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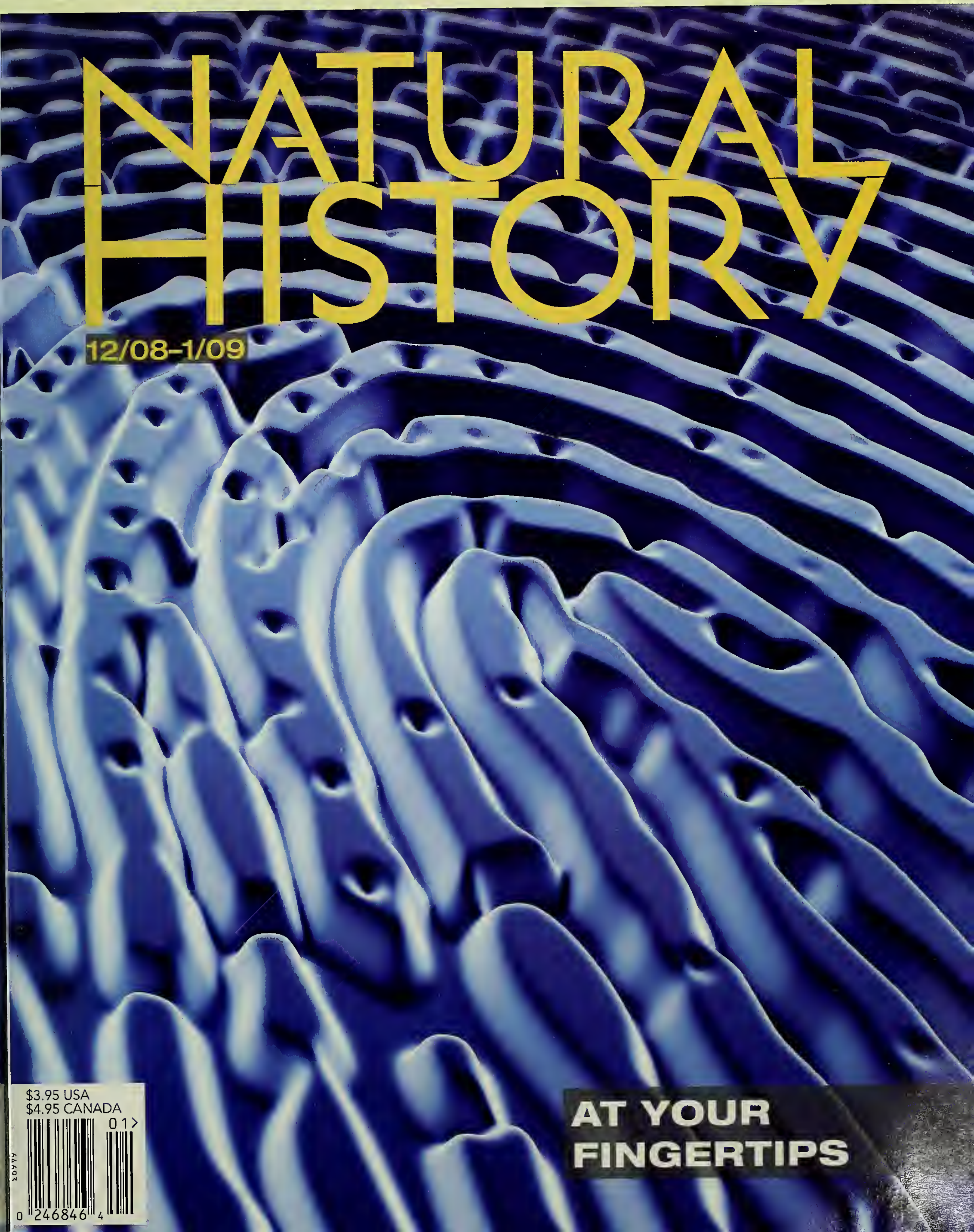
NATURAL HISTORY

12/08–1/09



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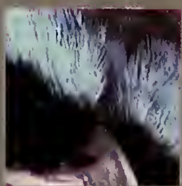
NATURAL HISTORY

DECEMBER 2008/JANUARY 2009 VOLUME 117 NUMBER 10 www.naturalhistorymag.com

FEATURES

DEPARTMENTS

ON THE COVER: *Human fingerprint, computer generated from a two-dimensional monochrome ink print. Image by Alfred Pasieka / Photo Researchers, Inc*



THE NATURAL MOMENT

CRITICAL MASSES

Photograph by Jerry S. Merrill

◄ *See preceding two pages*

THE NATURAL EXPLANATION BY ERIN ESPELIE

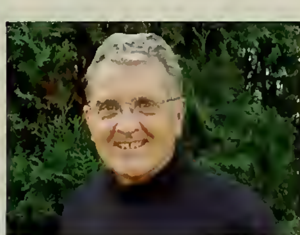
Aldo Leopold, staunch conservationist and gifted forester, wrote "What if there be no more goose music?" in one of his most moving essays, published posthumously in 1953. Looking to the future, he worried about the bleak but real possibility that the jubilant sound of geese would be extinguished by habitat destruction and overhunting. Leopold's most famous book, *A Sand County Almanac,* was published in 1949—the year after his death from a heart attack suffered while quenching a Wisconsin neighbor's brush fire—and so celebrates its sixtieth anniversary in 2009. Imagine the relief and joy he might have felt to see this massive flock of migrating snow geese (*Chen caerulescens*), photographed last Easter Sunday in upstate New York by Jerry S. Merrill.

Snow geese were heavily hunted in the 1800s—as were Canada geese (*Branta canadensis*). But with some government protection, populations burgeoned during the twentieth century. In North America today, according to the United States Fish and Wildlife Service, "light geese" (the snow goose and its close relative, Ross's goose) number around 4.7 million, and Canada geese around 7.5 million.

That's far too many, some people say. Canada geese have become notoriously pesky—in part because about half of them no longer migrate, content to settle on farmland, golf courses, and airfields. Their feces are a nuisance and can even contaminate water supplies. Perhaps more worrisome, however, is the damage being done to exceedingly fragile nesting habitat in Canada and the Arctic by geese still making the seasonal round trip.

Last year, hunters bagged approximately 560,000 snow geese and 2.7 million Canada geese in the U.S. Those population checks have been supplemented by even more extreme measures, such as spraying eggs with corn oil, which suffocates the embryos, and spraying the habitat with methyl anthranilate, a grapey food flavoring that repels birds.

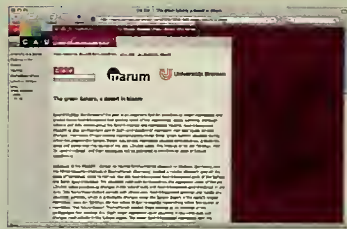
Even so, too many geese may be more preferable than too few. "Goose music" should be destined to last, and is already inspiring a new generation. Merrill's six-year-old grandson, Max, also witnessed the snow-goose spectacle. For weeks afterward he enthusiastically imitated the "thumpthump" of wingbeats as the birds funneled into the sky, circled, and thundered back to the ground to feed.



Jerry S. Merrill lives in upstate New York, not far from his former art teacher, Klaus Ebeling, who alerted him to the snow geese gathered in a local cornfield last March. Merrill and Ebeling have ice-sculpted together, often competing around the U.S. and internationally, over the past twenty-one years. Merrill's work as an oil painter can be found at www.jerrysmerrill.com.

nature.net by robert anderson

DESERT MENU



LOOK AT AFRICA FROM SPACE, and you'll notice a belt of dark green across the continent's midsection. A friend studying a poster of Earth once asked me what caused that "shadow." It's vegetation, of course, and what makes it stand out is the contrast with the continent's arid regions, most notably the Sahara Desert. Scientists at the University of Kiel, Germany, however, have shown that three times within the past 120,000 years, the Sahara region was covered in grassland, lakes, and ponds (see "The Green Sahara, A Desert in Bloom" at www.uni-kiel.de/aktuell/pm/2008/2008-088-klima-sahara-e.shtml). For my guide to Web sites exploring the Sahara's climate and ancient history, please visit the magazine online (www.naturalhistorymag.com).

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

WORD EXCHANGE

Acid Indigestion

In one of his "Samplings" ("Arm Wrestling," 9/08), Stéphan Reebs refers to "seawater that was either normal (pH 8.0) or acidified (pH 7.7)." As a high school science teacher, I tell my students that anything above 7.0 is basic, and anything below 7.0 is acidic. How can pH 7.7 seawater be considered acidic?

Jennifer Hauenstein
Canton, Georgia

STÉPHAN REEBS REPLIES: Normal seawater does have a slightly basic pH of 8.0. By "normal" I meant "usual," not "neutral." Thus 7.7 is acidified, though indeed it is not acidic. Lack of space made it difficult to avoid the ambiguity.

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.*

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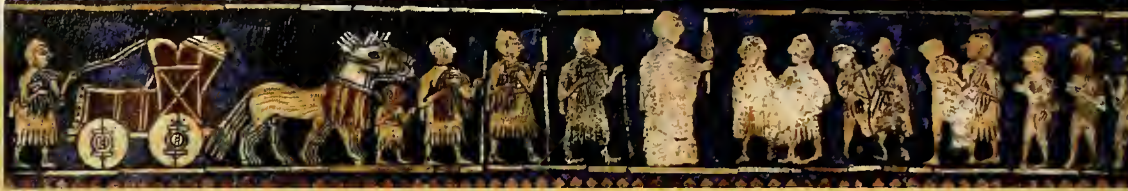


Mosaic from Ur, Iraq, circa 2600 B.C. (detail)

Creative Destruction

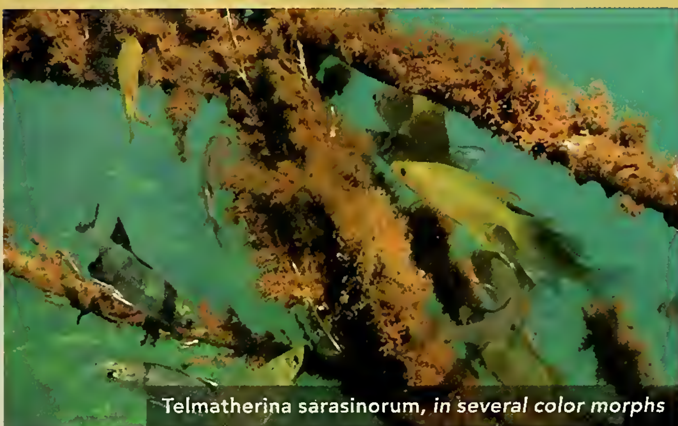
The seats of ancient civilizations were great meeting places. Trade routes, ideas, and cultural currents converged there—as did tectonic plates, says archaeological geologist Eric R. Force of the University of Arizona in Tucson.

On a map of the Eastern Hemisphere, Force overlaid the locations of plate boundaries and the founding cities of thirteen ancient civilizations. He discovered that eleven of the thirteen fell within 120 miles of the Eurasian plate's southern boundary—too many, and too close, to be just coincidence. (Among the eleven cities were Rome, Corinth, Mycenae, Jerusalem, Ur in Iraq, and Hastinapura in India; the two exceptions were Memphis in Egypt and Zhengzhou in China.)

The great plates of the Earth's crust collide at tectonic boundaries, which often feature active volcanoes, earthquakes, and large water springs, and which parallel seacoasts for long stretches. Some of those features would seem to obstruct cultural advancement, others to help; whether any, alone or in combination, can explain why civilizations tend to arise near tectonic boundaries remains subject to speculation.

Force points out one intriguing possibility: that frequent shake-ups by earthquakes, tsunamis, or other natural disasters destroy the old, making way for improved infrastructure and new customs. The seats of civilizations that sprang from older civilizations hugged tectonic lines more closely than the seats of self-generating societies, he found. Similarly, the farther a civilization was from a boundary, the longer it endured. (*Geoarchaeology*)

—*Stéphan Reebs*



Telmatherina sarasinorum, *in several color morphs*

Games Fishes Play

He's quite handsome and he's got all the right moves. He looks foreign, but his courtship is intoxicating. You decide to spawn with him—oh, yes, I forgot to mention, you're a female fish—and then, the horror! Instead of fertilizing your eggs, the little devil eats them!

Such are the games sailfin silversides play. Several species of the small, brightly colored fishes inhabit the Malili Lakes of Sulawesi, Indonesia. Suzanne M. Gray, now at Queen's University in Kingston, Ontario, went to Indonesia in 2003 and 2004 to study one of them, *Telmatherina sarasinorum*, which lives only in a single lake. Now she and three colleagues report four sightings of *T. sarasinorum* males that each followed a courting pair of the closely related species *T. antoniae*, and that eventually chased off the courting male, took his place, enticed the female to spawn, and then devoured her eggs.

An unrepentant cannibal, *T. sarasinorum* regularly eats eggs of its own species, as well as those of others. Some males even gobble up eggs they may have fertilized themselves, especially when their paternity is in doubt (cuckolders abound in this decidedly sneaky species). So perhaps the false courtship is nothing more than a misdirected innate behavior followed by a normal caviar meal. It's tempting, however, to see the dastardly deed as a Machiavellian attempt by one fish to deceive another to get food. (*Journal of Fish Biology*) —*S.R.*

How to Harvest a Harvester

Harvester ants are among the most aggressive and venomous stinging insects known. Although their stings, in quantity, can kill, the horned lizard captures harvesters by the dozen—in a typical lizardlike manner. What comes next, however, doesn't conform to typical lizard table manners.

Mucus-bound harvester ant from a horned lizard's stomach

Most lizards bite and chew their prey before swallowing, but after nabbing one of the nasty ants with its long tongue, the horned lizard rolls its snack straight into its esophagus, merging intake, transport, and swallowing into a single thirty-millisecond move. Using high-speed videography, Wade C. Sherbrooke of the American Museum of Natural History's research station in Portal, Arizona, and Kurt Schwenk of the University of Connecticut in Storrs revealed that remarkable process. But if horned lizards don't kill harvester ants with their teeth, how can they possibly avoid getting bitten and stung as their pugnacious meals go down the hatch?

The lizards' stomach contents provided the answer. Sherbrooke and Schwenk found the ants enveloped in mucus—their mandibles, limbs, and stingers completely immobilized. The goo, the scientists discovered, is produced in specialized cells distributed on the reptilian ant eater's tongue, larynx, trachea, and pharynx.

