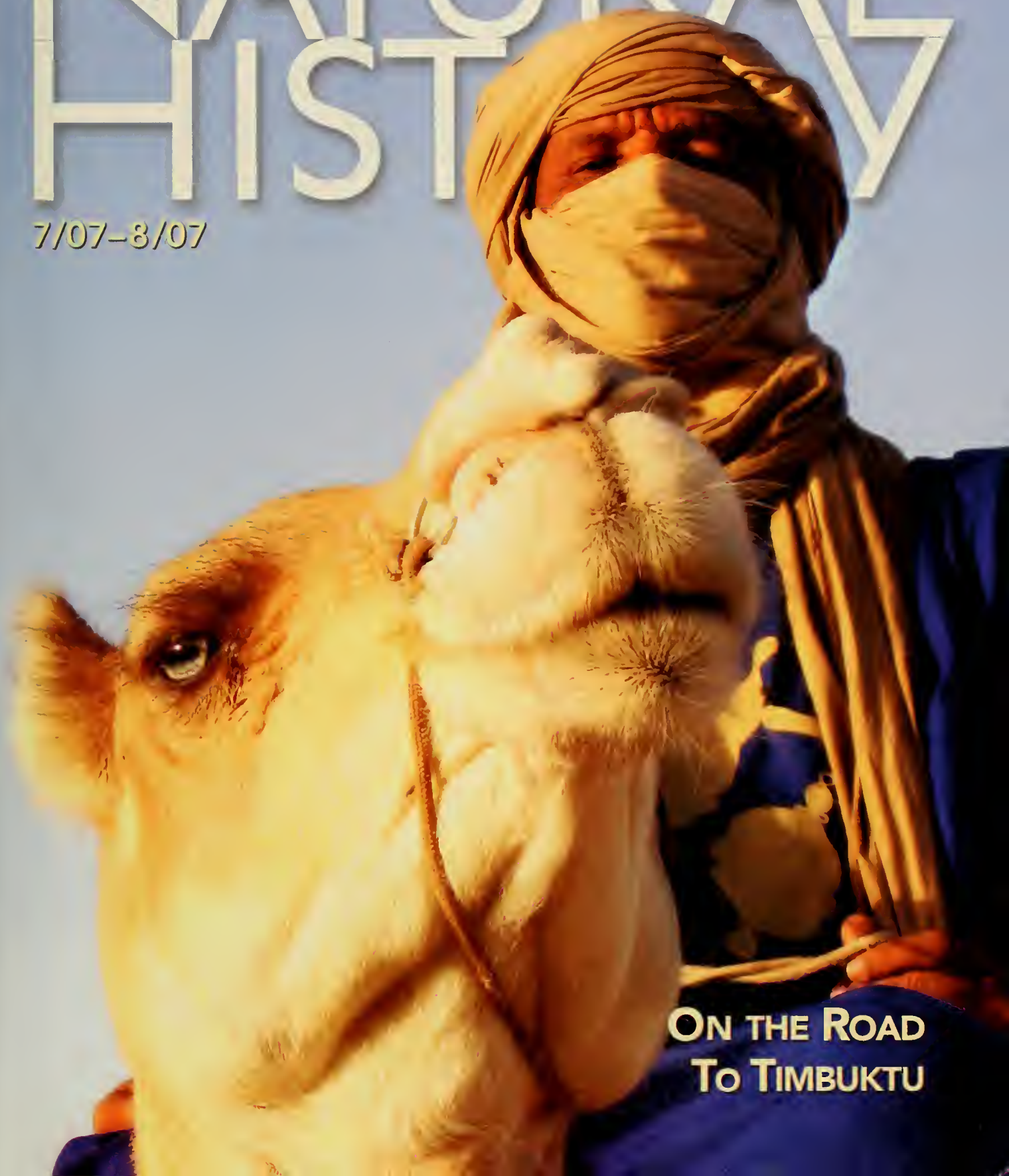


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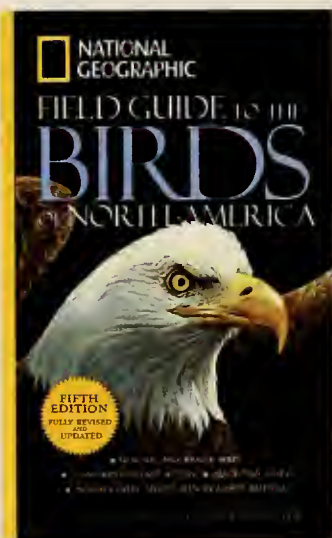


ON THE ROAD
TO TIMBUKTU



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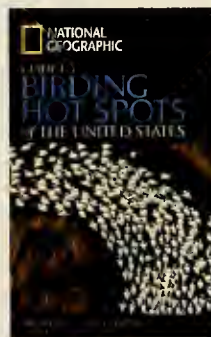
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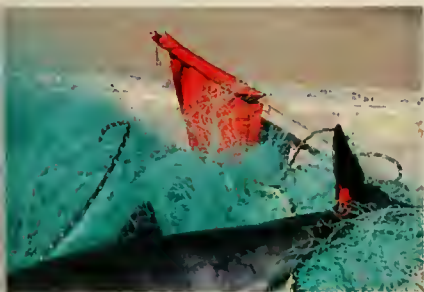
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The legendary city can boast a history of wealth and intellectual prowess, but political power has eluded it.

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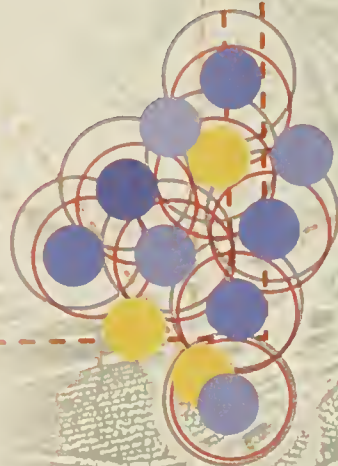
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THE NATURAL MOMENT

Laid-back in the Outback

Photograph by Mitsuaki Iwago





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THE NATURAL MOMENT

◀ See preceding two pages



Dry, scorching days of summer call for long hours of lounging on both sides of noon. And in parts of central Australia, where the average rainfall is less than nine inches a year, warm-blooded animals must heed that call. Photographer Mit-suaki Iwago kept cool, mostly by staying in his car to travel through Sturt National Park. Sturt lies in the northwest corner of New South Wales (NSW)—a hot, isolated place known as “Corner Country.” There, red kangaroos save their bounding and grazing for night, or at least for the edges of the day.

On his drive, Iwago happened upon this male red kangaroo, stretched out in the dirt, asleep in the midday heat. As Iwago tried to ease out of his car and around the back without startling the kangaroo, the animal “jumped to his feet and started to scratch himself with his sharp nails.” After a good deal of scratching and twitching, the male settled back down to his nap, and Iwago got his picture.

