And certainly the scale of rural poverty in southern Tanzania and northern Mozambique is heartbreaking.

But the fact is that very simple technology now makes man-eating lions almost trivially easy to kill. And the word spreads fast. A few years ago, an elderly couple were sleeping in their hut one night when the wife had to go to the outhouse. She didn't come back, and the husband went out to look for her. At the outhouse, he found the upper half of her body lying on the ground. He quietly went back to their hut, fetched a box of rat poison, and came back to lace the remains of his wife. It worked.

Open-air home among banana trees, typical of southern Tanzania and northern Mozambique, offers little protection from lions.

Whether independently or in recollection of this first case, a man in another village found the lower half of his mother-in-law's body a year or so later. He, too, laced her body with rat poison. It worked again. Now people know what to do, and rat poison is something anyone can afford. In some areas, people tolerate lions because they help control the bushpigs, but most people would rather deal with bushpigs than with man-eating lions, so they have even started lacing bushpig carcasses with poison and setting out poisoned goats as bait.

This started about five years ago, and it seems likely that most of the lions have been eradicated from the rural areas of southern Tanzania, because we have only heard of a dozen or so fatal attacks each year since 2005. But there will always be lions emerging from Tanzania's vast Selous Game Reserve (which, at 17,300 square miles, is larger than Switzerland and held as many as 4,000 lions a decade ago) and Mozambique's vast Niassa Reserve (which is nearly as large as the Selous and may be home to a thousand more lions). And rural villagers quickly become complacent after the last lion has been destroyed in a particular outbreak, thinking that it will never happen again—but, eventually, it will. Thus it would be best to take precautionary steps to protect people from being eaten in the first place.

OUR SCIENTIFIC RESEARCH FOCUSES ON SOMEhow trying to mitigate this brutal conflict. Currently a new Tanzanian wildlife student, Harunnah Lyimo, is testing various strategies for keeping pigs out of the villagers' fields. Bushpigs cannot be eradicated, but it should be possible to exclude them from the fields with trenches or a string of chili peppers or even the sort of animal repellant used in America to deter raccoons and deer from suburban gardens. And even if those measures don't fully protect the villagers against lions, they could at least reduce crop losses.

Education may be useful, too; it is simply not a good idea to walk alone at night. And certainly, friends should never allow friends to walk home alone drunk in the dark—lions seem to have a particular fondness for drunks. But then they also catch the simple and delusional outcasts: schizophrenics and the slow-witted.

It is difficult to exaggerate the toll that even a few man-eating lions can exact on the psychology of a rural community. Harvest season is man-eating season. Beyond the direct costs of injury and loss of life, people can become almost paralyzed with fear, leaving their crops to rot in the fields.

There are fewer than 50,000 lions left in all of Africa; Tanzania is their final stronghold. There may only be a dozen or a hundred lions in the coastal scrublands. But what can you do when one of those lions comes from nowhere? It's hungry. It strikes in the dark. You have no weapons.

That lion could be anywhere, even under your bed.

Craig Packer has studied the lions of the Serengeti since 1978. He spends several months a year in Africa and the remainder in Minnesota, where he is Distinguished McKnight University Professor in the Department of Ecology, Evolution, and Behavior at the University of Minnesota in St. Paul. Packer serves on the advisory board of Panthera, a foundation devoted to the conservation of wild cat species (www.panthera.org).

Web links related to this article can be found at www.naturalhistorymag.com

A Shot in the Dark

Underground worlds see the light.

Story and Photographs by
Benjamin von Cramon

Turn off the lights, close your eyes, and try to imagine "cave dark." Nope, the real thing is unspeakably darker. Certain commercial cave tours provide a taste by momentarily cutting the lights, but knowing the guide's hand is safely on the switch doesn't compare to total immersion off the beaten path. Take my unexpected encounter with cave dark when I got separated from my group during a survey trip into Table Rock Cave in South Carolina.

Glory Hole Cave, Georgia

I had been working my way through a steep, narrow passageway on my belly. Trying to make progress, I struggled too violently and, instead of wriggling free, dislodged a watermelon-size chunk of granite that came to rest on my back, knocking loose my light cord, which connected to a hip-mounted battery pack. Plunged into darkness and barely able to move, I had all the time in the world to contemplate a book I had just read, *Trapped*, which details the demise of a famous Kentucky caver, Floyd Collins. I realized that cave black has shades of gray—and there I was peering anxiously into the blackest shade of it. Fortunately, Collins's story contained many valuable lessons that helped save my life.

As a cave photographer, I have long had an interest in how best to penetrate the darkness. Cavers need their hands free for climbing, crawling, and passing packs, so they rely on a helmet-mounted light. But pointing a light on the same axis as your gaze throws a shadow directly beyond each object you look at, so that the object masks its own shadow, robbing the scene of visual cues. This diminished depth perception pulls focus away from the cave, down to the business of foot placement. So a caver's perspective is inherently myopic: impressions built up from one poorly-lit swatch of rock at a time. Perversely, we like it that way. Ultimately, however, curiosity about what's beyond the dark means we also value the big picture.

A light came on for me while I was photographing Fantastic Pit, the deepest known free drop in any cave in the continental United States. A hike to its rim, on Pigeon Mountain in northwest Georgia, requires stamina: the deep shaft lies a quarter-mile inside Ellison's Cave, and getting to it involves, among other maneuvers, rappelling down the so-called Warm-up Pit (a mere 120-foot drop). Finally, after a few mazy sections, you reach the lip of a smooth-walled well of blackness hardly dented by a caver's headlamp, or even a video light pointed downward. Only the distant sound of crashing water hints at the true danger.

The conventional approach to photographing Fantastic Pit has been to illuminate it in stages: a rappelling caver stops every hundred feet or so and sets off a powerful flash. Inevitably, the multiple exposures appear patchy. How to see the entirety of the pit—a shaft of skyscraper proportions—illuminated in a single burst of light? Enter the 2,400-joule Super Strobe: a fancy chunk of lighting gear

Cavers climbing the 586-foot Fantastic Pit, in northwest Georgia, can't see or begin to understand the strange behavior of its waterfall without special lighting.

Snake petroglyph in Indian Cave, Tennessee

designed by William (Willie) A. Hunt, an electronics engineer.

Willie and I tested the equipment in Fantastic Pit and then examined the many exposures we had made with Super Strobe. We immediately realized that the understanding of waterfalls in deep pits might change thanks to the new technology. In some of our exposures a heavy spray filled the pit, yet in others the first 200 feet appeared relatively devoid of moisture. What explains so variable and uneven a distribution of water?