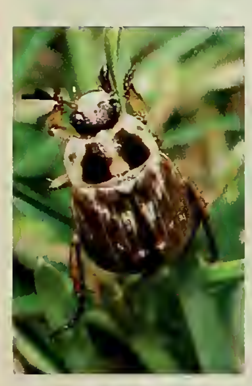
The horned lizard's feeding mechanism and anatomy are unique among lizards—as is its taste for harvester ants. You've got to get creative to deal with food that fights back. (*Journal of Experimental Zoology*) —*Graciela Flores*

Texas horned lizard

More Before Less

Parasites typically don't have as many genes as their free-living relatives do. Life is simple because their hosts do the hard work of moving about, getting food, and avoiding predators. Consider the nematodes (aka roundworms). The common free-living soil

dweller *Caenorhabditis elegans*—which in 1998 became the first multicellular animal ever to have its genome decoded—has about 20,000 genes, whereas *Brugia malayi*, the parasite that causes the tropical disease filariasis, has just 11,500. Yet in the course of parasite evolution, genomes may need to grow before they can shrink.



Oriental beetle, the host of the nematode Pristionchus pacificus (top, magnified 100×)

Ralf J. Sommer and Christoph Dieterich of the Max-Planck Institute for Developmental Biology in Tübingen, Germany, along with fifteen colleagues, have sequenced the genome of *Pristionchus pacificus*, a nematode that invades the bodies of beetles but does not live off them. Instead, it waits in a state of suspended animation for its host beetle to die of natural causes before popping out and feeding on bacteria and fungi that grow on the carcass. *P. pacificus* has about 23,500 genes, the team discovered, 17 percent more than *C. elegans*.

The ability to live both inside and outside a body, as *P. pacificus* does, is probably a stepping-stone on the evolutionary road to true parasitism, and it takes a big genome to get by in multiple habitats. Only once adaptively committed to spending its entire adult life within a host could a true parasite—perhaps a descendant of *P. pacificus*—pare down its DNA baggage. (*Nature Genetics*) —*S.R.*

TOP LEFT AND MIDDLE: MATTHIAS HERRMANN AND RALF J. SOMMER, MPI DEVELOPMENTAL BIOLOGY

African wild dogs feast on a kill.

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The Power of Ten

Packs of African wild dogs run down impalas and other fleet-footed prey for a living. But that lifestyle is energetically precarious: running takes a lot of work, and food must be divvied among pack members. Moreover, small stomachs, an adaptation to running, mean the dogs must sometimes abandon their leftovers. What pack size lets wild dogs maximize their hard-won calories?

The magic number is ten, according to a study by Gregory S.A. Rasmussen, of the University of Oxford, and three colleagues. From 1994 through 2002, Rasmussen tracked twenty-two wild-dog packs in and around Hwange National Park in Zimbabwe, monitoring their activity level, the distance of their chases, their hunting success, and the size of their prey. From those data, the team calculated that packs ten strong posted the greatest caloric intake per dog. Any other number, and the calories dropped; in packs smaller than five, they plummeted.

The team also found that smaller packs breed fewer pups. They posit that in packs of four or fewer wild dogs, lack of food limits the number of offspring, further reducing pack size—a downward spiral toward oblivion. Most packs at the study site numbered just six, too close to that limit for comfort, particularly given that the species is endangered. The team says populations with small packs should get priority in conservation measures, such as the introduction of new members or special protection from hunters. (*The American Naturalist*) —*S.R.*

Andean High Life

The Puca Glacier, perched above 16,000 feet in the Peruvian Andes, is retreating by seventy feet per year. Its withdrawal is exposing some of the driest, most barren terrain on Earth for the first time in at least 700 years. The soil, nearly devoid of organic carbon and nitrogen, seems a poor home for life of any kind.

Yet large communities of microbes known as cyanobacteria spring up immediately in the glacier's wake, says Steven K. Schmidt of the University of Colorado at Boulder. With ten colleagues, he catalogued microbial DNA at various distances from the glacier and analyzed chemical and structural changes to the soil caused by cyanobacteria over a five-year study period.

As the glacier vanishes, cyanobacteria riding in icebound soil pockets drop onto the dry ground, the team found. The cyanobacteria quickly improve the soil by fixing carbon (through photosynthesis) and nitrogen from the air, as well as by leaving behind rich remains at death. Other cyanobacteria, borne in by the wind, can then establish themselves, and within just four years, colonies of increasingly complex microbes take hold. Soil exposed seventy-nine years ago now supports lichens and other plant life.

The Puca Glacier is subjected to intense ultraviolet radiation, extreme daily temperature variations, and a lack of rain. Scientists looking for evidence that life might once have existed on Mars may find clues by studying the microbes that inhabit such harsh Earthly environments, says Schmidt. (*Proceedings of the Royal Society B*) —*Harvey Leifert*

SAMPLINGS

Picky Mouse Club

Some mice shop for a new home much the way people do: they repeatedly visit several nest sites before deciding on one.

Brush mouse

After being weaned, brush mice (*Peromyscus boylii*), which live throughout western North America, venture forth from their birthplaces to find living quarters of their own. Wondering just how the mice go about choosing their lodgings, Karen E. Mabry and her graduate adviser at the University of California, Davis, Judy A. Stamps, followed the movements of thirty-one juveniles fitted with tiny radio collars in a university nature reserve. Noting where the nocturnal rodents slept during the day for the week or more they spent nest hunting, the two biologists discovered that the mice visited an average of three potential nest sites before finally picking a permanent home.

Notably, individual mice often revisited potential nests, and didn't necessarily pick the last one they visited. Thus they appeared to be comparing the suitability of various possible homes, rather than settling for the first nominally acceptable one. Many animals are known to employ a similar strategy when choosing mates—another important life decision—but this is the first time comparison shopping for a home by a mammal has been demonstrated in the field. (*The American Naturalist*) —*S.R.*

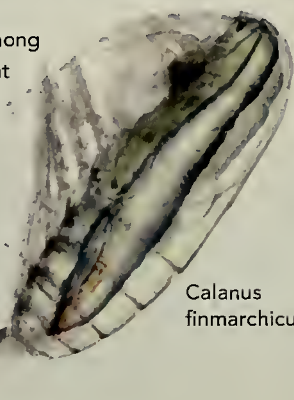
THE WARMING EARTH

Copepods Cope with Climate Change

A small zooplankton species, the copepod *Calanus finmarchicus*, is the dietary mainstay of many economically valuable fishes in the North Atlantic Ocean. Climate change is shifting the region's cool waters northward, and some of the copepods have managed to tag along. Scientists have worried, however, that most are trapped in dangerously warming waters by vast, circular oceanic currents called gyres. Indeed, as a result, *C. finmarchicus* numbers have plummeted 70 percent during the past four decades, sparking fears that there may soon be too few to maintain a viable population—or food web. Now, Jim Provan and four colleagues, all at the Queen's University of Belfast in Northern Ireland, have shown that the copepods are more mobile and resilient than had been feared.

If *C. finmarchicus* couldn't successfully disperse, genetic differences would have cropped up among the populations living near Nova Scotia, Greenland, Iceland, and Norway. Yet after extensive sampling throughout the North Atlantic, Provan's team found no evidence of such genetic isolation. Some individuals must escape their gyres and follow the cool waters north.

Moreover, though there was little genetic variability among *C. finmarchicus* populations, there was a moderate amount within them. For that to happen, Provan calculated, the species would have had to maintain fairly high numbers for the past 350,000 years. Several warm spells occurred during that time, including the one that ended the last ice age 18,000 years ago. The little critters appear to be climatic survivors—but the unprecedented speed of the current warming may test their survival skills. (*Proceedings of the Royal Society B*) —*S.R.*



Calanus finmarchicus

Tholos, or circular building, at the Shrine of Athena Pronaia, Delphi, Greece

Holy Ground

To honor their gods and goddesses, ancient Greeks often poured blood or wine on the ground as offerings. Now a new study suggests that the soil itself might have had a prominent role in Greek worship, strongly influencing which deities were venerated where.

In a survey of eighty-four Greek temples of the Classical period (480 to 338 B.C.), Gregory J. Retallack of the University of Oregon in Eugene studied the local geology, topography, soil, and vegetation—as well as historical accounts by the likes of Herodotus, Homer, and Plato—in an attempt to answer a seemingly simple question: why are the temples where they are? No clear pattern emerged until he turned to the gods and goddesses. It was then that he discovered a robust link between the soil on which a temple stood and the deity worshiped there.

For example, Demeter, the goddess of grain and fertility, and Dionysos, the god of wine, both were venerated on fertile, well-structured soils called Xerolls, which are ideal for grain cultivation. Artemis, the virgin huntress, and her brother Apollo, the god of light and the Sun, were worshiped in rocky Orthent and Xerept soils suitable only for nomadic herding. And maritime deities, such as Aphrodite, the goddess of love, and Poseidon, the sea god, were revered on Calcid soils on coastal terraces too dry for agriculture. The pattern suggests that the deities' cults were based on livelihood as much as on religion. And, says Retallack, temple builders may have chosen sites to make the deities feel at home. (*Antiquity*) —*G.F.*

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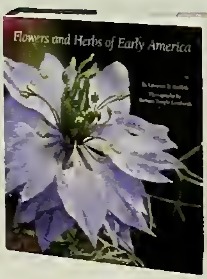

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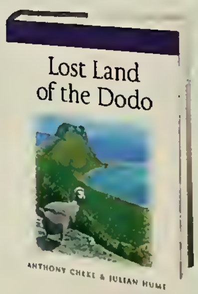

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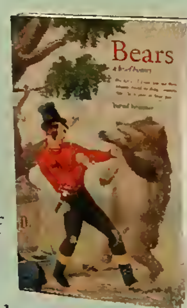
Bernd Brunner

Translated by Lori Lantz



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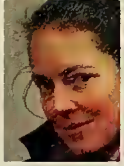


Sticky Fingers

Fingerprints are one of the oldest biometric measures of identity. What do we actually know about them?

In 1905, two brothers, Alfred and Albert Stratton, were found guilty of murdering a shopkeeper and his wife in Deptford, a town outside London. The evidence? A thumbprint at the scene of the crime. The brothers were hanged.

The Stratton trial was the first time in Western jurisprudence that fingerprint evidence had been presented in a murder case. As such, it was a triumph for Charles Darwin's cousin Francis Galton. Galton had spent years collecting fingerprints, studying and classifying their patterns of loops, arches, and whorls. It was he who had not just speculated, but demonstrated that fingerprints are a reliable way of telling one person from another, and persuaded the police that they could be used to solve crimes.

Up to that point, fingerprints had been used not as a means to identify criminals, but as a way for you to prove that you were you and not someone else. The ancient Babylonians sometimes impressed fingerprints on clay tablets that recorded business transactions, and centuries ago the Chinese made use of thumbprints on clay seals. In India in the nineteenth century, a fingerprint took the place of a signature for people who were illiterate and could not, therefore, sign their names. The first use of fingerprints by "officialdom" didn't come until the 1860s, when William Herschel, a magistrate for the British colonial administration in India, realized that fingerprints could be used as a means of identification when people came to collect their pensions. The person collecting the pension would give a print, which would be compared to a print on file; in that way, fingerprints could be used to prevent identity fraud.

In instituting this, Herschel made the assumption that individuals have unique fingerprints; the fact that it was actually so remained to be proved. That proof was provided by Galton, who demonstrated statistically that the odds of two people having the same fingerprints are vanishingly remote. He also—using prints sent to him by Herschel—confirmed Herschel's observation that fingerprints do not change with age, a crucial feature if they were to be a reliable form of identification. And Galton began to develop a method for cataloging fingerprints, so that police could file fingerprints by type and quickly compare any two sets. (A full-fledged cataloging system, based on Galton's, was subsequently developed by Edward Richard Henry, who had served as inspector general of police in Bengal; the fingerprint classification system came to be known as the "Henry System.") In short, Galton laid the groundwork for the police to begin to build a usable fingerprint database.

In the hundred or so years since the Strattons went to the gallows, many other forms of biometric identification have been invented: dental records, iris scans, DNA fingerprints (a way of typing, or describing, someone based on a set of genetic markers; unless they are identical twins, the chance that two people have the same DNA fingerprint is close to nil), face and gait recognition, and so on. While iris scans are a hi-tech means of proving that you're you, in criminal cases the DNA fingerprint is now the evidence of choice. DNA can be gathered from bloodstains, saliva on a cigarette butt, or even a few skin cells left behind in a regular fingerprint. Since 1989, more than 200 people in the United States have had criminal convictions overturned on the basis of new DNA evidence. Incidentally, a regular fingerprint can be mined not

JOHN NORTON/JOHNNORTONART.COM

In addition to arches, loops, or whorls, each fingerprint contains a variety and arrangement of details, such as those identified here, that make it unique.

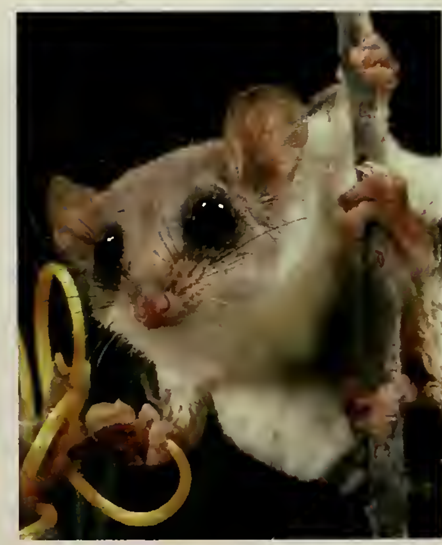
not only for residues of DNA but for traces of other substances, such as narcotics and explosives.

But even in these days of DNA, the plain old finger-based fingerprint remains the most widely used method of identification. For the time being at least, databases of fingerprints are far larger (ten times larger, in the FBI's case) than those of DNA. Moreover, fingerprints are easy, quick, and cheap to collect. Foreigners visiting the United States today are fingerprinted on entry, for example, a process that uses an inkless digital scanner and takes a few seconds.

But how do fingerprints form? And why do we have them in the first place?

The foot pads of a cat or a dog don't have patterns of ridges and lines: they are essentially smooth. So are the hands and feet of flying lemurs—small gliding mammals that live in the forests of Thailand, on the islands of Indonesia, and in the Philippines. But a large number of other mammals do have fingerprint-like markings. Among them are primates, tree shrews, koalas, and several species of possums. Indeed, Henry Faulds, the first person to write about fingerprints in a scientific journal—his letter to *Nature* was published in 1880—had noticed that monkeys have fingerprints similar to those of humans. Later, the keepers of at least one colony of captive chimpanzees would fingerprint the animals as a sure means of telling them apart.

Fingerprints—meaning now the actual ridges that leave the prints—play a role in our sense of touch. But their more important role seems to be in improving grip. For example, rodents that climb bushes and trees have dense, distinct ridges on their paw pads; rodents that dig do not. Or, consider the tiny possum *Acrobates pygmaeus*, otherwise known as the feathertail glider. That dainty mouselike creature has pronounced ridges on its paws that allow it to run up smooth vertical surfaces—even a pane of glass—as easily as a fly or a gecko. (The ridges are only part of the story: the paws of that climber also have sweat glands, which increase the stickiness and help the animal to cling.)



"Fingerprint" ridges on the pads of digits are most common in mammals that use their hands and feet for grasping and for climbing shrubs and trees, such as the feathertail glider, above.