Red kangaroos usually travel in “mobs” of about ten: one male plus several females and young. So, perhaps the male that Iwago encountered was in search of a mob to control. There’s certainly no shortage of them to compete for: more than 2 million red kangaroos live in NSW. Because of the dense populations, hundreds of thousands of red and gray kangaroos, plus wallaroos, are culled every year for the sake of preserving local vegetation. Nevertheless, plans to cut back on the high numbers of kangaroos near Canberra, southeast of Sturt, are arousing some locals to a state far from repose.

—Erin Espelie

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UP FRONT

Long Ago and Far Away

If you had to name a town, a landscape, a place so remote that getting there would take you to the ends of the earth, few would quarrel if you answered, “Timbuktu.” To many people, at least in the West, Timbuktu is the stuff of legend, far more remote and unreal than Garrison Keillor’s fictional Lake Wobegon. According to the BBC, a small survey made last year among young people in England found that a third of them did not think Timbuktu existed at all, and the other two-thirds regarded it as a mythical place.

Of course, Timbuktu is much more than just a romantic state of mind. It’s as real as the hot sand from the encroaching Sahara, as real as poverty and resignation, a city of 30,000 souls built a thousand years ago next to a vast floodplain of the Niger River, now a part of the West African nation of Mali. Shortly after we prepared our cover story for this issue, “Space, Time, and Timbuktu” (page 22), I spoke to Marq de Villiers about the time he spent in Timbuktu with his wife and coauthor Sheila Hirtle, doing the research for their forthcoming book, on which their article is based. (For a full audio recording of my interview with de Villiers, go to our Web site for the July/August issue, www.naturalhistorymag.com; a link to the interview will appear under the heading “Featured Story.”)

• • •

One of the most remarkable things about Timbuktu,” de Villiers told me, “is that the city was a major center of Islamic scholarship. There was a university in Timbuktu [the University of Sankoré] that rivaled the great centers of Islamic learning in Egypt and even in Mecca. In the fourteenth and sixteenth centuries scholars arrived from all over the Islamic world to study in Timbuktu. Today there are still substantial depositories of manuscripts and ancient libraries.”

So did Timbuktu represent a particular school of Islamic thought? Absolutely, de Villiers replied. The version of Islam that flourished in Timbuktu became a very liberal branch—the rough equivalent of the Jesuits among the Roman Catholics. “They were very tolerant of outsiders, and the intention of most of their schools and scholarship was essentially peacemaking . . . and accommodation—a position of tolerance that, as we know, is not universal in Islam.

“The sad thing about this today,” he continued, “is that Mali is so poor that many of the young people of Timbuktu and other cities go to the Gulf [Persian Gulf states] to get work and to study. Some of them, alas, get infected with the more fundamentalist, Wahhabi view of Islam.” Some of that, inevitably, has come back to Timbuktu. “There’s a big squabble going on in the town between the tolerant wing and the more fundamentalist wing of Islam, and it’s a fascinating case study. The fundamentalists regard the older and more tolerant people as un-Islamic.”

Perhaps Timbuktu is not so distant from the modern world after all.

—PETER BROWN



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In his twenty-five years as a nature photographer, **MITSUAKI IWAGO** ("The Natural Moment," page 2) has made award-winning photographs in more than seventy countries. He is the author and photographer of *Serengeti: Natural Order on the African Plain* (Chronicle Books, 1987), which he worked on from 1982 until 1984 while living with his family in Africa. His most recent book is *Animals on Earth*, published by Fukuinkan Shoten in Tokyo. He is now at work on a documentary series, *Mitsuaki Iwago's Nature World*, in partnership with the Japan Broadcasting Company (NHK). Go to his website (www.digitaliwago.com) for more of his images.



A husband-and-wife team who live in Port Medway, Nova Scotia, **MARQ DE VILLIERS** and **SHEILA HIRTLE** ("Time, Space, and Timbuktu," page 22) have collaborated on a number of books. Their latest joint effort, the basis for their article in this issue, is *Timbuktu: The Sahara's Fabled City of Gold*, which is being published in August by Walker & Company. Among their earlier collaborations are *Sahara: The Life of the Great Desert* and *Into Africa: A Journey Through the Ancient Empires*. In sharp thematic contrast, they are also the authors of *Blood Traitors*, the saga of German immigrant families caught up in the American Revolution, and *Sable Island*, the story of an enigmatic sandbar off Nova Scotia. De Villiers was born in South Africa, and his first book, *White Tribe Dreaming*, was a history of the Afrikaners of South Africa. His other books include *Windswept: The Story of Wind and Weather*. A native Canadian, Hirtle is an editor and researcher with a background in fine art and design, marketing, and journalism. Her projects include a wide-ranging study of African art and music.

Coauthors **ROBERT L. PITMAN** and **LORENZO ROJAS-BRACHO** ("How Now, Little Cow," page 28) have both taken up the cause of the endangered vaquita, a porpoise that lives only in the northern Gulf of California. Pitman is a marine ecologist with the Southwest Fisheries Center of the National Oceanic and Atmospheric Administration in La Jolla, California, where he specializes in marine birds and mammals. His current research interests include the ecology of flying fish and the evolution of the Antarctic killer whale. With coauthors Thomas A. Jefferson and Marc A. Webber, he is completing a field guide, *Marine Mammals of the World*, which will be published this fall by Elsevier. Rojas-Bracho is a marine biologist at the National Institute of Ecology/Center for Scientific Research and Higher Education of Ensenada (CICESE) in Ensenada-Tijuana, Mexico, where he coordinates the National Marine Mammal Program. In recent years he has concentrated his time on research and conservation efforts to prevent the extinction of the vaquita. He is the founder and chair of the International Committee for the Recovery of the Vaquita.



Pitman

Rojas-Bracho

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Natural History (ISSN 0028-0712) is published monthly, except for combined issues in July/August and December/January, by Natural History Magazine, Inc., in affiliation with the American Museum of Natural History, Central Park West at 79th Street, New York, NY 10024. E-mail: nhmag@naturalhistorymag.com. Natural History Magazine, Inc., is solely responsible for editorial content and publishing practices. Subscriptions: \$30.00 a year, for Canada and all other countries: \$40.00 a year. Periodicals postage paid at New York, NY, and at additional mailing offices. Canada Publications Mail No. 40030827. Copyright © 2007 by Natural History Magazine, Inc. All rights reserved. No part of this periodical may be reproduced without written consent of Natural History. If you would like to contact us regarding your subscription or to enter a new subscription, please write to us at Natural History, P.O. Box 5000, Harlan, IA 51593-0257. Postmaster: Send address changes to *Natural History*, P.O. Box 5000, Harlan, IA 51537-5000. Printed in the U.S.A.