As any visitor to Niagara Falls can attest, waterfalls above ground produce significant winds as falling water displaces air. Underground waterfalls set up the same dynamic, but in a closed conduit. All that displaced air confined by rock has nowhere to go but up. The bursts of air retard the flow of falling water, not only impeding an even rate of fall, but also pushing a significant percentage of the moisture back up the pit. The revelation has implications for better understanding the sculpting of Fantastic Pit's smooth, bell-shaped walls [*see photograph on previous page*].

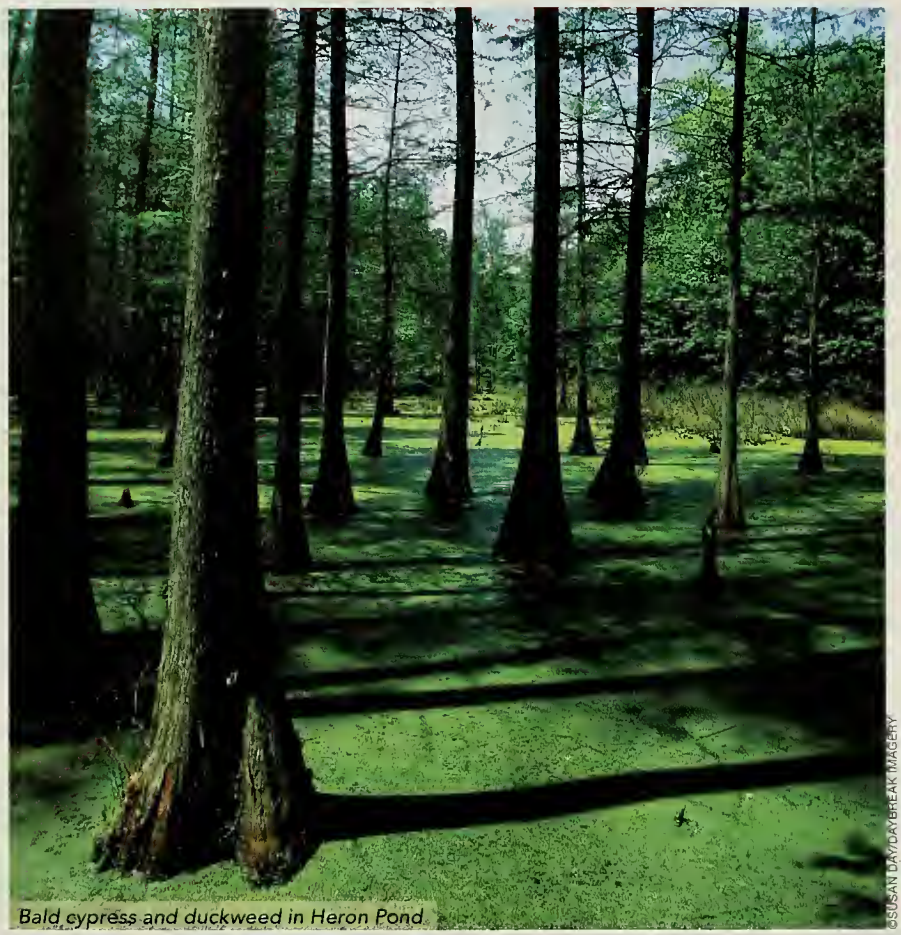
Teasing out a cave's dark secrets doesn't always call for the sledgehammer approach of the Super Strobe. Cavers routinely overlook some amazing features that can be highlighted by simple means. Take, for example, the faint etchings along passage walls inscribed by pre-Columbian peoples who made extensive ritual use of caves throughout the southeastern United States. For a seven-foot-long petroglyph in Indian Cave in eastern Tennessee, I used extremely oblique lighting, one light per exposure, and then layered those exposures in a digital composite; the technique afforded me ultimate control and flexibility with straight light beams crossing the curved wall of the cave [*see photograph above*].

Applying this one-light-at-a-time approach to large chambers, I photographed a 50-foot calcite mound at the base of a 220-foot pit in Flowing Stone Cave in the northwest corner of Georgia [*see photograph below*]. The resultant im-

Flowing Stone Cave, Georgia

age was unintentionally surreal, appearing highly manipulated, yet all I did was join tiny pieces of unmanipulated exposures together. Ironically, the increased visual detail robs the image of depth and scale. Just as clothing leaves something to the imagination, the heart of a cave is its darkness, and I've learned that not all of it should be dispelled.

Benjamin von Cramon is an independent filmmaker, one of a small handful worldwide to film professionally underground. His wife, Dawn, also a caver, assists him on shoots. With a home in Marietta, Georgia, the two enjoy adventuring to faraway places around the world, as well as in the many caves in the Southeast. You can learn more about von Cramon's work at www.bvcproductions.com.



Bald cypress and duckweed in Heron Pond.

On Heron Pond

Illinois dips its toe in a southern swamp.

It is a warm day in early May. Mist hangs low over the swamp. Bald cypresses and tupelo gums, their swollen bases disappearing beneath the black water, tower above the fog. A prothonotary warbler in its iridescent yellow-green plumage perches on a waving wand of Virginia sweetspire. Red-bronze blossoms of copper iris stand above rings of small white flowers borne by featherfoil, a jointed, fleshy-stemmed plant. In places, dense colonies of duckweeds cover the nearly still water, punctuated here and there by the intricate purple leaves of mosquito fern and the heart-shaped leaves of spongeplant. The water's surface corkscrews where a cottonmouth just passed. This could be a Louisiana swamp, except I am in the southern tip of Illinois. Known as Heron Pond (for its heron rookery), this is one of three bald cypress swamps in the 1,939-acre Heron Pond–Little Black Slough Nature Preserve. Heron Pond and its companions—Watson Pond and Goose Pond—are the northernmost bald cypress swamps in the nation's heartland.

The swamps lie about thirty miles northeast of the confluence of the Mississippi and Ohio rivers, along an Ohio tributary, the meandering Cache River. During the last glacial peak, about 18,000 years ago, the ice reached almost this far south. When the glaciers melted and retreated some 11,000 years ago, the swollen Ohio River carved out a vast floodplain before settling into its current bed. Extensive bald cypress swamps took root in huge, watery depressions. Just to the north, the upper reaches of the Cache River sculpted a smaller, more intricate basin where limestone bluffs overlooked gemlike swamps.