But perhaps the clearest evidence that fingerprints help with grasping comes from the spider monkey and its relations. Those animals have long, prehensile tails, which they use to suspend themselves from branches and to manipulate objects. Such a tail is, in many respects, an extra hand. And near its tip, it has a "friction pad"—a hairless area of skin with ridges and other markings that look like a fingerprint. That strongly suggests that fingerprints help us get a grip. Without them, we'd be a species of butterfingers.

Fingerprints appear in the womb. By week twenty, a fetus has the fingerprints that he or she will carry for the rest of his or her life. The way they form isn't entirely understood, but what seems to happen is that as the embryonic hands and feet form and grow, protuberances called "volar pads" swell outward on the palms and soles, fingertips and toes, and then shrink back again. As the volar pads regress, putting pressure on the fastest-growing middle layer of skin, this "basal layer" buckles into ridges, laying the foundation for a pattern of loops, whorls, and arches resembling the lines on a contour map.

Interestingly, fingerprints are not predetermined by genes in the way that hair and eye color are. That is to say, as far as anyone knows, there aren't genes that cause, say, a fingerprint with three whorls. That probably explains why identical twins don't have identical fingerprints (although the fingerprints of identical twins will be more similar to each other than to those of a random person in the street). Fingerprints apparently emerge as a result of both gene expression (directing, say, the shape of volar pads and the timing of development) and environmental chance, and thus contain an element of randomness.

However, a number of genetic

TOP: HEATHER GORDON, AFTER FDIC; BOTTOM: A.N.T. PHOTO LIBRARY/NHPA/PHOTOSHOT

disorders affect the appearance of a fingerprint. For instance, individuals with cri-du-chat syndrome, a disease that results from a large deletion of part of chromosome 5, have fingerprints crowded with more ridges than usual. Along with making high-pitched catlike cries at birth, victims of the disease typically have small jaws, small heads, low-set ears, and severe mental retardation. What's notable is that many manifestations of the syndrome are due to abnormal growth in the womb. The deletion evidently includes at least one gene involved in growth, so there's no surprise that also affects fingerprint growth.

Similarly, individuals with an extra copy of part of chromosome 4 have fingerprints characterized by extra whorls. Here, too, individuals have stunted growth, small heads, and low ears. (Since the problem originates in having an extra copy of some genes, rather than in missing some as with cri-du-chat, perhaps that part of chromosome 4 contains growth-*inhibiting* genes.)

Left: Print of left index toe of a young orangutan; right: print of right third finger of an adult koala

LEFT: © PHOTO RESEARCHERS, INC.; RIGHT: R MURPHY/NATURALSCIENCE

Other factors that affect the growth of the fetus before week twenty can also affect the fingerprints. For instance, infection with the virus that causes rubella results in (among other things) fingerprints with more whorls than average. Starvation in the womb alters fingerprints, too. One study even found that the season of conception influences fingerprint patterns, changing the ratio of ridges found on the thumb to those on the little finger. Whether that is due to light levels, or vitamin D, or diet, or some other factor, is entirely unknown.

Such observations suggest that, in principle, fingerprint reading could give some clues to the circumstances an individual experienced in the womb, the time of year he or she was born, and even, potentially, his or her genetics. Perhaps fingerprint—and palm—reading has something to it after all?

Not really. Fingerprints are so complicated, and yet so generally similar in structure that it's hard to infer anything about a person just from looking at them. Even the gross fingerprint traits that arise when entire segments of chromosomes are duplicated or deleted are rarely diagnostic on their own. Rather, they are just one of a suite of abnormalities that help to diagnose a disease.

Galton would be disappointed, but probably not surprised. He had hoped that fingerprints would give insights into other aspects of someone's character—such as intelligence, or criminality. But he found nothing. He also hoped that people of different races would have different fingerprints, that ethnicity would be, so to speak, stamped onto people's hands. Again, despite examining many thousands of fingerprints—including those of African, Jewish, and Welsh schoolchildren—he found nothing. For that kind of identification, he'd have had to be able to analyze DNA (it's starting to become possible to use DNA to tell someone's ethnicity). A fingerprint can solve many crimes. But it isn't a window into a person's being.

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

The Art of Bones

BY ROBERT MCCRACKEN PECK

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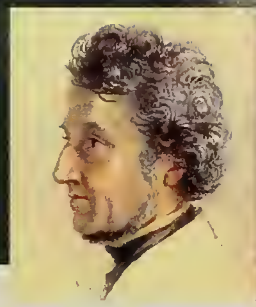
Benjamin Waterhouse Hawkins's life-size reconstructions of prehistoric animals take shape in 1853, in preparation for their installation on the landscaped grounds of the Crystal Palace in Sydenham, London.

Reconstructed skeletons of dinosaurs and life-size models of how they may once have appeared are now commonplace. But until the British artist Benjamin Waterhouse Hawkins created such things in the second half of the nineteenth century, dinosaurs and their kin were poorly understood and of little interest to anyone but a handful of professional paleontologists. Hawkins was responsible for designing public displays both in Great Britain and in the United States depicting prehistoric life; he also produced a wealth of drawings, paintings, and lithographs to illustrate the publications of such influential figures as Charles Darwin and Thomas Huxley. Indeed, no other artist had direct involvement with so many of the leading scientific lights of that seminal period. Yet Hawkins, who changed forever the way people thought of time and the history of life on Earth, never came to believe in evolution.

The beginnings of Hawkins's lasting influence in paleontology can be traced to September 1852, when he earned an extraordinary commission: to fashion a group of life-size sculptures of "antediluvian monsters" for London's Crystal Palace. The building, which had originally housed the Great Exhibition of 1851 in Hyde Park, was to be re-erected as part of a commercially owned and operated exhibition ground in Sydenham, in South East London. A landscaped park was to feature lakes, fountains, and a series of islands on which Britain's geological and paleontological history would be portrayed for the public to enjoy. Hawkins

British artist Benjamin Waterhouse Hawkins, who sparked dinosaur mania in the nineteenth century, still influences how natural history museums represent prehistoric life today.



was given a prime location, a substantial budget, and a mission, in his own words,

> for the first time to illustrate and realise—the revivifying of the ancient world—to call up from the abyss of time and from the depths of the earth, those vast forms and gigantic beasts which the Almighty Creator designed with fitness to inhabit and precede us in possession of this part of the earth called Great Britain.

With scientific guidance from Richard Owen, the eminent comparative anatomist and paleontologist who was head of natural history collections at the British Museum, Hawkins went about his re-creation of the prehistoric world with typical diligence, carefully researching the current understanding of geology, stratigraphy, geography, and paleontology.

Since the end of the eighteenth century, fossil finds in Great Britain and elsewhere in Europe had stimulated thinking about prehistoric life on Earth. Discoveries by naturalists and collectors had provided tangible evidence that large reptiles once roamed the oceans and shorelines of a "pre-Adamite" world. In 1821, British paleontologist Gideon Mantell and his wife, Mary Ann, discovered the fossil teeth of a large reptile in Sussex. Mantell eventually named the creature from which the teeth had come *Iguanodon* because of a similarity between the fossil teeth and those found in living iguanas.

Over the next few decades, as other fossils were discovered, scientists began to acknowledge that they might represent newfound classes of ancient creatures whose existence had previously been unknown. In a paper published by the British Association for the Advancement of Science in 1842, Owen proposed assigning the name *Dinosauria*, or "terrible lizards" (from the Greek *deinos*—terrible—and *sauros*—lizard), to three of the terrestrial finds.

Hawkins had followed the news of those discoveries and scientific debates with great interest. Now he was given the opportunity to examine the actual fossils at the British Museum, the Royal College of Surgeons, and the Geological Society and in other collections around England. Using them as the foundation for his speculative reconstructions, Hawkins created clay models of dinosaurs, extinct reptiles, and early mammals. He worked to scale, one-sixth to one-twelfth the natural size. Once his models were approved by Owen, Hawkins began turning them into full-size

Top: 1855 portrait of Benjamin Waterhouse Hawkins by his wife, Frances Louisa Hawkins. Right: Hawkins stands beneath the skeleton of Hadrosaurus foulkii. *The articulated mount, prepared by Hawkins for the Academy of Natural Sciences in Philadelphia in 1868, set the standard for exhibiting fossil bones.*

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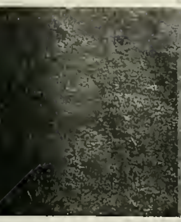
sculptures. In an address to the Royal Society of Arts, he later explained the enormous undertaking:

> Some of these models contained 30 tons of clay, which had to be supported on four legs, as their natural history characteristics would not allow of my having recourse to any of the expedients for support allowed to sculptors in an ordinary case. I could have no trees, nor rocks, nor foliage to support those great bodies, which, to be natural, must be built fairly on their four legs. In the instance of the Iguanodon [it] is not less than building a house upon four columns, as the quantities of material of which the standing Iguanodon is composed, consist of 4 iron columns 9 feet long by 7 inches diameter, 600 bricks, 650 5-inch half-round drain tiles, 900 plain tiles, 38 casks of cement, 90 casks of broken stone, making a total of 640 bushels of artificial stone.
>
> These, with 100 feet of iron hooping and 20 feet of cube inch bar, constitute the bones, sinews, and muscles of this large model, the largest of which there is any record of a casting being made.

Although Hawkins tried, when possible, to re-create extinct animals "of which the entire, or nearly entire skeleton had been exhumed in a fossil state" (namely *Iguanodon, Plesiosaurus,* and *Megatherium*), there were some, such as the *Mosasaurus,* "of which only the fossil skull and a few detached bones of the skeleton" had been discovered. These Hawkins only partially represented, obscuring their unknown body parts in the water that surrounded his island displays. Other species, such as the *Labyrinthodon* and *Dicynodon,* he tried to reconstruct imaginatively. Although plausible by mid-nineteenth-century standards, and convincing to the public, those sculptures were, in Owen's words, "more or less conjectural."

While the accuracy of Hawkins's reconstructions could—and would—be debated among the scientific cognoscenti, the life-size antediluvian monsters made an enormous impression upon the many people who saw them. Millions of visitors flocked to the Crystal Palace and its beautiful grounds after the exhibition was opened by Queen Victoria in June 1854. Forty thousand people attended the opening ceremonies alone.



Left: Hawkins's design for New York's Paleozoic Museum, a project that was closed down by the city's infamous politician William "Boss" Tweed. Below: *Jurassic Life of Europe* was one of seventeen canvases Hawkins completed in 1875-1877 for the Elizabeth Marsh Museum of Geology and Archaeology at the College of New Jersey (now Princeton University).

Hawkins's work at Sydenham firmly established his reputation: no one else had ever combined an artistic interpretation of the fossil evidence with the complex engineering skills needed to reconstruct such colossal creatures on a life-size scale. Inevitably, in a fast-emerging field such as paleontology, new discoveries and interpretations would soon reveal errors in Hawkins's speculative reconstructions. But whatever criticisms were leveled at the sculptures were really thinly veiled attacks on Richard Owen, whose imperious personality and conservative (and later, anti-evolutionary) views made him a popular target for younger scientists. Such critiques did little to diminish Hawkins's achievement. While a small number of scholarly publications had been discussing and even illustrating "deep time" for a century or more, it was Hawkins's installations that brought the concept into the open and began to prepare the public for the contentious debates about evolution that were to emerge within just a few years.

In 1868, after a hiatus in which he mainly worked as a freelance illustrator and lecturer, Hawkins received a second major commission, to create a grand "Paleozoic Museum" in New York City. There he would "undertake the resuscitation of a group of animals of the former periods of the American continent" in Central Park. Community leaders, self-conscious about what they considered the city's cultural shortcomings, envisioned an installation comparable to the one at the Crystal Palace.

Just what to put in the new museum was another matter. The discovery of the first reasonably complete dinosaur skeleton in New Jersey ten years earlier, along with additional finds in England, revealed that Hawkins's heavy, mammal-like reconstructions of *Iguanodon* and *Megalosaurus* were in error and that Owen's ideas about the appearance of those creatures had been wrong. Hawkins's new challenge was to design a dynamic display of life-size extinct animals from America, as he phrased it, "clothed in the forms which science now ventures to define."

Because neither the specimens nor the scientific expertise he required were available in New York, Hawkins traveled to Philadelphia, to the Academy of Natural Sciences, to seek the advice of Joseph Leidy, a curator who had become the country's leading expert on prehistoric life. Leidy was generous in sharing his deep knowledge and innovative thinking about dinosaurs with Hawkins, to whom he gave access to the important fossil specimens in his care at the Academy.

In September 1868, with Leidy's encouragement and the approval of the Academy's curators, Hawkins began the painstaking process of reconstructing a complete skeleton of *Hadrosaurus foulkii*, a thirty-foot herbivore. The result forever changed the way dinosaurs were displayed in museums around the world. Up to that time, dinosaur bones, if they were exhibited at all, were usually shown as isolated paleontological specimens, without context or meaning to any but a very few specialists. With Leidy's guidance, Hawkins took a new approach to the ancient bones. He carefully suspended plaster casts, bone by bone, from a metal armature, filling in the missing bones with plaster reconstructions, and topping his model with an invented skull, based loosely on the skull of a modern-day iguana. In a little more than two months of feverish activity, he created the first fully articulated dinosaur-skeleton display in the world, which he presented as a gift to the Academy in thanks for the institution's generosity in allowing him access to its collections.

BRUCE M. WHITE/PRINCETON UNIVERSITY ART MUSEUM

Hawkins's *Hadrosaurus* skeleton was put on exhibition in the Academy's museum in November 1868. The public's response was overwhelming. Even though the museum was open to the public only two afternoons a week (and closed for the month of August), nearly 100,000 people came to see the *Hadrosaurus foulkii* in 1869—almost twice as many as had visited the museum in the previous year.

Most of the Academy's members were highly appreciative of Hawkins's gift, but not everyone was pleased with its unexpected con-

Right: Lithograph plate by Hawkins of the Indian crested porcupine, for **Illustrations of Indian Zoology** by John Edward Gray. Below: Skeletal anatomy of a horse was drawn by Hawkins from measurements of bones said to be those of the renowned eighteenth-century racehorse Eclipse.

sequences. In a year-end report, the secretary described the wreckage the new *Hadrosaurus* display was causing in the formerly staid Academy:

> The crowds lead to many accidents, the sum total of which amounts to a considerable destruction of property, in the way of broken glass, light wood work, &c. Further, the excessive clouds of dust produced by the moving crowds, rest upon the horizontal cases, obscuring from view their contents, while it penetrates others much to the detriment of parts of the collection.

Hawkins had introduced "dinosauromania" to America. The curators concluded that the only way to reduce the "excessive number of visitors" was, for the first time in the Academy's history, to charge an admission fee.