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LETTERS

Thanking the Stars

I am a single mother and as such, I often struggle with daily life in a big city where, as Langston Hughes once said, a nickel costs a dime. But tonight, for just a few minutes while I read Neil deGrasse Tyson's "The Cosmic Perspective" (4/07), I was lifted up to a higher place, where I was able to see that many of my daily worries are actually insignificant. A sense of peace came over me as I imagined the chemical elements inside my body being the same as those scattered all across the universe. How sad that in most of our barrios today the light created by our earthly activity has blocked

out our view of the stars. Perhaps if we could still see them, we could all remember how small we are. For now, I must be content with the gift afforded me by Mr. Tyson. Those words you labored over have touched at least this one soul.

*Franziska Castillo
Bronx, New York*

Neil deGrasse Tyson's 100th column is a brilliant reminder of why we should rediscover the awe of the universe that we all felt on seeing the Milky Way for the first time. I wish this article were required reading for every world government leader and anyone else who

thinks waving the flag is more important than the cosmos around us.

*Velo Mitrovich
London, United Kingdom*

Neil deGrasse Tyson's 100th article shows off his artistry for putting cosmic thoughts into words. This wasn't surprising to me, as I've been a fan for years. What I found enlightening were his thoughts in the preceding "Up Front" interview. His concerns about his writing process mirror those of people in the other arts—the jubilation and satisfaction, self-doubt about the next project, exhaustion, and ultimately, fulfillment. Mr. Tyson is a true artist.

Thanks for the inspiration.
*Mark Garro
Livingston Manor, New York*

NEIL DEGRASSE TYSON REPLIES: I am moved by the overwhelmingly positive response I have received to my 100th "Universe" essay. I try hard on these pages to bring the universe down to Earth. I am glad to know that I occasionally succeed.

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SAMPLINGS

Smelting Gun

The abundance of pre-Columbian bronze, copper, and silver artifacts in Peru indicates that the region was a center for metallurgy in the New World. But archaeologists have long been puzzled because they have never found remnants of smelting furnaces in the highlands of the Peruvian Andes, the source of much of the region's mineral reserves. Indeed, seventeenth-century Spaniards were long thought to have been the first metallurgists in the highlands. A new study, however, shows that pre-Columbian civiliza-

tions were smelting there after all: metallurgists started polluting a local lake with lead and other metals 1,000 years ago.

When metals were extracted from ore in ancient wind-drafted furnaces, small particles of floating debris would have settled in nearby bodies of water. To detect such ancient pollution, a team led by Colin A. Cooke, a graduate student of environmental science at the University of Alberta in Edmonton, hammered a three-foot-long plastic tube into the muddy floor of Lake Pirhuacocha, in Peru's Morococha mining region, and withdrew a cylinder of sediment.

Chemical analysis detected signs of smelting in sediments from as early as A.D. 1000, soon after the decline of the Wari Empire. Most of the early smelting produced copper and bronze. Lead pollution, a sign of silver production, turned up only after A.D. 1450, first during the Inca reign, later under European colonialism, and finally in modern Peru (a working mine and smelter stand nearby). Cooke thinks the missing furnaces were simply destroyed by landslides, which plague the highlands. (*Environmental Science & Technology*)

—Brendan Borrell

Lake Pirhuacocha

Escape from the Vortex

Black holes draw matter in, but they can also send a little of it flying out through space, borne on winds of hot gas that develop when matter is superheated by the black hole's own radiation. Some astronomers have proposed that those winds might help scatter such "heavy" elements as carbon and oxygen—the stuff of planets and life—across vast intergalactic distances, perhaps seeding empty parts of the universe with the materials to form planets. New observations provide the first experimental evidence in support of the seeding hypothesis, but they also hint that the effect might be considerably more local than originally proposed.

A team of astronomers led by Yair

of the National Autonomous University of Mexico in Mexico City studied the black hole at the center of NGC 4051, a galaxy 35 million light-years away in the direction of the Big Dipper. The team determined that a wind of hot gas originates 5 billion miles away from the black hole—certainly farther away than the corner store, but still much closer than previously thought possible.

Although some matter can escape such a close encounter with a black hole, not much actually does. Krongold's group calculated that the wind blows away only between 2 and 5 percent of the material that orbits the black hole at any given time. That's too little to have much of a seeding effect outside the NGC 4051 galaxy.

Bigger black holes in other galaxies, however, may yield different results. (*Astrophysical Journal*) —Stéphan Reeb

Galaxy NGC 4051

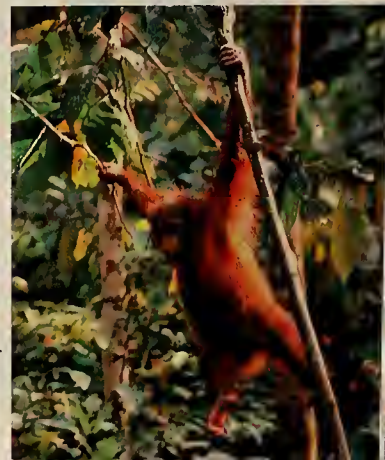
In the Swing of Things

Orangutans are the heaviest of all chiefly arboreal animals: males can weigh 200 pounds. But bulkiness can hinder a tree dweller, particularly when it has to cross from tree to tree; many branches are too thin and flexible to support an orangutan's weight.

Undaunted, the big apes have discovered another way to move through the canopy, one that puts their bulk to good use. The behavior is aptly called tree sway: an orangutan is heavy enough to oscillate a tree trunk until the arc of the tree's swing carries the animal over to a neighboring tree or vine.

Tree sway is certainly clever, but is it an energetically efficient means of locomotion? Susannah K.S. Thorpe, a primatologist at the University of Birmingham in Edgbaston, England, and two colleagues videotaped tree sway in Sumatra, Indonesia. By analyzing the tapes and accounting for various physical properties, including orangutan mass and tree-trunk stiffness, the investigators estimated that tree-swaying orangutans spend only half the energy they would if they jumped the gap. Furthermore, tree sway spends between ten and twenty-three times less energy than climbing down, ambling over to the next tree, and climbing back up.

Tree sway isn't the only way orangutans turn a tree's flexibility to their advantage. They, and certain other primates, have also been spotted using branches as catapults or springboards to propel themselves to destinations that would otherwise be just out of reach. (*Biology Letters*) —S.R.





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Phytoplankton to the Rescue?