European American settlers, mostly farmers from Kentucky, Tennessee, and the Carolinas, began to trickle into this part of Illinois in 1803, and to build permanent settlements by about 1816. They engaged in small-scale farming and logging. Because of annual flooding, however, the farming was poor, and beginning in 1870, when the railroad arrived, lumber companies bought up the deeper, less accessible swamps. With their expertise and

HABITATS

Swamp The water depth varies from a few inches to about six feet. Bald cypress trees, some of them several feet in diameter, dominate, though other typically southern swamp-tree species occur, including Drummond's maple, pumpkin ash, swamp cottonwood, tupelo gum, and water elm. Shrubs are mostly buttonbush, swamp rose, and Virginia sweetspire. The partly submerged trunks of some trees that have fallen into the swamp support clearweed, false nettle (a real nettle, though stingless), Walter's Saint-John's-wort, and several species of beggar-ticks.

Swampy woods Surrounding the swamp is low terrain with poor drainage, where pools of standing water may remain most of the year. American elm, green ash, northern catalpa, pin oak, stiff dogwood, swamp chestnut oak, and sweet gum are among the trees that grow here. The forest floor supports ditch stonecrop, jack-in-the-pulpit, swamp white milkweed, water horehound, and, in pools of water, camphorweed and lizard's-tail. Crossvine and trumpet vine climb high into the trees.

heavier equipment, they cut much more virgin timber. Industrial-scale drainage for cropland and flood control began in 1916 and continued through much of the twentieth century, leaving only a few pockets of bald cypress swamp intact.


Trumpet vine

©PETER ARNOLD, INC./ALAMY

Along with John W. Voigt, a colleague at Southern Illinois University, Carbondale, I explored Heron Pond during the 1960s. The two of us also paid a visit to the office of the Main Brothers Lumber Company, a local firm that held the swampland back then. We impressed upon the owners the importance of this northernmost swamp, with its southern plant and animal life, and they expressed willingness to sell it for purposes of preservation. In the years that followed, the state of Illinois, with the assistance of the Natural Land Institute of Rockford and the Illinois chapter of the Nature Conservancy, began acquiring that and other property to create preserves, and by 1977 the Heron Pond–Little Black Slough Nature Preserve had attained its present form. Also designated a National Natural Landmark, it is managed by the Department of Natural Resources as part of the Cache River State Natural Area.


Cottonmouth, or water moccasin

©BRUCE COLEMAN INC./ALAMY

Having spent some time at Heron Pond, I knew it was significant, but I did not initially know the extent of its floral diversity, particularly in the more remote parts of the swamp. In 1971 Jack White, a graduate student of mine, completed an inventory of the plants of Heron Pond and adjacent swamps for his master's degree. He identified 773 species of ferns and flowering plants, many of them at their northernmost limit in the central Midwest.

Since I had never ventured far enough into the swamp to see the heron rookery, I accompanied White one day to see it. After putting on our waders, we started to tread through the water, which sometimes came up almost to my armpits. As we neared the rookery, we could hear the squawking of the birds in the trees, and by the time we arrived beneath them, the noise drowned out any conversation. The herons reacted to our intrusion by regurgitating partially digested fish down upon our heads. With the intense noise, the rain of fish, and the threat that a cottonmouth might swim by, I announced that I had seen what I had come to see!

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VISITOR INFORMATION
Cache River State Natural Area
Henry N. Barkhausen Cache River Wetlands Center
8885 State Highway 37 South
Cypress, IL 62923
618-657-2064
www.dnr.state.il.us/lands/landmgt/parks/r5/cachervr.htm

The Illinois Department of Natural Resources has since built a one-lane gravel road that leads to a parking lot just 300 yards from the swamp. From there a trail takes you down through sloping woods, across a bridge over the Cache River, through floodplain woods and even wetter swampy woods, to the edge of standing water. A floating boardwalk there extends some 75 yards into the swamp. The rookery I once visited used to be several hundred yards farther on, but because of the increased visitor traffic during the 1970s, the herons abandoned it and established a new rookery in a less accessible area.

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

Floodplain woods In low areas where drainage is better, the dominant trees are American hornbeam, cherrybark oak, shellbark hickory, Shumard oak, sugarberry, swamp chestnut oak, and sweet gum. Deciduous holly, pawpaw, and spicebush are common in the understory. Blooming in abundance on the forest floor in the spring are bulbous cress, Missouri violet, swamp buttercup, and white dog-tooth violet. Summertime beauties include purple fringeless orchid, spider lily, and white turtlehead.

Slope woods The swamp, swampy woods, and floodplain woods occupy a basin with wooded slopes on the east side. These slopes support such typical southern Illinois trees as American beech, shagbark hickory, sugar maple, tulip poplar, and white ash. Among the wildflowers are the spring-blooming mayapple, wild blue phlox, wild geranium, and yellow ladies'-slipper; the summer-blooming beaked groovebur, foxglove beardtongue, Indian pipe, starry campion, white avens, and wild bergamot; and the autumnal frostweed, hairy pagoda plant, and various asters and goldenrods.

How many solar systems are there in the universe, and how typical is the one we live in? Two decades ago it was impossible to say, since astronomers knew of no other solar systems but our own. Since 1995, however, when the detection of the first planet orbiting a star like our Sun was announced by Swiss astronomers, the number of known extrasolar planets has grown exponentially. As I write this review, the official number (at http://exoplanet.eu) stands at more than 340, with new ones being added almost weekly. The majority are detected, not by direct photography, but by measuring the subtle wobble their gravitation induces in the motion of their parent stars.

We can now say, with some confidence, that planets are common, though many of the newly discovered worlds are strangely different from our own. Many are what astronomers call "hot Jupiters," giant balls of gas several hundred times more massive than the Earth, but orbiting only a few million miles from their stars—so close that they take only a few days to go around. Others move in elongated looping orbits. Until the discovery of these new worlds, astronomers had assumed that most planetary systems would be like our own, where Jupiter-size giant planets are located hundreds of times farther out from their star, taking tens of Earth years to orbit, and where all the planets travel on nearly circular paths.

Alan Boss, an astronomer at the Carnegie Institution of Washington, has been at the forefront of research in the origin of solar systems. As the number of known systems has grown, he and his colleagues have been able to get a clearer picture of their origins and a fuller understanding of how our own solar system fits into the picture. In this short and lucid review of his field, he traces the developments of the last fifteen years in chronological, diarylike entries, so that we can share with him the excitement of discovery.