Despite the tremendous success of his display in Philadelphia, Hawkins's New York venture did not fare so well. Corrupt politicians in Tammany Hall, led by the infamous William "Boss" Tweed, suspended Hawkins's contract in the middle of his work on the lucrative museum project. When Hawkins complained publicly of their interference, their retribution was shockingly brutal and complete. On May 3, 1871, a gang of "vandals," hired by one of Tweed's henchmen, broke into Hawkins's New York studio and completely destroyed the models, molds, and completed sculptures that Hawkins had been preparing for over three years.

Five months later Tweed and his gang were arrested, to be tried and convicted for their egregious corruption, but for Hawkins, this justice came too late. The great Paleozoic Museum he had been hired to imagine and create would never recover. Heartbroken by the loss of his work, Hawkins moved on to other projects, augmenting his artistic commissions with a busy schedule of public lectures on life in the prehistoric world. Those lectures, though popular, were not what one might have expected from the man who had brought dinosaurs to life.

Hawkins had once worked for Darwin as an illustrator, on *The Zoology of the Voyage of H.M.S. Beagle* (published 1839–43), and had received letters of endorsement from him. Subsequently the artist's vision of the prehistoric world had been affected by Darwin's theories, leading him to create violent and competitive scenes of deep time. Ironically, though, Hawkins never became a believer in evolution. Like his mentor, Richard Owen, he believed that the ancient creatures he was depicting had been created fully formed by God, and, while well suited to their time and place, had been extinguished by one or more cataclysmic events.

The themes of stability in nature's design and human superiority to the rest of creation were ones to which Hawkins subscribed long before his arrival in America, even in publications ostensibly devoted to art. In his introduction to *A Comparative View of the Human and Animal Frame* (1860), for example, Hawkins expressed his belief that "one primary pattern was created and fixed by the Almighty Architect in the beginning, and persistently adhered to through all time to the present day."

Bolstered in his beliefs by contact with well-known anti-evolutionists, Hawkins became even more open about his anti-Darwinian beliefs after his arrival in America. In a series of well-illustrated public talks, Hawkins explained the "harmonious fitness of all animals for that place in Creation, which they were originally designed to fill."

In 1875, after completing a long American lecture tour, Hawkins was invited to create mural-size oil paintings of ancient life for the Elizabeth Marsh Museum of Geology and Archaeology at the College of New Jersey (now Princeton University). Hawkins saw the commission as his chance to make permanent his vision of past life as it had been created—and ultimately destroyed—by God. He fashioned a sort of panorama made up of seventeen canvases. Each painting reflects a particular time and place and

A new exhibition, "*Hadrosaurus foulkii:* The Dinosaur That Changed the World," will be on view at the Academy of Natural Sciences in Philadelphia from November 22, 2008, until April 19, 2009. Coinciding with the 150th anniversary of the dinosaur's scientific description by Academy Curator Joseph Leidy, the display includes the dinosaur's real bones, a new mounted cast, and re-creations of Leidy's office and of the studio of Benjamin Waterhouse Hawkins.

has its own self-contained composition and story, and yet they are clearly intended to be seen together, an animated time line of life on Earth.

Like a theatrical set designer, Hawkins used light to evoke the eerie atmosphere of the world before humanity. Landscapes and seascapes devoid of vertebrates are shown as morning scenes, the literal dawn of life. As the Sun (or Moon) rises and intensifies in subsequent scenes, vertebrates appear and move onto the land. Early mammal life, including mastodons, hyenas, and saber-toothed cats, are illuminated by a filtered but fully risen Sun, more closely approximating atmospheric conditions that contemporary audiences would have found familiar.

The most dramatic and arresting of Hawkins's paintings are of the creatures he knew best from the Cretaceous and Jurassic periods. *Cretaceous Life of New Jersey* appears to be an expanded version of the scene he proposed creating in three dimensions for New York's ill-fated Paleozoic Museum. It shows a group of three predatory tyrannosauroid *Laelaps* (now called *Dryptosaurus*) attacking a retreating pack of hadrosaurs. The pyramidal composition of the painting focuses the viewer's attention on a life-and-death struggle between two of the giant dinosaurs whose bones had been found not far from Princeton, in the greensand deposits of New Jersey. In the painting's foreground two mosasaurs and four elasmosaurs (species studied firsthand by Hawkins at the Philadelphia Academy) watch the conflict from the relative safety of the sea.

Hawkins's painting of *Jurassic Life of Europe* seems to pay homage to his earlier work for the Crystal Palace [*see illustration on pages 26-27*]. Here a frightened herd of iguanodons are shown retreating from a snarling, barely bipedal megalosaur who has just slain one of their number. Groups of other extinct reptiles, including *Cryptosaurus* and the crocodilian *Pelagosaurus*, peer up admiringly at the dominant carnivore, as if learning a lesson about fitness and survival. By the time Hawkins made this painting, most paleontologists had rejected Owen's physical description of *Iguanodon* and concluded that it was more likely to have been bipedal than quadrupedal, yet Hawkins painted the species much as he had sculpted it in his 1854 installation in Sydenham.

HAWKINS FAMILY COLLECTION

The oils went on public display at the College of New Jersey's Elizabeth Marsh Museum, then in Nassau Hall, in conjunction with a new cast of Hawkins's *Hadrosaurus foulkii*. To the college's four hundred undergraduates and twenty-some faculty members, the creations must have offered an arresting view of the primordial world. The paintings were rehung in a new building devoted to geology and biology in 1909 and continued to be on view until 2000. Now stored in the Princeton University Art Museum, they are seldom displayed, but they remain powerful testaments to Hawkins's vision.

Hawkins spent his final years in England. By the time he died in 1894, at the age of 86, scientific thinking had moved on, and his views on prehistoric life were no longer welcome. His Crystal Palace creations fell into disrepair and his name was all but forgotten, even in the places where he had lived and worked so intensely. In recent years, however, Hawkins's contributions to the history of science and art have begun to gain new recognition—not least of all for his lasting influence on how natural history museums engage the public. And now refurbished, his antediluvian monsters once again draw visitors to Sydenham.

Robert McCracken Peck, Curator of Art and Artifacts and a senior fellow at the Academy of Natural Sciences in Philadelphia, is a naturalist, writer, and historian. Peck's earlier articles for *Natural History* have profiled the renowned ornithologist Alexander Skutch and the paleoartist Charles R. Knight. When not at the Academy's museum, he can be found accompanying Academy research trips. His favorite destination to date: Mongolia, about which he wrote a story for *Natural History* in 1998.

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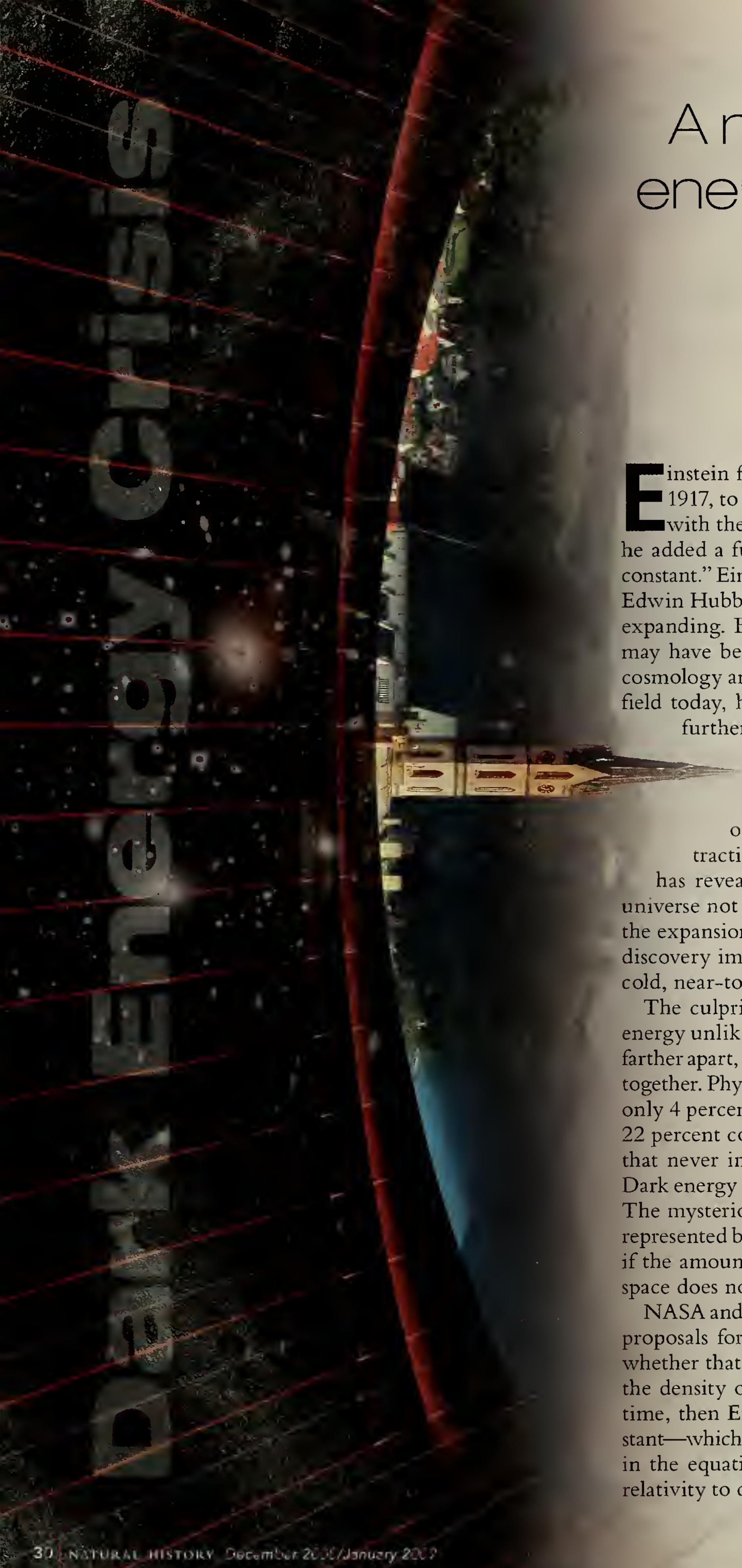


A new NASA missio energy, but at the cost genera

Einstein famously called it "his greatest blunder." In 1917, to reconcile his equations for general relativity with the then-prevailing notion of a static universe, he added a fudge factor, later named the "cosmological constant." Einstein abandoned the idea after the astronomer Edwin Hubble demonstrated in 1929 that the universe is expanding. But recent observations imply that Einstein may have been right after all. Given the complexity of cosmology and the profound confusion that reigns in the field today, however, any vindication will surely entail further twists.

Ever since the big bang, space has expanded, carrying galaxies along with it; but astronomers expected to find the galaxies' outward rush slowing down owing to the attractive force of gravity. Instead, the past decade has revealed that not only is the expansion of the universe not slowing down, but in fact it is accelerating: the expansion is proceeding at an ever-greater rate. That discovery implies an eventually lifeless cosmic future of cold, near-total emptiness.

The culprit is a force called "dark energy," a kind of energy unlike any already known, which pushes galaxies farther apart, counteracting gravity's effect of pulling them together. Physicists estimate that visible matter accounts for only 4 percent of the mass of the universe, while another 22 percent consists of "dark matter," a ghostly substance that never interacts significantly with ordinary matter. Dark energy makes up the vast remainder of the universe. The mysterious energy could be the cosmic component represented by Einstein's cosmological constant—but only if the amount of dark energy within a given amount of space does not vary over time.

NASA and the U.S. Department of Energy have invited proposals for a $600 million space probe to determine whether that is true. Here's one twist: if it turns out that the density of dark energy in the universe evolves over time, then Einstein was not only wrong about the constant—which would be an "inconstant"—but also mistaken in the equations he derived from his theory of general relativity to describe the universe. In that case, physicists

may shed light on dark of Einstein's theory of relativity.

BY DONALD GOLDSMITH

will have to rethink major assumptions about the universe and the fundamental laws that govern it.

HOW DID WE REACH THIS critical juncture in cosmology? Tremendously successful astronomical observations over the past decade have revolutionized our understanding of the cosmos. First, astronomers made great strides in measuring how rapidly galaxies are moving toward or away from us, thanks to more precise measurements of how much the Doppler effect shifts light toward shorter or longer wavelengths. The radiation from the most distant stars and galaxies, for example, consists primarily of infrared, which has a longer wavelength than visible light, because the expanding universe has stretched (or red-shifted) the visible light waves into the infrared portion of the electromagnetic spectrum.

It was the redshift of distant specimens of a rare class of exploding stars called Type Ia supernovas that revealed the existence of dark energy. Type Ia supernovas all have essentially equal luminosities, so if one looks fainter to us than another, it must be farther away. That makes them handy for estimating the distances to faraway galaxies that host such supernovas. In 1998, after searching through thousands of remote galaxies to compile a sampling of more than four dozen Type Ia supernovas, two teams of astronomers made improved estimates of the distances to the galaxies and correlated them with the galaxies' and supernovas' redshifts. Most of the astronomers expected that their more precise measurements would provide evidence of a slowdown in the universe's expansion. Instead, they discovered that the expansion is accelerating. What was driving this acceleration was unknown; eventually it was attributed to what was called "dark energy."

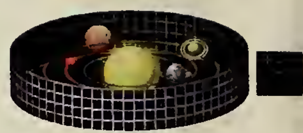
Cosmologists confronted with the surprising evidence of accelerating expansion turned to Einstein's formerly rejected calculations for a possible solution. Although Einstein himself offered no physical description of his cosmological constant, it can be said to represent a weird tension, intrinsic to empty space, that counteracts gravity—in effect a sort of universal negative pressure that makes space expand. The exact value that Einstein assigned to his cosmological constant has long since been ruled out by observational data compiled during the six decades after 1917, yet theoreticians have occasionally tried other values in hopes of finding a better fit to those observations.

Even if we set the value of the cosmological constant to account for the accelerating expansion of the universe, the implications of a nonzero constant boggle the mind. The constant's mathematical value corresponds to the amount of dark energy that lurks in every cubic centimeter of space. It follows that, as the cosmos expands and new space comes into existence, every cubic centimeter of new space will contain just as much dark energy as every old cubic centimeter does. Accordingly, the universe not only expands at an accelerating rate, but also produces a correspondingly growing amount of dark energy. Here we find the ultimate free lunch—energy produced without any investment beyond the original creation of the universe. But doesn't this violate the law of conservation of energy, which states that the total amount of energy remains constant, though it may change its form (matter being a form of energy, with a value expressed by Einstein's famous equation, $E = mc^2$)? No, because this law applies to any isolated, closed system—and the universe, which continuously creates new space, does not satisfy that condition.

But that's not the only amazing conclusion that needs getting used to. As time goes by, the steady increase in the total amount of dark energy increases the ratio by which dark energy exceeds all other forms of energy. The ratio of dark energy to the mass-energy in visible and dark matter currently equals about three to one, but that proportion must inevitably change. In the distant future, with the universe ballooned to many times its current size, dark energy will dominate overwhelmingly. Once again we are left with a disturbing conclusion.