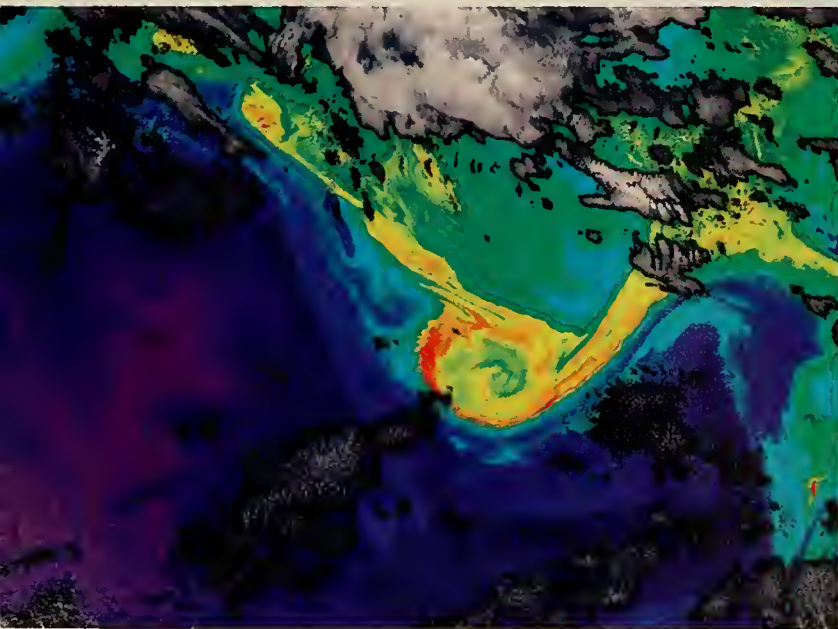
The Southern Ocean, surrounding Antarctica, is rich in nutrients, yet relatively little phytoplankton lives there. That's largely because the seawater is poor in dissolved iron, an element essential for phytoplankton growth. So some investigators have proposed fertilizing the Southern Ocean with iron to nourish larger populations of the microscopic algae. More phytoplankton, they have argued, would absorb more carbon dioxide through photosynthesis, ultimately storing tons of carbon deep in the ocean. There it could no longer contribute to global warming.

A recent study by Stéphane Blain of the University of the Mediterranean in Marseilles,

in the Southern Ocean. The bloom is a real whopper, lasting three months—a long time for a bloom—and covering more than 17,000 square miles of ocean, an area greater than twice the size of Massachusetts.

Blain confirms that the phenomenon is fueled by dissolved iron and other nutrients that well up from deeper waters. What's more, the amount of carbon taken out of circulation when some of the phytoplankton sinks to the ocean floor is surprisingly large: between ten and a hundred times more per unit of iron than had previously been estimated from small-scale experiments.

The oceanographers are quick to point out, however, that



Phytoplankton concentrations on the ocean surface are shown by colors that range from warm to cool in this false-color satellite image.

France, and a team of oceanographers sheds some light on the feasibility of that strategy. The team monitored the growth of a phytoplankton bloom near the Kerguelen Islands, which lie roughly equidistant from Africa, Antarctica, and Australia

artificial iron fertilization is unlikely to sequester carbon as effectively as does the deepwater iron around Kerguelen: it would be hard to replicate the slow and steady upwelling of iron and other nutrients in the region. (Nature) —S.R.



Basalt layers in eastern Greenland

Past Gas

People are to blame for much of today's climate change, but when the Earth warmed 55 million years ago, it wasn't our fault. At the time, a massive release of greenhouse gases caused global temperatures to rise more than nine Fahrenheit degrees and the oceans' acidity to increase sharply; numerous marine and terrestrial species went extinct. But what triggered the gas release has remained elusive, despite tantalizing clues that its onset might have coincided with volcanic activity so massive that what is now Greenland broke apart from Europe and the basin of the North Atlantic Ocean opened up.

Separate geologic records, however, hold traces of the two events: the temperature surge appears in North Atlantic marine sediments, and the massive volcanism appears in basalt layers of eastern Greenland. Now Michael Storey, a geochronologist at Roskilde University in Denmark, and two colleagues have pre-

cisely dated suspiciously similar ash layers that overlie both records. Sure enough, the layers were deposited at the same time, enabling Storey to sync the two records, and thereby to definitively link the ancient warming with the volcanic birth of the North Atlantic.

The new data strengthen a theory that magma from the volcanic activity heated marine sediments rich in organic matter, unleashing more than 1,500 billion tons of carbon into the atmosphere and oceans in the form of carbon dioxide or methane. Those greenhouse gases triggered the Paleocene-Eocene Thermal Maximum, as the ancient warm period is called.

Although the gases were released in just 20,000 years, it took more than 200,000 years for global temperatures to return to normal. Today, notes Storey, the burning of fossil fuels is releasing greenhouse gases at a much faster rate than did the Earth-shaping volcanism of eons ago. (Science)

—Corey Binns

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Captive tuna

Neptune's Farms

Most of the terrestrial plants and animals farmed today were domesticated between 11,000 and 2,000 years ago; after that, domestication rates stagnated until the twentieth century. Yet since around 1900, according to a new analysis, domestication has skyrocketed, bringing more than 430 wild species into cultivation. If that number seems high, it's because almost all those species live out of sight—in the water. The domestication of algae, worms, mollusks, crustaceans, echinoderms, and of course fishes heralded the rise of aquaculture during the twentieth century.

Several such intriguing statistics were recently compiled by Carlos M. Duarte, a marine ecologist at the Mediterranean Institute for Advanced Studies in Majorca, Spain, and two coworkers. The investigators depict an industry poised to play a major role in meeting the world's rising demand for protein—yet one that, like agriculture, is potentially harmful to the environment and wild populations. Aquaculture production is growing at a rate of 7 to 8 percent a year. Some 106 aquatic species have been domesticated in the past decade alone. And about 250 marine and 180 freshwater animal species are now being “farmed,” compared with just forty-four species of land animals.

The rise of aquaculture seems to have come none too soon, particularly because fisheries are ravenously depleting wild ocean stocks. Duarte notes, however, that for aquaculture to be sustainable, practitioners must reduce harmful side effects. Those include the overfishing of wild species to feed captive ones, the polluting of natural ecosystems with concentrated fish waste, and the potential for undesirable genetic mixing when farm escapees mate with wild stocks. (*Science*) —S.R.

Humongous Fungus (No Longer Among Us)

What's twenty feet tall and dines on detritus? *Prototaxites* fossils reminiscent of branchless tree trunks have been unearthed all over the world. In their day—between 420 million and 350 million years ago—they were by far the biggest things alive. But figuring out just what they were has long stumped paleontologists, who have variously suggested they might be coniferous plants or oversize algae, lichens, or fungi.

To nail down *Prototaxites*'s identity, C. Kevin Boyce, a paleobotanist at the University of Chicago, and several colleagues analyzed *Prototaxites* specimens from Canada and Maine to determine how much of the carbon in them is made

up of the isotope carbon-13 rather than carbon-12. The percentage of carbon-13 in an organism's tissues depends on its food. Photosynthesizers make their own food, of course, and distinct groups, depending on their method of photosynthesis, have characteristic levels of carbon-13.