In 1999, we read, astronomers first observed one of the newly discovered planets passing in front of its star, causing the star's light to dim. The observation enabled the astronomers, by timing the eclipse, to determine the size and density of the object. A few years later, astronomers were routinely using such eclipses (called *transits*) as a complement to searching for planet-induced wobbles. By 2007, the roster of planets included "super-Earths"—rocky bodies ranging from several times to more than twenty times the mass of Earth—some of them in close, hot orbits, others far enough from their stars to be frigid. Astronomers have even been able to use space telescopes to measure the constituents of some of the new planets' atmospheres, detecting both water and methane, two of the "biomarkers" exobiologists look for in searching for inhabited worlds.

The tone of Boss's book, accordingly, is excited and hopeful, but there's also a note of wry irony in his descriptions of the political trials astronomers have gone through trying to promote their research. And despite the successes of the past decade, Boss senses that it may be increasingly difficult for astronomers to attract the sums needed to continue the search for habitable planets. Readers of this book, I am certain, will hope his fears are unsubstantiated.

At the beginning of one chapter of this entertaining and charmingly illustrated book on seeds, there's a sketch of two beans engaged in what, if they were human, might be called necking. Vegetables don't really cuddle and coo, of course, but according to Jonathan Silvertown, a professor of ecology at the Open University in England, when it comes to reproduction in the plant kingdom, practically anything else goes.

Silvertown's short essays sample the broad panorama of strategies plants employ to spread their spawn around. In one chapter he describes winged and gossamer seeds, delicately structured because they have evolved to be spread by the wind. Gliders produced by a tropical vine named *Alsomitra macrocarpa* sport wingspans of nearly five inches, and if there's a good breeze they can travel hundreds of yards in search of a good spot for germination. The course of true love, though, doesn't always run smooth—seeds that travel too far run the risk of landing outside the hospitable environment of their parents and failing to thrive.

Other plants employ deception to get animals to provide a motive force that they do not possess. The seeds of many Australian plants are equipped with fatty warts called elaiosomes, which are as attractive to ants as apples are to humans. The ants carry the seeds to their nests, bite off the succulent elaiosome, and toss the seed on their underground trash heap—and so

the seed finds a safe place to sprout.

Seed stories like these are enlivened by a potpourri of facts and figures. The oldest seed ever germinated? A 2,000-year-old date seed found in the ruins of Masada, near the shores of the Dead Sea. The smallest seeds? Those of some orchids, which weigh only a ten-millionth of a gram.

For all its erudition, however, this is not an encyclopedia of botanical lore, nor a definitive text, but rather a little gem of science writing that deserves a spot on any natural history lover's bedside bookstand. To be sure, it may help you make small talk at a convention of palynologists or Burpee seed salesmen, but, at its root, it is simply a delight to read.

One Square Inch of Silence:
One Man's Search for Natural Silence in a Noisy World
by Gordon Hempton and John Grossmann
Free Press, 2009;
368 pages, $26.00

I write this review at a remote observatory in the Southwest, a place I considered exceptionally quiet until I read *One Square Inch of Silence*. Now, standing outside the shuttered telescope dome, I hear the drone of a distant plane above the whistle of the wind, and, from time to time, the gravelly crunch of a passing car on the county road at the foot of the mesa. Holding my breath, I even notice the rumble of traffic on the interstate, fifteen miles away as the crow flies. The noise of civilization intrudes, even deep in a national forest.

Gordon Hempton, the principal author of this ear-opening book, documents nature with an audio recorder rather than a camera. He won an Emmy for a PBS documentary that followed the dawn chorus of birdsong around the globe, and his sound clips have been featured on National Public Radio. He's become distressed by what he hears of late. "Natural quiet," he writes, "has become an endangered species."

Except, perhaps, along the Hoh River Valley of Olympic National Park in Washington State. "One Square Inch of Silence" is a spot deep in the woods there, a site Hempton has chosen as the focus of a personal campaign to preserve the soundscape of the wilderness. He's marked it with a stone, and written a proposal for the Department of the Interior to establish a prototype sound-management area surrounding it, so that it will remain "a sanctuary of silence for present and future generations to enjoy unimpaired by noise pollution."

To promote his project, Hempton recently embarked on a 10,000-mile "pinball route" from the Olympic Peninsula to Washington, D.C., for a lobbying session with lawmakers and federal officials. Along the way, he documents sound pollution from the backcountry to Chicago's backed-up highways. At the Indianapolis Speedway, for instance, the decibel levels approach the threshold of pain.

Hempton starts his cross-country search accompanied by his self-absorbed, iPod-addicted daughter Abby. Although she abandons her father early in the trip, she returns to the narrative in the end, somewhat older and somewhat wiser. In this deeply personal call to action, Hempton seems to be sending a message to the next generation: Turn down the volume, shut off the engines, and simply listen, simply listen. "Silence is not the absence of something," he writes, "but the presence of everything."

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

Vacation

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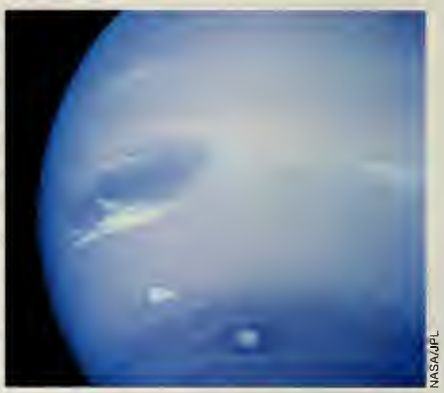
SKYLOG BY JOE RAO

Beginning this month, two planetary "couples" will be dancing in the sky, thanks to two factors: the relative motions of the partners in each planetary pair, as they move along their own orbits; and Earth's motion along its orbital path, which changes our viewpoint over time.

The easier pair to spot is Venus and Mars. They rise roughly one and a half hours before the Sun on May 1, with the Red Planet about 5 degrees to the lower left of Venus, which shines some 160 times brighter. Mars is lumbering along on the far side of the Sun, while Venus is zipping by on our side. The two appear to drift slowly apart until mid-month, reaching as much as 6.6 degrees separation by May 16. Then Venus starts to swing back around the Sun, and from our shifting point of view they remain within 5 degrees of each other from June 2 through July 4. Their closest encounter comes on the morning of June 21, when Mars is just 2 degrees above and to Venus's left.

The other couple to watch is Jupiter and Neptune. This month the duo engage in the first of three conjunctions in 2009. Typically, those two gas giants pair off once about every twelve or thirteen years. Their last "triple conjunction" was in 1971; the next will be in 2047-2048.