COSMOLOGISTS ORIGINALLY BALKED AT the idea that dark energy existed. By now, however, the description of the universe as a mix of visible matter, radiation, dark matter, and dark energy has achieved wide acceptance as the new "standard model." The existence of dark energy has been convincingly demonstrated; the daunting challenge that cosmologists now face is to explain it.

Quantum mechanics—the physics of space and time and the interactions of matter and forces, all at extremely small scales—seems to offer cosmologists a good starting point. Quantum mechanics implies that dark energy could arise naturally from the flickering, nearly instantaneous appearance and disappearance of "virtual particles," particles that cannot be experimentally detected but which constantly flit through "empty" space. But when physicists use quantum-mechanical principles to calculate the amount of dark energy, their result exceeds the actually observed amount by 120 orders of magnitude! As the cosmologist Michael S. Turner of the University of Chicago has put it, "That is the biggest embarrassment in theoretical physics." If dark energy existed in that enormous amount, the universe would have instantaneously expanded to reduce the density of all types of matter essentially to zero, and no humans would exist to be confused about dark energy's existence.



Universe thought to be static

The discrepancy between quantum physics and its application to the cosmological scale shows that there are serious flaws in our current understanding of the fundamental laws of nature. So what game plans do cosmologists have?

One approach will strive for still more precise measurements of the brightnesses, and hence the distances, of Type Ia supernovas in other galaxies, together with any other data that can reveal the expansion history of the universe. As we go to press, NASA had delayed launching a space-shuttle mission to extend the Hubble Space Telescope's operational lifetime. If successful, that mission will include equipping Hubble with an infrared camera capable of detecting and measuring distant supernovas with unprecedented accuracy. Ground-based surveys of enormous numbers of galaxies, already under way and continuing for several more years, will complement those space-borne observations. While awaiting new astronomical results, cosmologists also hope to learn more about fundamental particle physics, perhaps from the Large Hadron Collider, the high-energy nuclear accelerator near Geneva that experienced a false start this fall.

But those results may not suffice to answer the big question about whether or not the "cosmological constant" truly deserves its name. If cosmologists confirm that the dark energy per cubic centimeter has remained constant throughout the universe's history since the big bang, thus vindicating Einstein, theorists would still have to puzzle over the constant's value. But the alternative, the discovery that the amount of dark energy in the same space varies over time, would provoke a wholesale revision of our understanding of the cosmos, because in that case, Einstein's general theory of relativity would apparently need a thorough overhaul.

Because the currently planned efforts may prove insufficient to provide a definitive answer to this great cosmic

question, NASA commissioned three satellite designs for a Joint Dark Energy Mission, or JDEM: the Advanced Dark Energy Physics Telescope (ADEPT) from Johns Hopkins University in Baltimore, the Dark Energy Space Telescope (DESTINY) from the National Optical Astronomy Observatory in Tucson, and the SuperNova/Acceleration Probe (SNAP) from the Lawrence Berkeley National Laboratory in Berkeley. The satellite names offer proof that acronym competition proceeds apace among astronomers, but in an unexpected development announced on September 12, NASA opted for an integrated approach instead of choosing a single "winning" design. Whatever the final configuration, a launch is not anticipated until sometime in the middle of the next decade.

Each of the three satellite design teams laid plans for a wide-field telescope dedicated to searching for supernovas. Such an instrument can detect and study far more objects than the Hubble, with its narrow field of view and its limited time available for such observations. SNAP, for example, aimed to record the redshifts and thus the distances of some 2,000 Type Ia supernovas per year, covering a total area on the sky 2 million times larger than that surveyed by Hubble. Each design also included an additional means to study the universe's expansion history, DESTINY and SNAP favoring the observation of "weak lensing" and ADEPT choosing "baryon acoustic oscillations."

The weak-lensing technique measures the distortion of the light from distant galaxies as it passes through the gravitational field of intervening dark matter. Those distortions reveal the distribution of matter at various distances [*see "Dark Matter," by Donald Goldsmith, September 2007*]. Because the amount of dark energy has affected the formation of large-scale structures in the universe, precise measurements of the distribution of matter can reveal whether the amount of dark energy per unit volume has changed throughout past eras.

Baryon acoustic oscillations are traces of sound waves that rippled through the very early universe, a dense, superhot soup of mingled matter and radiation. When the formation of galaxies and galaxy clusters began, 400,000 years after the big bang, the ripples of the early universe were already imprinted upon the distribution of matter. Astronomers can still detect and measure those ripples, frozen like a vast snapshot in the cosmic background

NASA/ESA, THE HUBBLE KEY PROJECT TEAM AND THE HIGH-Z SUPERNOVA SEARCH TEAM

Supernova 1994D (lower left) exploded on the outskirts of disk galaxy NGC 4526 in 1994. This supernova, classified as a Type Ia, has the same intrinsic brightness as all other Type Ia supernovas. That consistency enables astronomers to calculate the distances of these supernovas from Earth, and ultimately to estimate the expansion rate of the universe.

radiation. "It's like dropping a stone into a pond," says the astrophysicist Adam G. Riess of the Johns Hopkins University, one of the leaders in the discovery of dark energy. "We can see the ripples long after the original disturbance has vanished."

Although the waves have expanded along with the universe, their crests and troughs continue to provide astronomers with a cosmic yardstick. Careful analysis of the spacing of galaxies at different distances from us—hence observed at different epochs in the past—should reveal just how the ripples' original wavelengths have stretched throughout the history of the cosmos. Such observations will allow astronomers to measure the universe's expansion rate during different epochs, providing insight into the evolution, and thus the nature, of dark energy.

Well before JDEM returns its first observations to Earth, data from ground-based telescopes and the refurbished Hubble may considerably advance our understanding of supernovas. The most significant progress in measuring weak lensing, however, will require a dedicated space-borne observatory. Because space missions consume so much time in their planning, construction, and operation, "if an observation can get done from the ground, it will get done from the ground," concludes Charles A. Beichman, an astronomer at the Jet Propulsion Laboratory.

THE DISCOVERY of dark energy has thrown cosmology into confusion, producing what Dickens might call both the best of times and the worst of times for cosmic theorists. Yes, it has opened up rich new avenues for investigation, but some scientists fear that the focus on dark energy is wrongheaded. "It smells wrong, and there's no real physics behind it," says Michael J. Disney, a cosmologist at the University of Wales in Cardiff. According to Disney, the dark energy idea relies too much on events that occurred just after the big bang, during what cosmologists call inflation, a period about which we have negligible confirmed information. And Disney worries that a single dominant paradigm, the model of a cosmos in which dark energy drives an ever-increasing acceleration, threatens to drown dissenting voices. "Acceptance of the current myth, if myth it is, could . . . hold up progress in cosmology for generations to come," Disney says.

For now, dark energy, the key to the acceleration of the universe, represents both an immense challenge to and a great opportunity for theoreticians. As the cosmologist Michael S. Turner notes, "Dark energy is possibly the most profound problem in science. This mysterious substance apparently links the destiny of the universe, the early inflationary epoch, the nature of space, and the details of particle physics." Solving the problem could lead to discovering and understanding a new type of energy, a new form of matter, or a new approach to understanding the cosmos. Whether Einstein turns out to be right or wrong, shining a clear light on dark energy could well herald the crowning of the next Einstein.

Donald Goldsmith, trained both as a research astronomer and as an attorney, devoted himself to popularizing astronomy more than thirty years ago. He has written or co-written more than twenty books, including *Connecting with the Cosmos* (Sourcebooks, 2002) and, with Neil deGrasse Tyson, *Origins: Fourteen Billion Years of Cosmic Evolution* (Norton, 2004), which was the companion book to the PBS *NOVA* series. Among his recent contributions to *Natural History* are "Turn, Turn, Turn" (December 2006/January 2007), "Ice Cycles" (March 2007), and "Dark Matter" (September 2007). He lives in Berkeley, California.

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Rain Bird

BY DAVID L. ANDERSON

MAP: JOE LEMONNIER; PHOTOS: DAVID L. ANDERSON

I sense the rain first as a breath of air that brushes the leaves at the top of the forest. The breeze strengthens, lifting branch tips in a gentle dance and then, as a distant roar grows louder, snapping them off and tossing them over the trees. A curtain of water sweeps in, pounding the forest canopy—where I cling, 150 feet above the ground. Rivulets pour off every leaf and branch around me, off my crossed arms, boots, and climbing harness, and I watch the water drizzle down in jagged paths of wind before splashing below.

Getting up to my perch was, as always, a matter of muscle and nerve combined with a bit of luck. I use a crossbow rigged with a fishing reel to fire a "bolt" (a crossbow arrow) that I have weighted with a lead fishing sinker. The bolt carries the fishing line over a high branch of a tree, and the weight of the sinker brings it back down through the tangle of foliage; I then use the line to draw a parachute cord over the branch, and the parachute cord to pull over the still heavier climbing rope. I tie one end of the rope to another tree, then make my way up the free end using a climbing harness and mechanical ascenders (essentially handholds that slide up, but not down, the rope). The whole process is cumbersome, so when it rains I have no choice but to soak it up. But as quickly as the storm comes, it passes, and I am back to watching forest-canopy birds of Honduras.

A country of little more than 43,000 square miles, smaller than Ohio, Honduras has some 720 species of birds, almost as many as are found in all of the United States and Canada combined. About two-thirds of those species breed in Honduras. Another 200 or so migrate from North America every year, and are familiar to birders from fields, forests, or yards all over the United States. Everything from common nighthawks and Swainson's hawks to the tiny ruby-throated hummingbird passes through Honduras as part of the yearly journey. I guess I'm like the migrants: I made my first trip here as a Peace

Dispersing seeds and drawing tourists, a sought-after bird helps preserve a forest in Honduras.

GREG R. HOMEL/NATURAL ELEMENT

The rugged terrain of Pico Bonito National Park, above, creates a safe haven for jaguars and other threatened wildlife. Right: A male lovely cotinga emerges from the rain. Opposite page: The author climbs into the forest canopy.

Corps volunteer in 1991, and since then Honduras has become part of my rhythm. I always come back, in large part because of the birds. First I did fieldwork for a year in the Moskitia rain forests, studying raptors in the Río Plátano Biosphere Reserve. Then warblers stole my attention, hummingbirds after that. Most recently I have worked in Pico Bonito National Park, whose tropical rain forest stretches from near the Caribbean coast up into the mountainous interior—and, as it happens, attracts one of the most spectacular of all birds.

Tropical rain forests are famous for their biodiversity, from trees and orchids to insects and reptiles to mammals and most definitely birds. Birds at ground and midlevels of the forest can be observed directly or at least captured in mist nets—nearly invisible fabrics of black threads—and studied briefly before being released. Canopy birds are another matter. Rain forests are packed with plants struggling against their neighbors for light, water, and nutrients. Observing birds in the upper levels of the forest from the ground can be nearly impossible; at best it leaves a lot to chance. Climbing to the top to watch them on their home turf is the only reliable way to make a thorough survey. In Pico Bonito I climbed as many trees as I could to document a complete annual cycle of the birds of the lowland forest canopy.

On a typical morning, I hiked in the dark for half an hour with my field assistant, Juan Lopez, to reach the base of a canopy tree we had set with a rope the day before. After Lopez clamped the ascenders on the rope, I inchwormed 30, 50, 90, then 150 feet up. By then sweat was dripping from my eyebrows and my shirt was sopping wet, but the fresh canopy breezes dried me in short order. I was perched in a *Virola koschnyi*, a species of wild nutmeg known locally as *sangre rojo*. *Virola* trees are towers of the forest. They have straight, bare trunks without any branches except in the high crown of the tree, where they radiate straight out like spokes on a wheel, spokes with large leaves scattered sparsely at the tips. Nutmegs are easy to climb, comfortable to sit in, and give me great vantage points.

Thirty minutes after sunrise I started a three-hour survey. With 10×42 Swarovski binoculars in one hand and a mini recorder in the other, I softly narrated the location and behavior of every bird I saw or heard: "*Chlorophonia*, upper third of canopy, outer reaches of foliage, mistletoe berry. Tropical gnatcatcher, middle canopy, butterfly larva in bill." When played back my voice remains calm, the narration methodical. That is, until suddenly I can be heard blurting, "LOVELY COTINGA! Upper canopy, eating figs!" No matter how often I see them, nothing diminishes the joy of sighting an adult male lovely cotinga (*Cotinga amabilis*). Electric turquoise with a burst of plum purple feathers, that bird isn't just bright; it glows.

The words "often" and "lovely cotinga" don't normally go together. "I waited fifteen years to see this bird," bubbled Greg R. Homel, a professional bird guide and wildlife videographer with extensive experience in Central America, after he first saw a male lovely cotinga. The sighting happened, oddly enough, not from a treetop harness but at the Lodge at Pico Bonito, an eco-hotel with cabins on the border of the park. Lovely cotingas are seen there, and often, from the canopy-viewing towers, the entrance road, and even the verandas. For the Lodge it is the money bird, attracting birders eager to lose their cotinga virginity. For Homel, being able to see a lovely cotinga over a cup of coffee and a plate of

French toast is almost as mind-blowing as the bird's exotic plumage.

In the weeks following his first sighting, Homel not only saw more cotingas, he filmed them eating, regurgitating seeds, and calling—behaviors probably never before captured in the species. Overall, though, the bird remains an enigma. Practically nothing is known of the species' breeding behavior or seasonal movements, and, unlike most birds, lovely cotingas are virtually silent. Females and juveniles, in contrast to the adult males, wear subdued shades of grayish brown speckled in white. But even how long it takes a young male to grow its adult turquoise coat is unknown.

GREG R. HOMEL/NATURAL ELEMENT

Blue-crowned motmot is one of five motmot species found in the park.