Prototaxites, however, show no such consistency. Some specimens have carbon-13 levels similar to those of nearby, contemporaneous plants (some of them preserved as coal); others have much higher levels. Based on that variability, Boyce concludes that *Prototaxites* was not photosynthetic, but instead, like many modern fungi, fed on whatever dead organic matter

it encountered in the soil. The unbranched stems, he says, were probably robust, perennial reproductive structures that arose, as mushrooms do, from an extensive network of underground filaments. Indeed, the stems are made up of numerous funguslike filaments. So *Prototaxites*, it seems, was a fungus.

But why would a fungus grow so enormous? Boyce thinks *Prototaxites* got big simply because nothing that could deter it had yet evolved: no tall plants to crowd it, no herbivores to eat it, no large animals to knock it down. Unhindered, the ancient giants reached for the stars. (*Geology*)

—Rebecca Kessler

Talk Is Toxic

When your cell phone dies or succumbs to obsolescence, it probably follows the path of most other unwanted electronics: it becomes e-waste and heads for a landfill. After that, it's only a matter of time before its contents, which include toxic compounds and metals, leach into the soil. To date, about 700 million cell phones have been discarded or stashed away for later disposal in the United States alone.

Oladele A. Ogunseitan, an environmental health scientist, and his colleagues at the University of California, Irvine studied cell phones under one federal and two California protocols for assessing the hazardous content of e-waste. They shredded cast-off cell phones, soaked them in water at various levels of acidity, and analyzed what oozed out according to each protocol.

What did they find? High enough levels of lead to classify cell phones as hazardous waste under federal regulations. (Fortunately, manufacturers are phasing out lead-based solder, the main source of lead in cell phones.) Less expected were antimony, copper, nickel, and zinc—all known threats to human health—at high levels that exceeded the standards set by California, but not federal, regulations.

Those and other differences among the state and federal standards create problems for manufacturers and regulators, highlighting the need to review testing procedures. Even better would be for manufacturers to roll out less toxic electronic products. (*Environmental Science & Technology*)

—Graciela Flores



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A Human Cell in Sheep's Clothing

Biologists in Nevada are gambling that sheep can grow spare body parts for people.

By Olivia Judson

I'm about to see something odd. I'm about to see the creation of a sheep with a partly human liver.

I'm visiting the University of Nevada at its campus in Reno—a town with all the vice of Vegas but none of the charm. I've come to take part in a documentary about biotechnology. The star of the episode is in front of me on an operating table: a pregnant ewe, lying on her back with her legs splayed. She's been knocked out with an anesthetic, and the wool on her belly has been shaved off. Her skin is pink. The surgeon picks up a tool that looks like a sharp soldering iron and starts to make a cut down the belly. Acrid smoke rises from the cut.

I wrinkle my nose. "Strong smell of burning flesh," I say.

"Just smells of roast," says the surgeon.

Well, up to a point. But the burning seals the blood vessels shut, so there is no bleeding. None at all.

The surgeon cuts down the middle of the belly, in the gap where the stomach muscles meet. (If the sheep had a six-pack, the cut would be down the

center.) A few more cuts, and we have a window into the sheep's insides. The surgeon slides a hand into the opening and starts to haul out the womb. It's red, and glistens. I feel I'm watching clowns getting out of a clown car: the womb keeps coming and coming. I watch in astonishment. I had no idea you could partly pull out an animal's insides like this.

"A sheep's womb is a different shape from a human womb," says the surgeon. "A human womb looks like a sack. A sheep's womb has two horns that join at the base." She arranges the womb so that I can see both horns and starts running her hands over them, squeezing slightly. "The fetuses can be in either horn," she says. "Sometimes you have one in each, sometimes you have three in one and none in the other. This sheep has only one fetus. Here it is. The hips are here." The outlines of the fetal sheep, now almost nine weeks old and about six inches long, show through the lining of the womb; it's like looking at a child covered by a blanket.

"What happens now?"

"Now we inject human stem cells into the fetus. We don't need to cut into the womb, we just inject the human cells by pushing the needle through the wall of the womb and

into the body of the fetus. This is very safe: we haven't lost a fetus since we started doing the operations this way" (they haven't lost any ewes either).

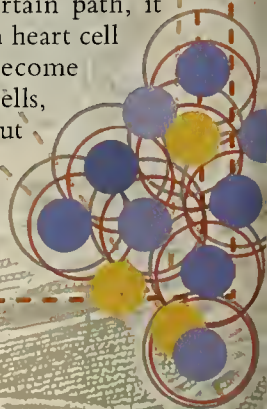
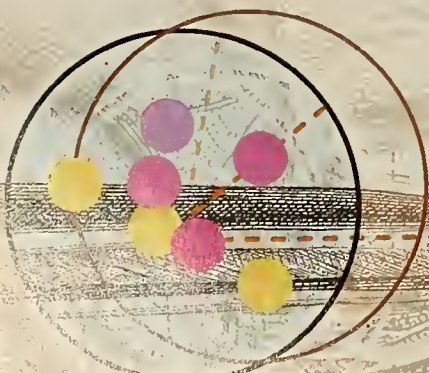
The surgeon's assistant picks up a long syringe filled with fluid.

"That contains the stem cells?" I ask.

"Yes. Stem cells from an adult," says the assistant. He positions the needle so that the fluid will be injected into the belly of the fetus, and pushes the plunger.

Each stem cell has the potential to become one of many kinds of tissue—which is why stem cells have become such a hot area of research. As stem cells differentiate into tissue of a particular type—heart, say—they switch off the genes they don't need for the heart and switch on the ones they do need. Thus a stem cell would take on such traits of a heart cell as shape and size. Once a cell has committed to a certain path, it loses its flexibility: a heart cell cannot suddenly become a liver cell. Stem cells, then, are cells without commitments.

Stem cells come from three main



sources. Embryos are one—they're the reason some of the work on stem cells is controversial. Many cells in an early embryo are stem cells, and they can form any kind of tissue. A second source is blood from the umbilical cords of newborn babies. And it turns out that adults also have a few stem cells, lurking in places such as bone marrow and skin. Stem cells from those sources are not quite as versatile as embryonic stem cells, but their use is uncontroversial. And it is a batch of human adult bone marrow stem cells that I've just seen injected. The surgeon stuffs the womb back into the sheep (somehow it all fits) and sews up the incision. The ewe is carried off to the recovery room. The operation has taken just fifteen minutes.

As for the fetus, "In another ninety days or so, it will be born," says the surgeon.

"And at that stage, part of its liver will be human?"