NASA/JPL

A Voyager 2 image features clouds and storms in Neptune's atmosphere. The planet's blue color has been intensified by filters.

The two planets, which we see lined up in their respective orbits, do not travel quickly from our point of view. The changes in their relative positions are mainly due to our own planet's motion. The closest of this year's three conjunctions falls on May 27, with Jupiter passing just 0.38 degrees south of Neptune. If you've never observed the most distant planet from the Sun—sorry, Pluto, it's Neptune—you'll have an excellent opportunity. The next conjunctions between these planets will be on July 9 and December 21.

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

MAY NIGHTS OUT

1 The Moon waxes to first quarter at 4:44 P.M. eastern daylight time (EDT).

2 Rising about one and a half hours before the Sun, Venus is at its most brilliant as morning "star" for 2009. That is because the lit part of Venus's disk covers the greatest area of sky for this morning apparition (even though the crescent we see is only about one-fourth of the planet's lit side). Mars sits about 5 degrees to Venus's lower left (see story above).

3 The bright yellowish "star" well above and to the left of the Moon is Saturn.

5 The Eta Aquarid meteor shower, usually the year's best for the Southern Hemisphere, peaks this morning, but is largely spoiled by a bright Moon.

9 The Moon is full at 12:01 A.M. EDT.

17 The Moon wanes to last quarter at 3:26 A.M. EDT. Jupiter sits only a couple of degrees below and to the Moon's right.

21 About an hour and a half before sunrise, look low in the east-northeast for a triangle formed by a crescent Moon, Venus, and Mars. Each side of the triangle measures about 6 degrees.

24 The Moon is new at 8:11 A.M. EDT.

27 Jupiter and Neptune are in conjunction (see story above). Jupiter rises about 1:20 A.M. local daylight time. With good binoculars or a small telescope, focus first on Jupiter, which is about 13,000 times brighter than Neptune, the tiny bluish "star" above it.

EXPLORER GUIDE

A male White-eared Hummingbird

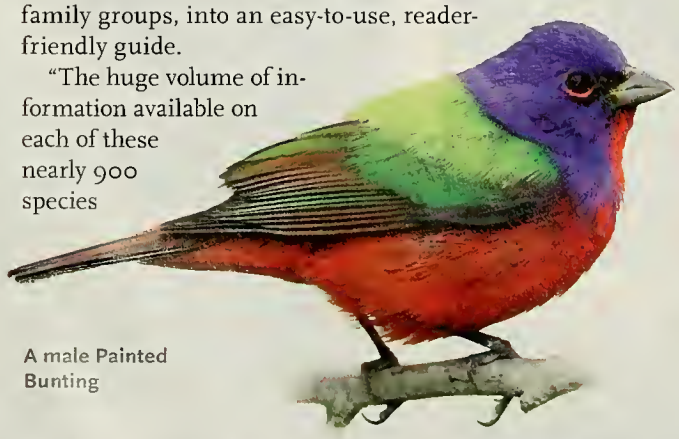
Bird by Bird:
A Comprehensive New Guide

They are the living legacy of dinosaurs, essential collaborators in the food chain, and the delight of watchers the world over. They are birds, and for scientists and amateur aficionados alike, *Birds of North America: The Complete Photographic Guide to Every Species* is a treasure, a book that begs to be stowed on a stand—preferably near a window and a pair of binoculars—to be consulted again and again.

Published this year in association with the American Museum of Natural History by Dorling Kindersley, an international firm renowned for its graphic excellence and comprehensive approach to subjects, the 744-page book covers all species of birds that occur in North America, from the Mexican border to Alaska and the high Canadian Arctic—a vast and extremely diverse area spanning Florida's subtropical mangroves to the tundra. In addition to over 650 regularly breeding species, the book also includes close to 60 rare species and an additional 160 occasional species, the so-called "vagrants".

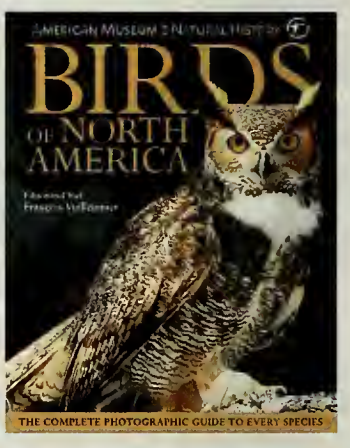
The editor-in-chief, François Vuilleumier, Curator Emeritus and past Chairman of the AMNH Department of Ornithology, described the "sheer magnitude of the task" of turning the expertise of more than twenty birders and ornithologists, each an expert on certain species or family groups, into an easy-to-use, reader-friendly guide.

"The huge volume of information available on each of these nearly 900 species had to be concentrated in short, usable, and pithy paragraphs that were fun to read and understandable to anybody interested in birds generally, as well as scientifically accurate and up-to-date," Dr. Vuilleumier explained.



A male Painted Bunting

The result is a generously illustrated, comprehensive source of useful facts and details, with each of the regularly breeding species given its own full page. Vivid photography and supporting visuals show important plumage variations (subspecies, adult/juvenile, male/female, and breeding/non breeding); flight patterns; similar species; and occurrence, including very precise distribution maps. Information is included throughout the book on behavior, voice, nesting, and habitat, topics often omitted from or difficult to find in many field guides.



Get your copy of *Birds of North America* in the Museum Shop at AMNH or amnhshop.com.

The classification of birds used in the book is based largely on the work of AMNH ornithologists. Those same scientists are currently involved in a project to reconstruct the avian Tree of Life using DNA technology, with a focus on the phylogenetic history of songbirds, which comprise about 60 percent of all living birds.

And *Birds of North America* couldn't be more timely. Birdwatching is said to be the fastest growing outdoor activity in the United States, and based on a recent survey by the U.S. Fish and Wildlife Service, more than 50 million Americans report that they watch birds. Dr. Vuilleumier himself has seen around 4,000 of the 10,000 bird species that exist today. Through his research, he is familiar in the field with all but a handful of the species in the book.

"I am very proud to be associated with such an extraordinary accomplishment," said Dr. Vuilleumier. "All the different components, including the interactions among the many people involved in its production and, of course, the photographs, figure captions, distribution maps, texts, and much more, eventually came together beautifully in a work that is spectacularly gorgeous, scientifically accurate, and unique among the rich literature on North American birds."