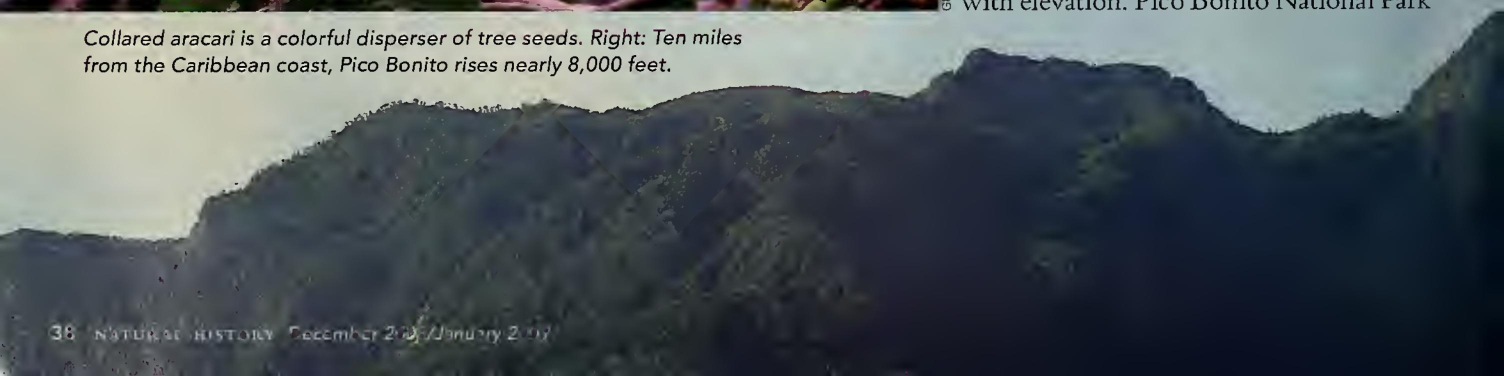
In my Pico Bonito study, I delineated a 100-hectare (247-acre) area of lowland forest on an isolated hillside in the park and made one to three canopy surveys there weekly. My goal was to describe in detail the community of canopy birds. One chief objective was to identify the species that are restricted to the canopy and rarely leave it, and those that prefer lower levels of the forest and use the canopy only occasionally. I also wanted to learn more about all the birds' diets. Some canopy trees, the wild nutmeg among them, have fruits with large seeds that only a few species can swallow, such as large toucans. A greater number have fruits with medium-size seeds favored by medium-size frugivores like trogons and cotingas (a lovely cotinga measures about seven and a quarter inches from tip of beak to tip of tail). Such canopy trees depend on avian dispersers to swallow their seeds, then fly off and scatter them in new places in the forest. Without dispersal, the seeds fall to the ground and perish under the shade of their parent, or from intense competition with the thousands of their sibling seeds piled together. We tend to think of animals as dependent on their habitat for survival, but in the tropics the opposite is just as true. Birds are engineers that play important roles in modifying the structure and composition of a forest through their actions as seed dispersers and pollinators, among other duties.

Given patience, skill, and time, an experienced observer can track down even the most cryptic and secretive birds of the rain forest. A bird that wears a coat of phosphorescent brilliance, like the lovely cotinga, can hardly hide from scientists and birders combing the forest. But sometimes when searching for a needle in a haystack, it is better to let the needle come to you. As my months in the trees passed, some patterns became evident. One is that cotingas come with the rain. Pico Bonito experiences a wet season generally from late September through February, and a dry season approximately March through September, although the length and intensity of either can vary. During the dry season, I saw maybe one cotinga in a month, whereas on one rainy day in December I saw six in one tree. Unbelievable! "More cotingas are seen in rainy months, and more are seen on rainy days," concurs James Adams, Assistant Manager at the Lodge. "When the weather is crummy the birds are out." Why that should be so is part of the bird's mystique.

One possible explanation has to do with elevation. Pico Bonito National Park

GREG R. HOMEL/NATURAL ELEMENT

Collared aracari is a colorful disperser of tree seeds. Right: Ten miles from the Caribbean coast, Pico Bonito rises nearly 8,000 feet.



starts almost at sea level and rises to more than 8,000 feet. The whole extent is cloaked in untouched primary forest, with six forest types depending on elevation. At the bottom is the moist lowland broadleaf forest—the tropical habitat of the imagination, deep green, shaded, and lush with vines and flowers—leading to submontane broadleaf and mixed pine–oak forests. Ascending farther one encounters moist upper-montane broadleaf forest and, usually shrouded in mist, cloud and elfin forests. Elfin forests are short, only waist-high, and blanketed in shaggy coats of moss. In the rain shadow on the south side of the park there are still more forest types, chiefly mixed pine–oak at mid-elevations, seasonal dry forests at low elevations, and very dry thorn forests at the lowest elevations. Just as birds from the United States migrate south for the winter, many birds in the tropics migrate downhill to track food resources when the high mountains are swaddled in rain and clouds. That is especially true for medium and large frugivores, a notable example being the resplendent quetzal. That the lovely cotinga is also an elevational migrant is an educated guess at this point.

GREG R HOMEL/NATURAL ELEMENT

Male blue-crowned chlorophonia, a species fond of mistletoe fruits

Downward seasonal migration from high mountain slopes is intricately linked to the landscape. Elsewhere in Central America, tall mountains like Pico Bonito with forests from top to bottom have become rare. Many bird species won't cross open fields or croplands. When a portion of forest is lost from the middle of a mountain, the population of birds that lives above it is cut off from seasonal foods below. And if the local population of avian frugivores dwindles, the effects on the forest can be dramatic and permanent. Over generations, large-seeded trees, such as the wild nutmegs, also begin to disappear. That can translate into a reduction of mistletoes, which commonly grow on nutmegs, followed by the small birds that eat mistletoe fruits. As trees dwindle, large rodents that feed on fallen seeds, such as agoutis, are lost, and so are the large cats that eat them. Gradually, the forest becomes a different place.

Fruit-eating birds play an even broader role in sustaining the forest. Conservation in developing countries works by a different paradigm than in North America. Although Pico Bonito is a Honduran national park, that doesn't keep poor farmers from illegally logging, hunting wildlife, and clearing the forest to plant beans and corn. In such a poor country, the government is stretched thin, social services are lacking, and park protection is minimal. Ecotourism, however, works in the forest's favor. The 200-acre Lodge, for example, located in Pico Bonito's buffer zone—an area encircling the park in which some human activity is permitted—provides a barrier of sorts to illicit activities. It also employs locals who might otherwise turn to the forest for survival. Sixty-four Hondurans work there, in both managerial and service roles—including as nature guides. And it is the cotinga and other sought-after species that largely pay the bills.

Honduras isn't as famous for its birds as some other Central American countries are, but should be. It has more macaws than Costa Rica, a healthy population of harpy eagles, and more species of motmots than any other country in the world. (With their bright colors, mysterious-sounding hoots, and crazy displays of tail wagging, motmots are emblematic of the rain forest.) If it takes the lovely cotinga, motmots, and other avian spectacles to attract guests and afford protection to this shoulder of Pico Bonito, then everyone from nutmegs to ocelots to waiters gets a hand.

David L. Anderson is completing his Ph.D. dissertation at the Museum of Natural Science at Louisiana State University in Baton Rouge, based on his surveys in Pico Bonito National Park in Honduras. Previously he worked in that country's Río Plátano Biosphere Reserve, examining how Amerindian agriculture diversified the landscape and how, in turn, the avian community responded. He is also investigating migrating cerulean warblers with Melinda Welton, a research associate at the Gulf Coast Bird Observatory.

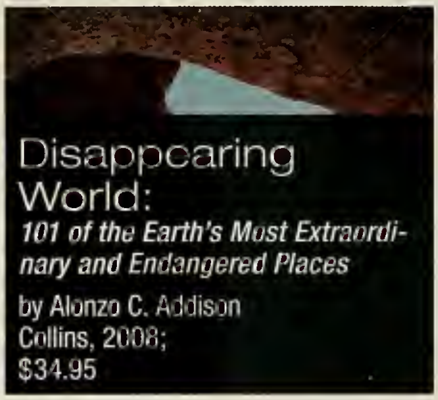
Web links related to this article can be found at www.naturalhistorymag.com

For the Coffee Table

Young boys and girls of the Surma and Mursi tribes, in the Omo Valley at the juncture of Ethiopia, Kenya, and Sudan, are arguably the last remaining adolescents on the planet who do not dress themselves in Western-style T-shirts emblazoned with logos. That is not surprising, according to photographer Hans Silvester, because until quite recently the nomadic residents of this remote region did not even have mirrors. Yet judging from the samples presented in this unusual book of portraits, Surma and Mursi teenagers are as image conscious as their counterparts in more developed parts of the world—and considerably more resourceful.

A brief introductory chapter describes how the young folks paint their faces and bodies with wild graffiti-like designs that range from intricate geometric patterns to flamboyant harlequin makeup. Individuality is key—no one, it seems, wants to look like anyone else. As art, this self-adornment is ephemeral, easily removed by a quick plunge in the river to be redone in completely different style. As culture, it is equally ephemeral: no profound tradition underlies the ornate decorations. "They simply enjoy them," Silvester reports, "are happy to have made them, and are even happier to have them praised."

The 160 elegant photographs speak for themselves. These are young people clearly having a good time. They are undoubtedly posing for the photographer, but also expressing genuine feelings to him and to their friends: sophisticated dignity, coy flirtation, unselfconscious happiness.



It is impossible to leaf through this lavishly illustrated album of selected UNESCO World Heritage sites without suffering a severe case of wanderlust. Some of the featured sites are popular tourist destinations, such as the Galápagos Islands and Istanbul's Hagia Sophia. Others are remote and unfamiliar, like the Ilulissat Icefjord in Greenland, where a fast-moving glacier calves icebergs almost continuously into the sea; or the minaret of Jam, an arabesque-covered tower more than 200 feet tall that keeps lonely watch over an isolated valley in central Afghanistan. Expressive photographs, many of them full-page, convey the specialness of these places, from a panoramic vista of the thundering Iguazu Falls in Brazil to a hushed interior of the Chilandar monastery on Mount Athos, Greece.

Alas, what qualifies these places for Alonzo C. Addison's compilation is not merely their designation as transnational treasures, but also their precarious condition. The author, a UNESCO advisor, has provided concise and compelling summaries of just what puts each of them at risk. He identifies the city of Samarra, Iraq, and the Roman remains at Baalbek, Lebanon, as two of several sites located amid regional conflicts. And the mangrove forests of the Sundarbans, in Bangladesh and India, are facing gradual inundation by rising sea levels—as are the lagoons and canals of Venice. Looting, poaching, pollution, excessive tourism, invasive species, climate change, earthquakes, and fires—all take their toll, and many sites face multiple threats. Addison's book reminds us that if we wish to continue to enjoy these marvelous places, we must renew and sustain our efforts to preserve them.

Scientifically speaking, owls are members of the order Strigiformes, which takes its name from the Latin word for witch. The association of a common bird with the dark arts may have come about because of its nocturnal hoots, shrieks, and moans; its inscrutable stare; or the ability to rotate its head through more than 180 degrees, like the demon-possessed girl in *The Exorcist*. But that association is largely unjustified. In light of this volume by Canadian nature writer Frances Backhouse, owls are revealed as scrutable, amiable, and even downright admirable.

Owls, for instance, are by and large family-oriented, mating with the same partner for at least several years, and caring for their young until the fledglings are able to strike out on their own. A little more than half of Backhouse's text is devoted to owl physiology and behavior, the rest to a detailed description of the twenty-plus species of North American owls. She's also selected dozens of remarkable candid images of the birds in flight and at rest. In one, a diving saw-whet owl, talons outstretched, is a second away from striking an unsuspecting deer mouse. In another, an entire clutch of young burrowing owls gazes at the camera with the sanguine grace of wealthy siblings in a John Singer Sargent portrait. Owls, in reality, may not be magical creatures, but this book is, nonetheless, positively enchanting.

Sometime in the eighth century A.D. a series of great earthquakes and floods struck the Nile Delta. The city of Thonis (known to the Greeks as Heracleion) and the port of Canopus were totally submerged, along with the royal quarter of ancient Alexandria. Memories of those once-prosperous towns receded into legend. Although interest in identifying their ancient locations surged starting in the eighteenth century, it wasn't until the 1990s that a team of submarine geologists and scholar-divers, led by French archaeologist Franck Goddio, began serious underwater exploration. It is difficult to see more than a few feet through the muddy water of what is today Aboukir Bay, east of Alexandria, but persistence, as well as high-tech sonar and magnetic survey tools, enabled Goddio's team to systematically map the ancient sites and recover their treasures.

This hefty tome, first published in 2006 for the Berlin debut of an exhibition of the salvaged artifacts and now reissued in a revised and updated second edition, provides a dazzling record of a lost trove of Mediterranean civilization. Goddio's scholarly narration describes the difficulty of the work and the historic results of the expeditions. The text, though, is secondary to the studio-lit photos, which display hundreds of charms and amulets, statues, and pottery vessels, representing both Egyptian and Roman cultures. Items range in size from small gold coins and earrings to a pair of almost perfectly preserved red-granite statues over fifteen feet tall. One spectacular relic—a stone chapel called the Naos of the Decades—has been reunited: its walls with its base and pyramidal top. But the most impressive images are of divers dramatically lit by underwater spotlights; they emerge like time travelers from the murky gloom, carrying up treasures that no one has seen for 1,300 years.

This is one of those rare natural history books that will be treasured

by specialists and general readers alike. It's the exquisite graphic design you notice first. Rosemary Woodford Ganf's superb illustrations have a light of their own and are nearly three-dimensional, sometimes overfilling the confines of a single quarto leaf to flow into the margin of a facing page. Australia's native mammals are vibrant with life, surveying the horizon from a lichen-covered rock or poised to leap from a slender branch. You can almost sense their noses twitching.

Next, you notice the unfamiliar names in the captions. Who knew Australia had the long-footed potoroo, the nabarlek, the crest-tailed mulgara, the dusky antechinus, the yellow-bellied glider, the quokka, and a host of others? In fact, according to zoologist Christopher R. Dickman, whose narration is as illuminating as Ganf's illustrations, over 6 percent of the world's mammal species are marsupials, the majority of which live in Australia. They range in size from diminutive creatures like the long-tailed planigale, weighing about a fifth of an ounce, to red kangaroos, males of which can be as heavy as two hundred pounds.

Dickman, an ardent student of marsupials, provides the reader with more than just a skeleton survey of the fauna, fleshing out hard facts with plenty of striking anecdotes. In a section on mouselike antechinuses and their close relatives the dibblers, for instance, he mentions that males can mate with up to sixteen females during breeding season, and that copulation with each one can last twelve hours, which some of us may consider fortunate. Yet, for reasons not fully understood, the males usually die within a few days thereafter, "literally shagged out," according to Dickman. Unfortunate for those little marsupial males, to be sure, but like so much in this memorable book, quite wondrous.