"Yes. The cells we injected will migrate through the fetus's body and settle into different

organs. Once the cells have settled in an organ, they start to divide. The cells around them tell them what tissue to become—so the human cells that arrive in the liver will become liver cells. Over time, as the cells keep dividing, you get clumps of human cells—so parts of the liver are purely human."

"Does that affect the sheep?"

"No. Although as much as 15 percent of the sheep may be cells of human origin, in all outward respects, these are normal sheep."

And indeed they are. On seeing some of them, I have no idea they are in any way remarkable. They are woolly, they say *baaa*, they look sheepish. Yet the more I think about it, the more remarkable they seem.

But first things first: why would anyone want to put human cells into a sheep?

The idea behind the research—which is the brainchild of Esmail D. Zanjani, a professor and chair of the university's department of animal biotechnology—is that one day, perhaps, livers grown this way could be transplanted into people.

At present there aren't enough organs available for transplant, so people in need often die while waiting for one. And even if you get the organ you need, your immune system may still reject it soon after the transplant—or years later.

The reason rejection happens is easy to understand. The immune system's job is to protect the body from intruders. Transplanted organs, unless

Continued on page 39



Cold Squirts

Antarctic scallops have lighter shells, less muscle mass, and more resilient hinge rubber than their tropical cousins.

By Adam Summers ~ Illustrations by Emily Damstra

Squids and octopuses are well known for their jet-propelled locomotion, scooting along by squirting water out of their mantles. But bivalves? Not many people have seen the ungainly, clapping flight of the scallop, but its motion is likewise jet-propelled.

The scallop is one of only a few bivalve mollusks—invertebrates with a two-part shell—that can truly swim. When threatened, the scallop claps the two halves of its shell together, and thus expels a jet of water that propels it to safety. By repeatedly slamming the shell, the scallop manages to wobble unsteadily through the water.

Simple enough, right? Yet it probably won't surprise regular readers of this column that basic research on the locomotion of scallops has implications for

scientific investigations of seemingly unrelated matters. It turns out that studying the swimming of cold-water scallops can guide applied research on manipulating polymers at various temperatures.

Like clams and mussels, scallops have two half shells, or "valves," attached to each other by a strong hinge. A large (and tasty) muscle, the adductor, is attached to the center of each valve, and when the muscle contracts, the shell closes to protect the animal's soft parts. The muscle can exert force only to close the shell; to open, the shell relies entirely on a little rubbery pad of protein just inside the hinge. The rubbery pad gets squashed when the shell closes, but as the closing muscle relaxes, the pad rebounds and pushes the shell back open. That's why when you're shopping for live bivalves for dinner, you want the closed ones: they are manifestly alive because they're still holding their shells tightly shut.

The jetting mechanism in a scallop works like a somewhat inefficient two-cycle engine. When the adductor muscle closes the shell, water squirts out; when the adductor relaxes, the rubbery pad pops the shell back open, allowing water back inside and replenishing the jet [see illustration across these two pages]. The cycles repeat until the scallop is out of predator range or closer to a better food supply. Unfortunately, the jet-power phase is delivered for only a short part of the cycle. Scallops, however, have adapted to make the most of what power and thrust they can produce.

One of their tricks is to lighten the load by having thin shells, whose weakness is offset by corrugations. Another adaptation—the key, in fact, to their culinary charm—is that large, tasty adductor muscle, physiologically suited to the powerful cycles of contraction and relaxation in jetting. Finally, that little rubbery pad is made of a natural elastic called abductin, which does an excellent job of returning the energy put into it by shell closure.

As inefficient as jetting is for all scallops, the cold-water species face even tougher challenges. For one thing, the power output of muscles decreases in the cold. For another, cold water is more viscous, and offers more resistance. And finally, in the Antarctic, where the water temperature is only



twenty-eight degrees Fahrenheit, the rubbery abductin should become less elastic. Those factors explain why the Antarctic scallop, *Adamussium colbecki*, is just barely able to sustain level motion.

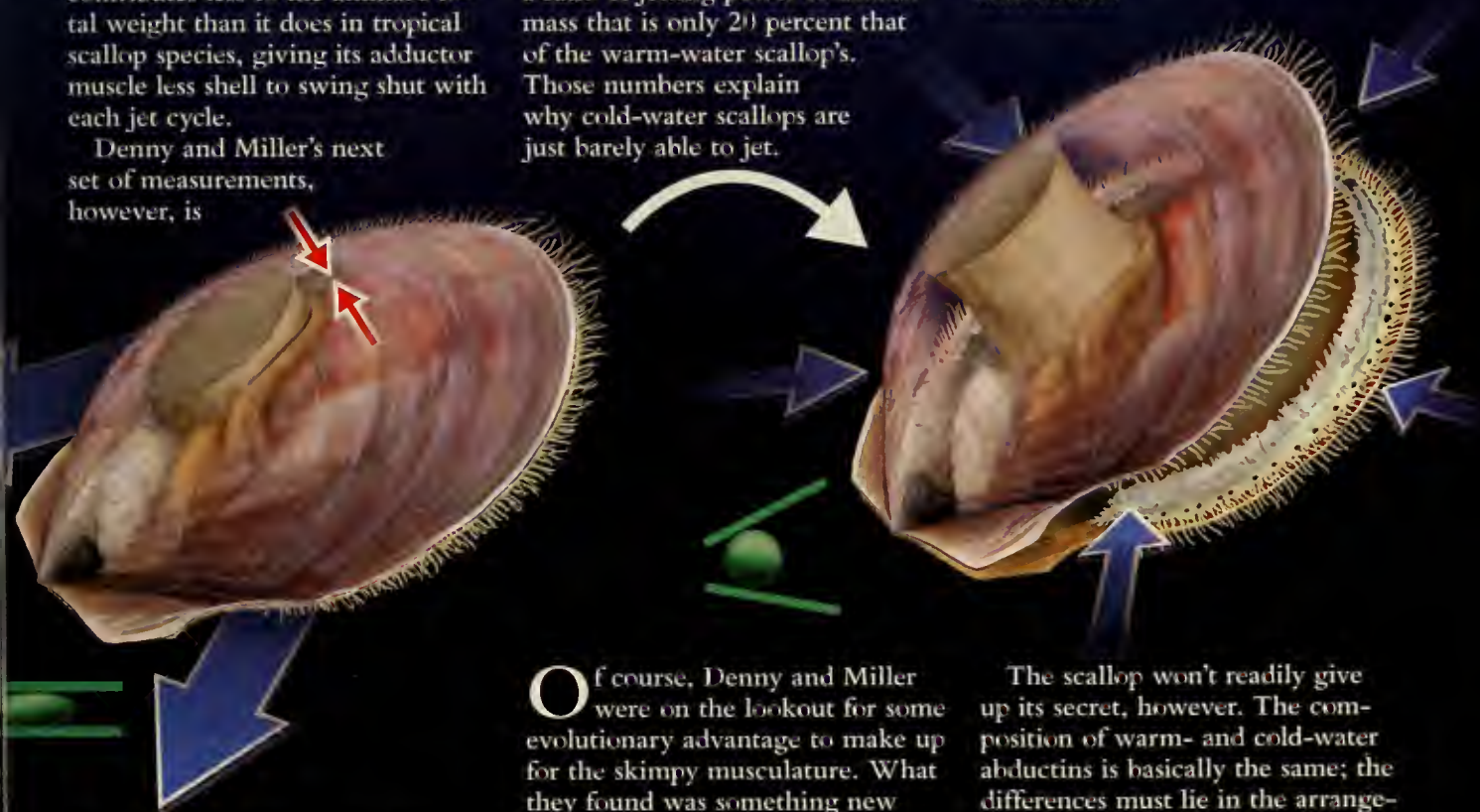
Yet despite the cold, *A. colbecki* manages to swim. Mark W. Denny and Luke P. Miller, biomechanists at Stanford's Hopkins Marine Station in Pacific Grove, California, traveled all the way south to McMurdo Sound to figure out how. Their initial findings were not unexpected: in *A. colbecki* the shell contributes less to the animal's total weight than it does in tropical scallop species, giving its adductor muscle less shell to swing shut with each jet cycle.