Opening This Month: *Extreme Mammals*

Everything in moderation, the saying goes, but not in *Extreme Mammals: The Biggest, Smallest, and Most Amazing Mammals of All Time*, which opens at the American Museum of Natural History on Saturday, May 23. In this thrilling new exhibition, curated by John J. Flynn, Frick Curator of Fossil Mammals and Dean of the Richard Gilder Graduate School, you'll meet animals as light as a dollar bill or as heavy as 20 tons, with antlers as wide as small cars or teeth taller than human beings. Some have oversized claws, fangs, snouts, and horns; some are speedy, others excruciatingly slow. Together, they make up a veritable catalog of astounding adaptations.

"*Extreme Mammals* will surprise and captivate visitors of all ages while also vividly illuminating the spectacular diversity of life," said Ellen V. Futter, President of the American Museum of Natural History.

Featuring spectacular displays from the Museum's fossil mammal collection—the largest of its type in the world, estimated at 400,000 specimens—as well as the Museum's vast modern mammal collections, *Extreme Mammals* follows the evolution of numerous species and examines how some lineages died out while others diversified to form groups of well-known mammals living today. Lifelike models, dynamic media displays, animated computer interactives, hands-on activities, and touchable specimens all bring the science to life.

Upon entering, visitors will encounter *Indricotherium*, the largest land mammal ever, an extinct rhinoceros-like herbivore three to four times the size of an adult African elephant, the largest land mammal alive today. The smallest known mammal, the extinct *Batodonoides vanhouteni*, with an estimated body weight of just 1.3 grams, is also represented in the exhibition; the smallest mammal alive today is the 2.3-gram bumblebee bat (*Craseonycteris thonglongyai*), which flaps its wings like a hummingbird.

AMNH/R. MICKENS

Cynognathus, an early relative of mammals, lived during the early to middle Triassic period, roughly 230-245 million years ago.

Among other highlights are one of the oldest fossilized bats ever found, the skeleton of the giant six-horned *Uintatherium*, and an engaging new diorama of a scene on Ellesmere Island in northern Canada about 50 million years ago, when this Arctic locale was a humid swamp. There are also curious creatures straddling land and sea, like the extinct *Ambulocetus*, or "walking whale".

Promising fun and fascination for the whole family, *Extreme Mammals* runs through January 3, 2010.

Extreme Mammals is organized by the American Museum of Natural History, New York (www.amnh.org), in collaboration with the California Academy of Sciences, San Francisco; Canadian Museum of Nature, Ottawa, Canada; and Cleveland Museum of Natural History.

Major funding for *Extreme Mammals* has been provided by the Lila Wallace-Reader's Digest Endowment Fund.

Additional support for *Extreme Mammals* and its educational programming has been provided by the Eileen P. Bernard Exhibition Fund and by Harlan B. Levine, MD and Marshall P. Levine.

Frogs: A Chorus of Colors

Did you know that frogs have existed on Earth for more than 200 million years—at least since the time of the dinosaurs? While they may be small in size, frogs play a big role in many ecosystems and display truly amazing adaptations that have helped them survive for millions of years. This spring, discover the diverse and colorful world of these complex amphibians when *Frogs: A Chorus of Colors* returns to the Museum on May 30th.

More than 200 live frogs, representing over 25 species from around the world, give children and adults a captivating peek at frogs' traits and behaviors. See if you can spot the Vietnamese mossy frogs (*Theloderma corticale*), whose spotty skin, bumps, spines, and tubercles camouflage them as clumps of moss or lichen. Learn how the waxy monkey frog, which originates from the dry Gran Chaco region of Argentina, Paraguay, and Bolivia, protects itself from dehydration by rubbing a waxy secretion all over its body. Get up close to the very deadly dart-poison frogs, found in Central and South America, so-named because the Emberá Chocó people of northwestern Colombia poison their blow darts by coating them with secretions from the backs of three local and highly toxic species of frogs. A single golden poison frog contains enough poison to kill 20,000 mice or 10 humans! (Don't worry—the frogs in the exhibition have been fed a diet that lacks poisonous compounds, rendering them harmless.) And meet many more amphibians while you explore their evolution and biology, their importance to ecosystems, and the threats they face in the world's changing environments.

© AMNH/R. MICKENS

Bumblebee Dart Poison Frog

This exhibition is presented with appreciation to Clyde Peeling's Reptiland.

Frogs: A Chorus of Colors is made possible, in part, by the Eileen P. Bernard Exhibition Fund.

At the Museum

AMERICAN MUSEUM ō NATURAL HISTORY

www.amnh.org

EXHIBITIONS

Extreme Mammals: The Biggest, Smallest, and Most Amazing Mammals of All Time
Opens May 23, 2009
Explore the surprising and sometimes bizarre world of extinct and living mammals with fascinating specimens and models, media displays, and hands-on activities.

Extreme Mammals is organized by the American Museum of Natural History, New York (www.amnh.org), in collaboration with the California Academy of Sciences, San Francisco; Canadian Museum of Nature, Ottawa, Canada; and Cleveland Museum of Natural History.

Major funding for *Extreme Mammals* has been provided by the Lila Wallace-Reader's Digest Endowment Fund.

Additional support for *Extreme Mammals* and its educational programming has been provided by the Eileen P. Bernard Exhibition Fund and by Harlan B. Levine, MD and Marshall P. Levine.

Climate Change: The Threat to Life and A New Energy Future
Through August 16, 2008
This timely exhibition explores the science, history, and impact of climate change on a global scale, providing a context for today's most urgent headlines.

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

Climate Change is proudly presented by **Bank of America.**

Major support has also been provided by **The Rockefeller Foundation.**

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

Frogs: A Chorus of Colors
Opens May 30, 2009
Back by popular demand, this delightful exhibition introduces visitors to the colorful and richly diverse world of frogs.

This exhibition is presented with appreciation to Clyde Peeling's Reptiland.

Frogs: A Chorus of Colors is made possible, in part, by the Eileen P. Bernard Exhibition Fund.

The Butterfly Conservatory
Through May 25, 2009
Mingle with up to 500 live, free-flying tropical butterflies in an enclosed habitat.

Saturn: Images from the Cassini-Huygens Mission
Through July 26, 2009
This stunning exhibition reveals details of Saturn's rings, moons, and atmosphere with images sent over half a billion miles by the Cassini spacecraft.

The support of the National Aeronautics and Space Administration is appreciated. Special thanks to the Cassini imaging team, especially those scientists at Cornell University's Department of Astronomy, along with the staff of Cornell University photography. The Eastman Kodak Company of Rochester, NY, printed the images.