Feathered Dinosaurs:
The Origin of Birds
by John Long and Peter Schouten
Oxford University Press, 2008;
$39.95

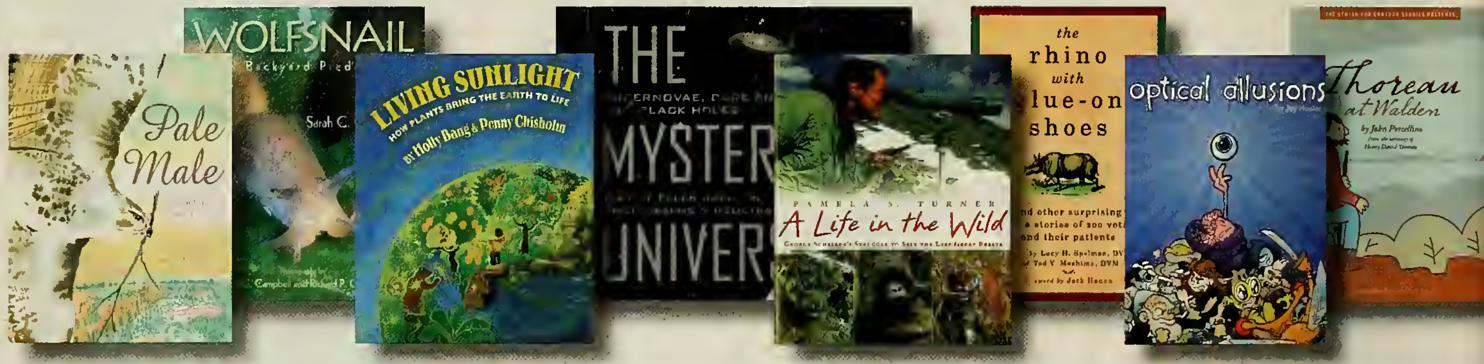
Had humans lived in the Late Cretaceous epoch, about 75 million years ago, they might have celebrated the winter holidays by dining on roast *Avimimus portentosus*. Although *Avimimus*—a dinosaur almost five feet in length—might have been a tad too large to fit in a standard-size oven, the creature bears an undeniable family resemblance to a Thanksgiving turkey. Seeing it, or any of the more than seventy other species illustrated in this book, makes it clear why paleontologists regard the feathered dinosaurs as the true ancestors of modern birds.

Because of the petrification and fragmentary state of most dinosaur remains, we can only imagine what those pioneering birds looked like in life, particularly in matters of feather configuration and coloration. Still, the hard data of paleontology blends with inference from observations of present-day bird species to create plausible plumage and likely poses. We will never see a live *Epidendrosaurus ningchengensis*, a small dinosaur that was one of the first to climb trees, or a *Microraptor gui*, which sported not two but four wings. But with this handsome field guide you can spend an afternoon happily "proto-birding," as it were, without leaving your living room.

Laurence A. Marschall is W.K.T. Sahm Professor of Physics at Gettysburg College in Pennsylvania, and director of Project CLEA, which produces widely used simulation software for education in astronomy.

Gifts for Budding Scientists

By Diana Lutz



FOR YOUNG READERS

Pale Male: Citizen Hawk of New York City, *by Janet Schulman; illustrated by Meilo So; Alfred A. Knopf, 2008; $16.99.*

The story of Pale Male, the light-bellied red-tailed hawk famously evicted from his ledge on a swanky New York City apartment building, has been told before, but not so well. Schulman, currently editor-at-large for Random House, tells the story in a witty, sophisticated way suited to its big-city setting. (She mentions, for example, that the apartment owners exploited a technicality in a wildlife treaty that the Bush Administration had weakened.) Schulman wrote the story for artist Meilo So, whose fluid watercolors, touched here and there with watercolor pencil, grace many other children's books cherished by my family.

Wolfsnail: A Backyard Predator, *by Sarah C. Campbell; photographs by Sarah C. Campbell and Richard P. Campbell; Boyds Mills Press, 2008; $16.95.*

This photo-essay for young children follows a carnivorous snail native to the southeastern United States as it emerges from beneath a backyard porch, climbs up a hosta plant, and searches for a snack—a slug or leaf-eating snail. Told in larger-than-life photographs, the story has a nice narrative arc and more drama than you might expect. Young children will warm to the snail, which has comical handlebar mustaches (mouthpiece extensions that help it track prey), and shares their predicament of being very small in a big world.

Living Sunlight: How Plants Bring the Earth to Life, *by Molly Bang and Penny Chisholm; illustrated by Molly Bang; The Blue Sky Press/Scholastic, January 2009; $16.99.*

Living Sunlight tells how the energy of the Sun is captured by plants and reworked into the stuff of all life. The text, an incantatory prose poem spoken by the Sun ("Do this one thing: Lay your hand over your heart, and feel") speaks to the reader much as a loving grandparent might speak to a small child. In the opening illustration a child, sitting on a swing at night, is covered with swirling designs of golden photons that power her beating heart. In the closing illustration, the same child sits in a Tree of Life that blooms and buzzes with flowers, birds, and animals, haloed by a glowing sunburst. Such illustrations celebrate the exuberant efflorescence of the Sun's energy first in vegetable and then in animal life. Despite the participation of Penny Chisholm, an M.I.T biologist, *Living Sunlight* is less a tutorial on photosynthesis than a magnificent celebration of life.

FOR ADVANCED READERS

A Life in the Wild: George Schaller's Struggle to Save the Last Great Beasts, *by Pamela S. Turner; Farrar, Straus & Giroux, 2008; $21.95.*

The legendary George Schaller, now in his seventies, was one of the first biologists to lay down the rifle and take up binoculars to study large animals live in the field. Nearly every chapter of *A Life in the Wild* describes Schaller's fieldwork with a charismatic "beast" in a fabled corner of the planet: mountain gorillas in the Congo, tigers in central India, lions in Tanzania, snow leopards in the Himalayas, pandas in central China, and the chiru (aka the Tibetan antelope) on the Tibetan plateau. Although Turner covers a lot of ground, including some fascinating behavioral science, she also tells the stories of individual animals, such as the panda named Zhen-Zhen. Once trapped for the purpose of getting a radio collar, Zhen-Zhen became a trap bum, seeking out traps to gobble bait, then waiting grumpily for equally grumpy scientists to release her. Schaller now works for the Wildlife Conservation Society, to which Turner is donating the royalties from this book.

The Mysterious Universe: Supernovae, Dark Energy, and Black Holes, *by Ellen Jackson; photographs* *and illustrations by Nic Bishop; Houghton Mifflin Company, 2008; $18.00.*

The Mysterious Universe is the latest addition to *Scientists in the Field*, the ambitious Houghton-Mifflin series that "embeds" writers with scientists at work. The scientist in this case is the lively Alex Filippenko, a professor of astronomy at the University of California, Berkeley, who once cracked a rib demonstrating how electrons jump between energy levels. Background information about dark energy and black holes is interspersed with biography and an account of an observing session at the Keck telescope in Hawaii. The reportorial passages are funny and engaging, but the explanatory ones are less successful. Astrophysics is a tough topic for a children's book because understanding current work requires so much background knowledge. Sidebars help, but paragraph-long extended metaphors are often at too low a level to assist a reader in following the rest of the book. Despite some signs of haste, *The Mysterious Universe* is a worthy addition to a first-rate series.

DOLLY SETTON

***The Rhino with Glue-On Shoes: and Other Surprising True Stories of Zoo Vets and Their Patients**, edited by Lucy H. Spelman, DVM, and Ted Y. Mashima, DVM; Random House, 2008; $22.00.*

This engaging anthology consists of twenty-eight case histories of ailing or otherwise stressed wild animals, each a zoo vet's most memorable case. ("Zoo" is short for "zoological," so the term "zoo vet" refers to any veterinarian who cares for wild animals.) Kids will devour the warmhearted stories like buttered popcorn. In one of the early chapters, a moray eel that had been raised in a tank in a tavern stopped eating when it was donated to the New England Aquarium. After three weeks of futile menus and medical tests, it was cured by a visit from its former owner, its old friend, for whom it emerged to dance and to dine. Who knew eels had friends? According to coeditor

Spelman, a former director of the Smithsonian National Zoo, very little was known about the medical treatment of wild animals until we reduced their numbers to the point where it became important to save every one of them. Vets have to make up their diagnostic techniques and therapies on the fly—such as doing a root canal on El Salvador's favorite hippo or giving chemo to a pet goldfish. If you let this book into your house, there will be trouble: it will "disappear" when someone gets up to fetch a cookie or a glass of milk.

Optical Allusions, *by Jay Hosler; Active Synapse Comics, 2008;* $20.00.

This self-published graphic novel, the third by Juniata College biologist Jay Hosler, describes the science of the eye by pairing comics with explanatory text. The protagonist is a naked brain named Wrinkles, who spends the book trying to find a missing magic eye. In one chapter, Wrinkles and his sidekick Cow-boy (a chimera of a cow and a boy whose "battle udder" shoots milk) fight a giant mechanical "eye-bot" called C.Y.K.L.O.P.S. They consider unplugging the rods and cones in its fovea but instead blow it up by blocking the canal of Schlemm that drains the aqueous humour. It's all a very clever way of introducing the evolution and physiology of the eye, but the book suffers from the confusing changes of setting. Wrinkles bounces from a desert island to a metropolis, to a pirate ship, to Polyphemus's cave, to somewhere near the Sun, to the laboratory of a mad scientist, to the branches of the world tree Yggdrasil. Hosler explains that *Optical Allusions* is an experimental hybrid between a comic book and a textbook (written with the help of a National Science Foundation grant) that he hopes will lessen students' science anxiety.

Thoreau at Walden, *by John Porcellino, from the writings of Henry David Thoreau; Hyperion, 2008; $16.99.*

John Porcellino's simple line drawings and Thoreau's own words combine in this magical graphic journal to capture not just what Thoreau said but also what he meant. Not much happens—Thoreau sits on the grass reading, watches an owl in the woods, and goes for a walk in the rain—but in Porcellino's hands those nonevents open a contemplative space into which Thoreau's words drop like pebbles in a still pond. Not many children are likely to "get" this book, yet it might prepare them for a day when they understand what is meant by "a life of quiet desperation" and are looking for another way.

DIANA LUTZ *is a freelance science writer and editor, as well as the former editor of* Muse, *a science magazine for young people. She lives in Madison, Wisconsin.*

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SKYLOG BY JOE RAO

On December 5 Mars arrives at conjunction with the Sun (whenever the two conjoin, Mars is behind the Sun from our viewpoint—only Mercury and Venus can also pass in front of the Sun). The Red Planet got increasingly lost in the solar glare starting in October, and we will be lucky to glimpse it again before April. But four other planets perform for us.

Venus soars to prominence in the southwest during December and January. If the air is clear and the sky deep blue, try looking for the planet shortly *before* sunset. Venus sets nearly three hours after the Sun on December 1, and lingers for almost four hours by New Year's Eve.

Jupiter starts December near Venus but then moves in the opposite direction. Each evening it sets earlier, so by month's end it is descending deep into the glow of sunset. In January, as the planet approaches its conjunction with the Sun on the 24th, it is too close to the Sun to observe properly.

Mercury reaches its greatest eastern elongation, 19 degrees east of the Sun, on January 4. That provides for a moderately favorable apparition, but the planet fades rapidly thereafter, reaching inferior conjunction (passing in front of the Sun) on January 20.

Saturn rises in the east around 12:30 A.M. local time on December 1 and is in excellent position for observation as morning twilight begins. Rising four minutes earlier each night, it will already be above the eastern horizon by 8:30 P.M. near the end of January. The planet slows to a stop on New Year's Eve, and then appears to move westward (retrograde) against the background stars until May 17, when it turns eastward (direct) again.

At winter solstice, rays of the rising Sun penetrate the ancient mound at Newgrange, in eastern Ireland.

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

DECEMBER NIGHTS OUT

1 Venus, Jupiter, and the crescent Moon are clustered closely together—within a 5-degree field—in the south-southwestern sky. The trio forms a triangle, with Jupiter and the Moon in the top corners and Venus at the bottom. It's a gorgeous sight!

5 The Moon waxes to first quarter at 4:26 P.M. eastern standard time (EST).

12 The Moon becomes full at 11:37 A.M. EST. On this day the Moon is also at perigee, its point in orbit closest to Earth. Moreover, this month's perigee is the closest one for 2008 (perigee varies by about 8,700 miles). The consequence will be a full Moon that is larger and slightly brighter than average, and unusually high and low tides around this date.

13 Just past full, the Moon casts a bright pall over the peak night of this year's Geminid meteor shower. The emanation point (called the "radiant") for those meteors is in the constellation Gemini, the Twins, near the star Castor, which sits high in the sky not long after midnight. Even in moonlight, a Geminid fireball can be bright enough to attract attention.

19 Saturn is 7 or 8 degrees above and to the left of the Moon as they ascend the eastern sky in the wee hours of this day. The Moon wanes to last quarter at 5:29 P.M. EST.

21 The Sun reaches its southernmost position (since the Earth's north pole is maximally tilted away from it) and begins to return northward. The solstice occurs at 7:04 A.M. EST; winter begins in the Northern Hemisphere, and summer in the Southern.

27 The Moon is new at 7:22 A.M. EST.

28 About a half hour after sunset, using binoculars, you might glimpse a very thin crescent Moon near the southwest horizon, with Mercury and Jupiter both hovering several degrees above and to its left. The Moon will be much easier to spot the following evening, having left the two planets to its lower right.

31 Look for Jupiter and Mercury side by side, beginning about a half hour after sunset, low in the southwestern sky. Jupiter, on the right, is the brighter of the two. Much higher up in the south-southwest, Venus shines below and to the left of the Moon. You won't notice it, but a leap second will be added just before the clock strikes 7 P.M. EST.

JANUARY NIGHTS OUT

4 The Moon attains first quarter at 6:56 A.M. EST. Mercury is at its greatest eastern elongation, 19 degrees east of the Sun. The planet sets in the west-southwest some minutes before the end of evening twilight.

10 The Moon becomes full at 10:27 P.M. EST.

14 Venus is at its greatest eastern elongation, 47 degrees east of the Sun; viewed through a telescope it appears half lit. Ascending the eastern sky during the late evening hours is Saturn, about 6 degrees to the left of the Moon.

17 The Moon wanes to last quarter at 9:46 P.M. EST.

26 The Moon becomes new at 2:55 A.M. EST. An annular (ring) eclipse of the Sun occurs over the Atlantic and Indian Oceans; only near the end of its track does the Moon's antumbra (as the annular shadow is called) finally score a landfall—over Sumatra, Java, and Borneo.

29-30 The crescent Moon slides past Venus: in the early evening of the 29th it is situated below and to the planet's right, while on the 30th it is high above Venus.

Germ Fanfare

New OLogy toy line from AMNH wins Dr. Toy awards

It's not often that one earns bragging rights for spreading germs, but AMNH has done just that—by taking two top toy awards for fun kits in which children make glycerine-soap models of bacteria and viruses to learn about good microbes (think digestive agents) and harmful ones (salmonella and the common cold). The Germ Soap Kit is among 15 items in the brand-new OLogy line of educational toys, launched by the Museum in November as a complement to OLogy's award-winning interactive website for children.

Dr. Toy, one of the world's leading experts on children's products and an authority in the toy industry, named the OLogy Germ Soap Kit one of the "Top 10 Educational Toys of the Year" and counted it among the "Top 100 Best Children's Products for 2008." Each year, the Dr. Toy Awards recognize the best toys and children's products on the market based on affordability, design, and how well they capture children's interests to serve developmental and educational needs. Past winners have run the gamut from board games, dolls, and construction toys to computer programs, DVDs, and electronic puzzles, from such trusted manufacturers as Tonka, Fisher-Price, Scholastic, Hasbro, and many others.