Denny and Miller's next set of measurements, however, is

harder to understand. Instead of an extra-large muscle to compensate for the cold, they found that *A. colbecki* has a closing adductor half as big as the adductor in a warm-water bivalve of similar size. Although that, too, saves weight, the shift in proportions implies that closing the shell takes less force but more time—not to mention that it takes more cold-water scallops to make a satisfying entrée. In fact, the combination of low shell mass and low muscle mass translates into a severe handicap for the scallop—a ratio of jetting power to animal mass that is only 20 percent that of the warm-water scallop's. Those numbers explain why cold-water scallops are just barely able to jet.

the Antarctic scallop's abductin, they did indeed find a decrease in bounce with a drop in temperature, but it was a smaller decrease than occurs in temperate-zone mollusks. Natural selection has thus fine-tuned the response of abductin to temperature.

The difference is small potatoes for the scallop; the energy returned by Antarctic abductin is only a small fraction of the total needed to jet. But a rubber that retains its bounce in the cold would make materials scientists take notice.



Antarctic scallop escapes capture by jet propulsion. The creature launches itself by closing the two halves of its shell with its adductor muscle. The closing action forces water out of the shell's interior and compresses the rubbery hinge tissue (green). As the hinge tissue rebounds, the shell slowly opens, water re-enters the shell, and the muscle returns to its initial position, ready for another thrust.

→ Movement of water
→ Force of adductor muscle

Of course, Denny and Miller were on the lookout for some evolutionary advantage to make up for the skimpy musculature. What they found was something new about the properties of polymers.

In severe cold, the abductin in the scallop's hinge should become less able to store energy. After all, as many readers may recall, the catastrophic explosion of the space shuttle *Challenger* in 1986 was caused by cold weather, which made the booster-rocket O-rings so hard and brittle that they allowed hot gases to escape. When Denny and Miller checked the effect of changing temperature on

The scallop won't readily give up its secret, however. The composition of warm- and cold-water abductins is basically the same; the differences must lie in the arrangement of the protein polymers that store and release energy. Identifying those minute differences will further confirm the rule of thumb that blue-sky (or in this case blue-water) research has unanticipated implications far outside the shell of the original work.

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Space, Time, and Timbuktu

The legendary city on the Sahara's southern fringe can look back on a history of commercial, intellectual, and religious wealth. Today as in the past, however, political power eludes it.

By Marq de Villiers and Sheila Hirtle

The Well of Buktu, so-called, is a paltry thing, about three feet across and not much deeper, and contains no water at all. A goat-skin bag hangs over the opening, suspended from three slender wooden poles poked into the ground, a show-and-tell of how the water was drawn to the surface in those days when there was water, if there ever was any. The whole thing is set up in a sandy courtyard that serves as a kind of anteroom to the municipal museum of Timbuktu.

An old man, wizened and sly, was sitting on a bench in the shade, smoking up a storm. He'd have sold us a postcard or even a goatskin bag if we had wanted one, but he didn't try very hard.

"Is this really the well of Buktu?" we asked.

He hesitated, assessing our credulity, then grinned. "It is a well of the same type," he said at last. "No one knows where the real well was, but there must have been one. Who is to say it wasn't here?"

Who indeed? A Well of Buktu, or Tin Buktu, is part of the founding myth of Timbuktu, a thousand-

year-old settlement on the southern border of the Sahara Desert. Although now it is a peripheral city of 30,000 in the modern state of Mali, its name evokes, for those familiar with its history, a luminous past as a crossroads of caravan routes and of learning, and still holds, for jaded Western tourists, the promise of a remote and exotic destination. Its name may even be a guide to fact, when fact is lost in the mists of unrecorded time. The most common version of the story of the city's origin goes like this:

Timbuktu was founded by a group of Tuareg herdsmen around the start of the eleventh century. This particular group's range was the desert between the Niger River and the oasis town of Arawan, about a week's journey north of the river. In the wet season (such as it is in the desert), they would linger in the north. In the dry season, the summer, they would bring their herds closer to the Niger to graze. They set up a camp in the dunes at a convenient spot a half-dozen miles from the river, where they dug a well. *Tin* means either "well" or merely "place" in



Aerial view of Timbuktu, top, looking northward toward the Sahara, shows a city of 30,000 people who live mostly in single-story mud buildings spread across about four square miles of desert. Strategically positioned near the Niger River, the city owed its rise to trade in gold and slaves, manufactured goods from the Mediterranean, and salt from the desert itself. Above: a market in the city today.

the Tuareg language, Tamashek—a member of the Berber family of languages. After a few years that convenient camp became more permanent, and the nomads would leave their goods there in the charge of an old woman named Buktū. Accordingly, the

Tuareg herders would refer to returning to Tin Buktū, “the place of Buktū.”

Well, as a story it’s tidy enough, though some traditions say *buktū* isn’t a person’s name at all, but means “woman with a large navel” in the language of the Songhai, an unrelated ethnic group centered downriver from Timbuktu. Others suggest that the woman referred to as Buktū was not a Tuareg at all, but a native Songhai. In a further refinement, the word is also translated as “woman with a large lump,” which is then taken to mean navel (no doubt one of the earliest references to an “outie” in literature). All such romantic notions were scorned by the nineteenth-century German explorer and linguist Heinrich Barth, who pointed out that the Songhai word for navel also means a shallow depression between sand dunes, and that in origin the city’s name, Timbuktu, most probably means nothing more than “the place between dunes.”