On Feathered Wings
Through August 30, 2009
This exhibition brings together the work of renowned wildlife photographers whose artistry showcases the majesty of birds in flight.

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

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

GLOBAL WEEKENDS

In Celebration of Indigenous Peoples
Saturday, 5/23, 1–4:30 pm
In recognition of the United Nations Permanent Forum on Indigenous Issues, this afternoon of performances, films, and panel discussions will offer interactive programs for the entire family.

Support for Global Weekends is made possible, in part, by the May and Samuel Rudin Family Foundation, Inc., the Tolan Family, and the family of Frederick H. Leonhardt.

MILSTEIN SCIENCE SERIES

Sundays Under the Whale
Fabien and Celine Cousteau with Ensemble ACJW
Sunday, 5/17, 1 pm
amnh.org/programs/milstein
Milstein Science Sundays explores the amazing underwater world of the orca whale, or killer whale, with **Fabien** and **Celine Cousteau**, third-generation ocean explorers. Featuring "Voice of the Whale," a special multimedia performance by **Ensemble ACJW** with George Crumb's landmark chamber piece **Vox Balaenae.**

Proudly sponsored by the Paul and Irma Milstein family

LECTURES & EVENTS

Self Comes To Mind
Music, Art, & Science Come Together in a World Premiere about the Evolution of Mind
Sunday, 5/3, 7 pm
Yo-Yo Ma performs the world premiere of **Self Comes to Mind**, a musical composition by **Bruce Adolphe**, composer in residence at the Brain and Creativity Institute and resident lecturer of The Chamber Music Society of Lincoln Center.

Co-produced by The Learning Maestros and the University of Southern California's Brain and Creativity Institute.

Global Kitchen
Michael Pollan: In Defense of Food
Thursday, 5/14, 6:30 pm
Author **Michael Pollan** has uncovered hidden aspects of the industrialized American diet. In his newest book, he encourages us to take control of our eating habits with a simple resolution: "Eat food. Not too much. Mostly plants." A book signing follows.

FAMILY AND CHILDREN'S PROGRAMS

Robots in Space III (Advanced)
Tuesday–Thursday, 5/26–28, 4–5:30 pm
If you are experienced with the Lego Mindstorms kit, this class will help you hone your skills as an expert robot designer. *(Ages 8–10)*

Astrofavorites: The NASA Mission Collection
Three Thursdays, 5/7, 5/14, and 5/21, 4–5:30 pm
Sign up for our three most popular children's workshops in one discounted series that includes Giants of the Outer Solar System; Moons, Meteorites, and Mars; and Fly Me to the Moon, on three consecutive Thursdays. *(Ages 4–6, each child with one adult)*

A Night at the Museum Sleepovers
Saturday, 5/9
Friday, 5/22
Friday, 6/19
Friday, 6/26
amnh.org/sleepovers

MEMBERS' PROGRAMS

Mineral Collecting by Moonlight
Saturday, 5/2, 5:30–10 pm
Join geologist **Joe Boesenberg** on this unique nighttime collecting expedition to the Sterling Hill Mine in Ogdensburg, New Jersey.

Cape May Weekend
Friday–Sunday, 5/15–17
Paul Sweet, Collection Manager, Ornithology, leads a tour to the Cape May Point State Park, South Cape May Meadows, and Higbee Beach for bird-watching. On Saturday afternoon, take a boat cruise around Cape May to view dolphins, shore birds, and maybe even a whale or two.

Cruise New York Harbor on Tug Boat Pegasus
Saturday, 5/9, 1–5 pm
Join geologist **Sidney Horenstein** for this unique four-hour cruise aboard Tug Boat Pegasus to explore the nooks and crannies of New York Harbor.

WALKING TOURS

Wild Plants of Central Park
Sunday, 5/10, 9:30–11:30 am
With **"Wildman" Steve Brill**, naturalist, author, environmental educator, you'll learn how to identify plants, and use them as renewable resources.

Geology of Riverside Park and Drive
Thursday, 5/28, 6:30–8 pm
Join geologist **Sidney Horenstein** on this evening walking tour from West 116th Street to Grant's Tomb and beyond.

HAYDEN PLANETARIUM PROGRAMS

TUESDAYS IN THE DOME

Virtual Universe
Behind the Scenes of the Next Space Show
Tuesday, 5/5, 6:30 pm

Celestial Highlights
Celestial Pairs
Tuesday, 5/26, 6:30 pm

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

LECTURES

Michael Lemonick on The Georgian Star: William Herschel and the Birth of Modern Astronomy
Monday, 5/11, 7:30 pm

These programs are supported, in part, by a grant from the Newman's Own Foundation.

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

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

IMAX MOVIES

Wild Ocean
Experience the massive feeding frenzy that takes place each year in the oceans of South Africa as billions of fish migrate up the KwaZulu-Natal Wild Coast.

Dinosaurs Alive!
This stunning film tracks AMNH scientists past and present on expeditions to New Mexico and Mongolia in search of dinosaurs.

LATE NIGHT DANCE PARTY

One Step Beyond
Friday, May 8
Visit www.amnh.org/onestepbeyond for details.

INFORMATION

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

TICKETS AND REGISTRATION

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

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

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ENDPAPER

Frozen Treasures

By Dorothy Harley Eber

Abiluktuk, the first Inuit to see John Ross's Victory, ran home in a fright according to local lore.

There's a stretch of the Boothia Peninsula in the heart of the Canadian Arctic that Inuit still call Kablunaaqhiuvik, "the place for meeting white people." And a few miles away is Killanaaqtuuk, "having desirable things." In 1999 I interviewed Bibian Neeveeovak, one of the oldest of all Inuit elders at the time, who told me, "I'm grateful that *qallunaat*—the white man—ventured up here, because their wreck made the Netsilik people survive."

The wreck she referred to was the *Victory,* a British vessel under command of John Ross, a Royal Navy captain on a private venture in search of the Northwest Passage. The search for the Passage—a waterway from the Atlantic to the Pacific—was Britain's motivation for its great nineteenth-century push into the Arctic Archipelago. The *Victory* was only one of many vessels that came to grief in that quest. But Inuit supposedly tell more stories about the *Victory* than any other wreck or expedition; the wood and metal she provided supplied them for generations.