To create OLogy's new toy line, the Museum's National Center for Science Literacy, Education, and Technology, which oversees the OLogy website, teamed with a toy manufacturer and Museum scientists to develop toys that would engage and educate children while reflecting the Museum's scientific work. For example, OLogy offers dramatic wall art depicting fossils of *Tyrannosaurus rex*, *Triceratops*, and *Deinonychus*, while the real things can be found on display in the Museum's famous fossil halls, which showcase specimens from the largest vertebrate fossil collection in the world. Likewise, the OLogy Stargazer kit allows budding astronomers to follow in the footsteps of the cutting-edge research on view at AMNH's Rose Center for Earth and Space, complete with binoculars, a map of the constellations, and other tools for studying the night sky.

The Germ Soap Kit, part of OLogy's new toy line from AMNH, took top honors in the 2008 Dr. Toy Awards.

Large-scale wall art captures children's imaginations and brings AMNH's dinosaur fossil collection to life.

Even the award-winning OLogy Germ Soap Kit, which comes in "helpful" and "harmful" versions, underscores the Museum's preeminent scientific work. In April 2007, the Museum's Center for Biodiversity and Conservation brought together microbiologists and conservation practitioners from around the world for a symposium on the very subject of harmful versus helpful germs. Titled *Small Matters: Microbes and Their Role in Conservation*, the symposium turned a spotlight on those countless unseen organisms that are beneficial in sustaining human life and explored how conservation practices take them into account. Who knew that a simple, fun soap-making kit could pack such a relevant educational punch?

To learn more about OLogy—and see the full line of clever, learning-friendly OLogy toys and products for children—visit amnh.org/ology, or visit the **AMNH Museum Shops**.

A Stone Diary

Visitors entering the Museum's 77th Street Grand Gallery may find themselves doing a double-take at what appears to be a cross-section of a huge crème de menthe parfait. But the recently installed polished jade slab is actually a much weightier treat, offering a rare object lesson in mineral formation and plate tectonics.

Like a geologic time capsule, the two-foot-long, 55-pound slice of a jadeite-type boulder tells the story of its own creation and offers clues to the dramatic processes involved. This striking specimen, which was recovered from northern Myanmar (formerly Burma), started as a small vein, or fracture, some 12 miles underground in Earth's crust. The vein was wrenched apart by the shifting of two tectonic places when India collided with Southeast Asia over 35 millions years ago. In the aftermath, mineral-rich fluids from the plunging sea floor rose through cracks in Earth's mantle and deposited jadeite rock into the open vein. Over time, as the tectonic plates continued to rub against one another, this vein of jadeite broke and reformed again and again, producing the exquisite emerald green and white marbling we see today.

"In order to look the way it does, this vein had to be broken and healed thousands of times," says George Harlow, Curator in Earth and Planetary Sciences at the Museum. "Imagine breaking a bone and allowing it to heal with a slight kink in it, then doing it again and again until it looks like a pretzel. That is what happened to this boulder."

Long prized as an ornamental stone, jade is the common name for two different kinds of rock that have similar properties: nephrite, a silicate mineral rich in calcium and magnesium, and the rarer, more valuable jadeite, a silicate mineral rich in sodium and aluminum. Sharing the display case with the jadeite slab are two intricately carved jade artifacts from China that date from the early 1900s: a nephrite jade vessel for incense and a jadeite jade carving of Guanyin, the Buddhist goddess of mercy. The display itself joins two other recent acquisitions in the Grand Gallery: a spectacular stibnite unearthed by miners in China and the fossilized, iridescent shell of an ammonite, an extinct marine animal.

Local Forecast or Long-Term Trend?

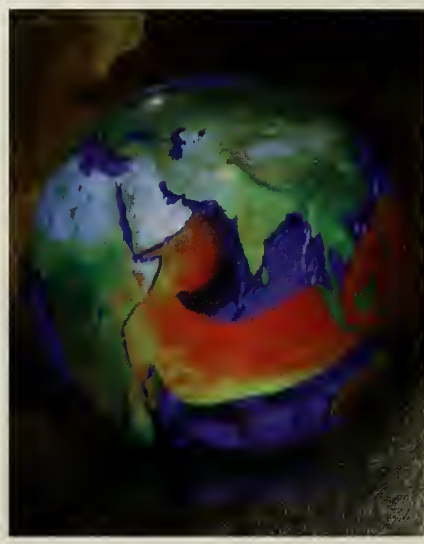
Eavesdrop on a typical conversation about the weather these days, and you're likely to hear someone idly attribute an unseasonably warm winter or the latest severe flood to "global warming" or "climate change." It's an understandable impulse, given the near-daily newspaper headlines and television images calling attention to very real potential effects of human-induced warming of Earth: more intense storms, longer droughts, and temperate winters that threaten to melt once-stable ice shelves. But climate and weather are two very different things.

This crucial distinction is just one of the issues addressed in the timely new exhibition *Climate Change: The Threat to Life and A New Energy Future*, and its many complementary public programs, including the children's program "What is the Difference Between Climate and Weather?", scheduled for January 11, 2009.

The difference is rooted in time frames. Weather describes the conditions today, tomorrow, or in the immediate days to come: today's chance of precipitation or tomorrow's forecasted high temperature. Climate, though, is much more complex: a particular month's normal temperature or a certain region's typical rainfall. Climate is the average weather over years, decades, or longer. A single weather event—a hot spell, for instance—doesn't say much about climate. Scientists are still puzzling out the long-term effects of the warming of Earth on weather patterns around the world. But this much they know for sure: around the world, the 1990s were warmer than the 1960s.

Are the winters of our childhood gone forever? Will the idyllic summers of distant memory ever return? For better or worse, the answer is: stay tuned.

For more information on climate change, visit the exhibition website at www.amnh.org/climatechange.



At the Museum

AMERICAN MUSEUM OF NATURAL HISTORY

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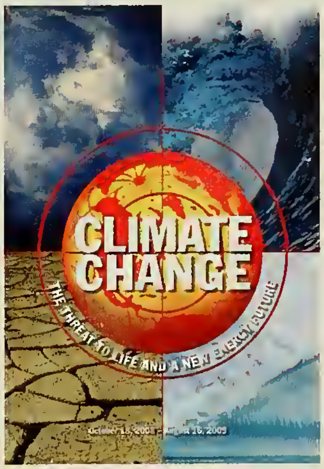


EXHIBITIONS

Climate Change: The Threat to Life and A New Energy Future
Through August 16, 2009
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. Realistic dioramas, dynamic animations, and interactive stations allow visitors to witness potential effects, such as the flooding of lower Manhattan as a result of melting ice sheets and ocean warming. The exhibition lays the groundwork for potential solutions, empowering and inspiring visitors of all ages.

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

Climate Change is proudly presented by Bank of America.

Additional support has been provided by The Rockefeller Foundation.

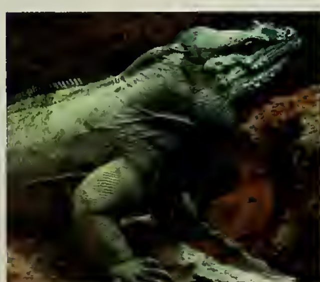
Additional support for *Climate Change* and its related educational programming has been provided by Mary and David Solomon, the Betsy and Jesse Fink Foundation, the Linden Trust for Conservation, and the Red Crane Foundation.

The Butterfly Conservatory
Through May 25, 2009
Mingle with up to 500 live, free-flying tropical butterflies in an enclosed habitat that approximates their natural environment. Learn about the butterfly life cycle, defense mechanisms, evolution, and conservation.

The Horse
Through January 4, 2009
This exhibition reveals the enduring bond between horses and humans, and explores the origins of the horse family, which extends back more than 50 million years.

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

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


© AMNH/R. MICKENS

Lizards & Snakes: Alive!
Through January 5, 2009
Meet more than 60 live lizards and snakes, and discover some of their remarkable adaptations.

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

Saturn: Images from the Cassini-Huygens Mission
Through March 29, 2009
This stunning exhibition reveals details of Saturn's rings, moons, and atmosphere with images sent over half a billion miles by the Cassini spacecraft.

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

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

On Feathered Wings
Through May 25, 2009
This exhibition brings together the work of renowned wildlife photographers whose artistry showcases the majesty of birds in flight.

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

Unknown Audubons: Mammals of North America
Through January 18, 2009
The stately Audubon Gallery showcases the last great works of John James Audubon.

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

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

GLOBAL WEEKENDS

Kwanzaa Fest 2008!
Saturday, 12/8, 12–5 pm
Celebrate the seven principles of Kwanzaa with a rich array of intergenerational performers and a marketplace of special foods. Visit www.amnh.org/kwanzaa for more information.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Obediah Wright, the artistic director of the Balance Dance Theatre

This event is co-produced with Community Works and the New Heritage Theatre Group under the artistic direction of James Stovall.

Living in America: Changing Climate, Changing Environment
Three Saturdays, 1/17–31, 12–5 pm
This year's series will feature environmental stories and narratives from local, national, and international communities, told through performances, discussions, films, and more.

This program is supported by funds from the New York State Department of Environmental Conservation.

LECTURES

A book signing follows each lecture.

Art/Sci Collision: Egg & Nest
Thursday, 12/11, 6:30 pm
Photographer Rosamond Purcell unveils the ornithological wonders found within the Western Foundation of Vertebrate Zoology, Camarillo, California.

This program is supported in part, by Kay Allaire and Ruth A. Unterberg.

The How and Why of Climate Change and What it Means for the Future
Tuesday, 1/6, 6:30 pm
An introduction to climate change presented by Edward A. Mathez, Curator, AMNH Department of Earth and Planetary Sciences and co-curator of *Climate Change: The Threat to Life and A New Energy Future.*

From the Field: Evolution: What the Fossils Say and Why it Matters
Thursday, 1/8, 6:30 pm
With Donald R. Prothero and Niles Eldridge, Curator, AMNH Department of Invertebrates.

Ivory's Ghosts: The White Gold of History and the Fate of Elephants
Wednesday, 1/14, 6:30 pm
With author John Frederick Walker.

Understanding Climate Change
Three Thursdays, 1/22–2/5, 6:30–8:30 pm

HAYDEN PLANETARIUM PROGRAMS

TUESDAYS IN THE DOME

Virtual Universe
Cosmic Climates
Tuesday, 12/2, 6:30 pm

Stories of Motion
Tuesday, 1/6, 6:30 pm

Celestial Highlights
Crossing the Lines
Tuesday, 12/30, 6:30 pm

Winter Skies
Tuesday, 1/27, 6:30 pm

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

LECTURES

Why Return to the Moon?
Monday, 12/8, 7:30 pm
With Professor Maria T. Zuber, Department of Earth, Atmospheric and Planetary Sciences, MIT

Mario Livio–Is God A Mathematician?
Monday, 1/12, 7:30 pm

Hayden Special IYA 2009 Lecture: The Journey to Palomar
Thursday, 1/15, 6:30 pm

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

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

Made possible through the generous support of CIT.

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

IMAX MOVIES

Sea Monsters: A Prehistoric Adventure
Through January 4, 2009
Travel back 82 million years to a time when strange creatures filled the seas that covered what is now the middle of North America.

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

Wild Ocean
Opens January 5, 2009
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.

LATE NIGHT DANCE PARTY

One Step Beyond
Friday, 1/16, 9 pm–1 am
Visit www.amnh.org/onestepbeyond for details.

INFORMATION

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

TICKETS AND REGISTRATION

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

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

ENDPAPER

Killer Snowballs

By Robert L. Pitman

Pamplona has the Running of the Bulls, but McMurdo Sound, in the southern Ross Sea, Antarctica, has something even more spectacular: the Stampeding of the Orcas. Each summer (December through February) an icebreaker penetrates miles into the frozen sea ice to open up a resupply channel to McMurdo Station, and the killer whales have learned to take advantage of the increased foraging area. With my colleagues Wayne Perryman and Don LeRoi, I have come to gather evidence that McMurdo killer whales—which have distinct color patterning and prey preferences—may be a separate species. To make our case, we are collecting skin samples for DNA, taking photographs, and simply getting to know the orcas a little better in their natural environment.

We are 300 feet up in a United States Coast Guard helicopter, working our way along an extended crack in the ice that has opened off the main channel, when we spot at least thirty killer whales in a long, scattered pod. We land the helicopter a half-mile ahead, well off the ice edge, and while the rotor blades are still whop-whopping, our pilot, Lieutenant Wendy Hart, signals that it's safe to get out. We charge across the frozen sea toward the sliver of water. As we approach, a four-foot-tall black letter opener slices across our view: the dorsal fin of an adult male killer whale. We see his small cloud of breath and, a full second after, an explosive gasp from the lung-pumping mammal reaches our ears. That kindred sound, so similar to our own labored breathing, raises the hair on the back of my neck.

When we get to the water we find it black and glassy calm. The helo has shut down and now the only sound on this frozen plain is the occasional squeak of our rubber boots in the powdery snow. But then, another blast of respiration announces that more killer whales have surfaced along the edge of the ice, ice so thick that we can walk right up to the rim of the whales' world. The water is clear, and their white eye-patches are easy to follow as they glide beneath the surface. Another adult male, maybe eighteen feet long, surfaces three feet away; his breath fogs my glasses before I instinctively jump back. Then a cow and her new calf charge through like a train with a small caboose. The calf—young enough that it still swims in jerky motions—lifts its head clear of the water, perhaps to get a better look at the novel creatures out on the ice. The adults seem to have more pressing business elsewhere.

Yesterday we saw a pod that was in less of a hurry. One of the whales, probably an adult female, was lolling in front of us. I wanted her to know we were there, so I tossed a snowball out to her. My throw was off: it tapped her on the side, and the dry snow vaporized with a muffled "pat." In response, she hesitated, and then, to my surprise, she started pushing around a piece of ice that was a couple of feet across. At one point she flicked it with the end of her snout, and it broke in two. She disappeared for a minute and brought back a replacement chunk of ice—about the size of a volleyball [*see photograph below*]. This time, when she arched her head back and snapped it forward, the ice flew out of the water and several feet ahead. For five minutes she motored around the small pond in front of us, repeatedly launching her ball of ice, before she lost interest and went on her way. I had to wonder: Did I just show a killer whale how to throw snowballs?

Today there will be no such dallying. The thundering herd takes about five minutes to blow by us. In the commotion, I frantically alternate between camera and crossbow. The photographs will allow us to estimate how many whales there are here, and with the crossbow we take a harmless snippet of skin for genetic analysis—to determine if the Ross Sea killer whales are in fact a different species. The whales ignore our efforts, and within a few moments we are left with only our samples, our photos, and the silence once again.

ROBERT L. PITMAN is a marine ecologist at the Southwest Fisheries Science Center in La Jolla, California. He has spent much of the past thirty-five years at sea studying whales and dolphins around the world.