Ross left England in 1829, sailed north between Baffin Island and Greenland, turned west into Lancaster Sound, and then explored Prince Regent Inlet to the south. On his way he visited the *Fury,* wrecked on Somerset Island five years earlier. He continued some 200 miles and anchored in what he named Felix Harbour on the Boothia Peninsula. (Ross named many points on his journey after his expedition sponsor, the gin manufacturer Felix Booth.) There he promptly jettisoned his engine, an experimental steam model that had proved "a very heavy grievance" from the start. In spring Ross found his vessel locked in the ice, and over the next two years he managed to sail less than twenty miles back up the coast. After the third winter he abandoned his ship in Victoria Harbour. Fortunately for Ross and his men, the Netsilik Inuit, who had never seen Europeans before, frequently helped them. "They were not only kind . . . they were the cause of kindness in those around them, including ourselves," Ross wrote later.

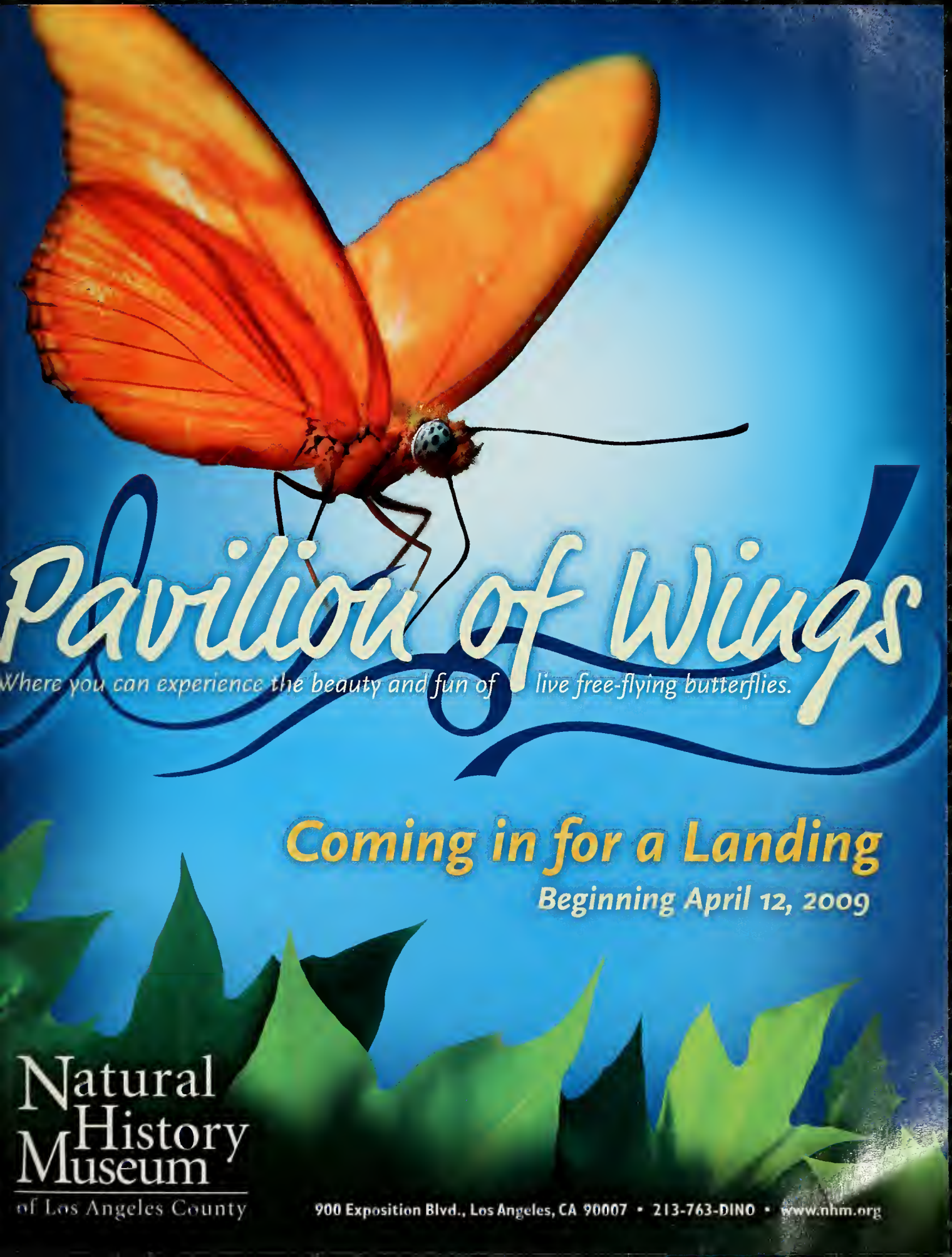
Another bonus for local inhabitants, in addition to the *Victory*'s treasure troves, resulted indirectly from Ross's misfortune. In 1832, as Ross was preparing to abandon his vessel, fears were growing in England that he and his crew were dead. Commander George Back of the Royal Navy volunteered to lead a rescue expedition. Back left England in 1833 and was already en route when he learned that Ross and his men were safe: they had returned to the *Fury,* wintered over, and then rowed out to Lancaster Sound where whalers rescued them all. Back continued on his journey in hopes of mapping more Arctic coastline. He traveled to the mouth of what is now the Back River (Inuit called it the Great Fish River) and discovered Chantrey Inlet. There he left a cache of items for the Inuit: "seed beads."

In 1983 Jessie Oonark, a well-known Inuit artist, told a Canadian government researcher: "There's no place like Chantrey Inlet . . . there were so many fish there that even the fish themselves would climb on top of the rocks and dry out." But the great river could turn cruel in the winter, bringing starvation and death. When that happened in 1958, Inuit left the land, with government assistance, and moved into settlements. Simon Tookoome, also an artist, told me of his life in that dreadful year. "The time I was most afraid was when my father said he didn't want to walk further distances just to starve to death. He wanted to camp and not move again, even if we starved. But we didn't do that . . . we survived."

Echoes of old stories about explorers traveling down the Back River still endure. Silas Kulluk, who isn't sure if he is ninety-one or ninety-nine, tells me, "I heard about early white men. . . . One of them visited an Inuit tent and gave a woman a paper. After he left, the woman threw the paper in the fire. Later she began to think, 'Maybe that paper was needles.'" Others recall that "some of those white men spat a lot . . . maybe the beginnings of roads?"

And up to today at a special spot on the shore of Chantrey Inlet, you can dig up the beads that spilled out of the cache left by George Back in 1834. Generations of Inuit women have dug them up to turn their parkas, as illustrated below, into works of art.

Dorothy Harley Eber has written a number of articles on the Inuit for Natural History. *Her most recent book* Encounters on the Passage: Inuit Meet the Explorers *was published in October 2008 by the University of Toronto Press.*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