Whatever the legends may say, most historians agree that the Tuareg are descendants of Berber groups that were driven from the Mediterranean plains of northern Africa by various invasions and conquests. One way or another, the nomads made the desert their home and founded Timbuktu in the eleventh century. Their camp gradually became an important gateway to the Sahara. Traders began showing up from the river and points farther south, accumulating goods for a venture across the desert itself.

The Tuareg did not hold sway over the city for long, however. Over the centuries Timbuktu has been owned by a succession of foreign emperors, kings, and sultans. From time to time the Tuareg have descended on the city to take it for a decade or two, or merely to loot and pillage before retreating to the desert again. Theirs has not been an altogether happy history. They’re a proud and even arrogant culture, but their present status is uncertain and their future bleak. Rather like Timbuktu’s.

A rawan lies some 180 miles almost due north of Timbuktu, a six days’ slog on foot and camel. It is the last real town—with the last wells—on the way to the historic salt mines of Taoudenni and Taghaza, more than 200 and 300 miles farther on. From



the thirteenth century until well into the seventeenth, that salt was quarried by slaves and carried in great blocks by camel to Timbuktu in exchange for gold. Modern salt gatherers from Timbuktu still use Arawan as a way station to Taoudenni (Taghaza is now abandoned). In its heyday, however, Arawan had 3,000 inhabitants and 170 productive wells; today, with the dunes rolling relentlessly in, it has only a handful of residents and two wells.

Arawan was also a way station for caravans headed still farther north across the desert. They would continue on to Taoudenni or Taghaza, or both, to water their camels and rest. Ahead they faced a desert that flattened into monotonous stony plains, with not even a dune or a ridge or a boulder as relief. Still, convoys of as many as 10,000 camels streamed across those reaches, carrying gold and slaves to the towns north of the Sahara, and bringing back manufactured goods from the Mediterranean along with salt from the desert itself [see map above].

The major sources of gold were to the south, in modern Ghana, Guinea, and Senegal. To the east, on the Niger River, was Gao, capital of the Songhai empire, considered one of the three greatest empires that arose in West Africa. While the empire flourished, from 1464 until about 1600, its kings ruled over Timbuktu. Beyond Gao, caravans from Timbuktu reached other peoples and centers, connecting via the Nile with Egypt and ultimately with the caliphs of Baghdad and the holy places of Mecca and Medina.

Nowadays, from Timbuktu west to the Atlantic it is all desert. Along the way the traveler passes

Walata, once a rival to Timbuktu but now much decayed, and the ruins of many far older cities. Among them is Koumbi Saleh, in what is now southeastern Mauritania. It was the capital of the Ghana-Wagadu empire, considered the first great empire of West Africa, which flourished ca. 300 B.C. until A.D. 1100. Today all one sees of the city is crumbling rubble. Also remarkable are the thousands of slag deposits from the smelting of iron ore that have been found on the north bank of the Niger. The area now has no forests for fuel. Southwest, upriver on the Niger, one encounters the city of Mopti, as old as Timbuktu, and the more ancient city of Djenné. Farther on is the heartland of the second of the great West African empires, which prevailed from 1235 until ca. 1500. That was Mali, for which the modern state is named, but the precise location of its capital, Niani, is unknown.

Caravan routes once led north across the desert from Koumbi Saleh and other early centers, as did the later routes from Timbuktu. Why those earlier routes fell into disuse and why the cities crumbled is one of the fascinating puzzles of African archaeology. It may have been a combination of ecological collapse, desertification (partly human-caused), and the turmoil of warfare and religious strife. Known climate changes in the southern Sahara provide important clues. Most of the abandonment of settlements took place during a dry phase from 1100 until 1500. The founding of Timbuktu also corresponds with the start of that phase, and may explain why the nomads showed up where they did at the Niger River.

Timbuktu itself is not short of water. Its municipal wells maintain their steady flow from aquifers deep below the surface: fossil waters left over from more verdant times, still being recharged by the Niger. Yet the city's immediate neighborhood is changing, the dunes edging ever closer.

Shindouk Mohamed Lamine Ould Najim [see his photograph on the cover of this issue] is the chief of a small tribe of Bérabiche whose desert camp is near Arawan. He has a house in Timbuktu, but spends much of his time in the desert. He makes his living operating camel caravans and as a guide, steering not only individual parties, but also movie crews, survey expeditions, prospectors, and adventurers through some of the most difficult terrain on earth. Shindouk comes from a long and illustrious line of desert experts, which is what his business card calls him: *guide de Tombouctou, expert du désert*.

Shindouk's father, Najim, was one of the most famous Saharan guides of them all. Tales of his exploits are legion. Once he even helped save a lost convoy at long distance, by radio. The convoy's

guides had become confused and disoriented. With only a few quarts of water remaining, they managed to get Timbuktu on the radio to ask for help. Someone called for Najim. When he came to the military post where the transmitter was, he asked to speak to the most senior guide present.

"Describe the place," he demanded. "What does it look like, the horizon? What is its shape to the west and the north, to the south and the east? Are there any hills? Are there dunes, and what size and shape? Is the ground stony?"

The guide did as he was asked.

"Pick up some sand," said Najim. "Tell me its color: is it clear, with white grains, or dark, with black particles? And its feel. How big are the grains? Is it sharp to the fingers?"

The guide obeyed once again.

Najim sifted the descriptions in his mind. Then he said, "You describe a small mountain ahead of you, to the north. Go there, turn west when you get there, travel for half an hour, and call me again."

Three hours later the convoy reached the mountain and turned left as instructed. Najim came back on the radiophone.

"Do you see a large free-standing rock off to your left?" he asked.

"We do."

"Get the men to push it over. There is water beneath it."

On another occasion, a military convoy had been trying to map the boundary with Algeria. The military frequently employed civilian freelance guides, who sometimes felt exploited and underpaid. Najim had taken this convoy deep into the desert, and one day, he stopped. "I feel dizzy," he said. "I can't even tell where the west is, or where the north. I don't know what to do."

The convoy leaders began to panic. "What can we do?" they asked.

"Two things might help," Najim replied. "More money, and an honorary commission in the Army."

An urgent phone call to Timbuktu military headquarters got patched through to Bamako, the capital, and a short time later the president of the republic himself called to personally award Najim his officer's commission. He also got more money. The mapping survey continued amicably.

In the past, the caravans coming in from the deep desert would have been met by a commercial agent and escorted into town. Then the tallest structure in Timbuktu would not have been the water tower one sees today, but the minaret of the Sankoré mosque, already more than a hundred

years old when Timbuktu was occupied by the forces of the Mali emperor Musa, in the middle 1300s. That event heralded the start of Timbuktu's first golden age, and its first great expansion as the main entrepôt for the southern Sahara and a haven



Minaret of the Sankoré mosque, built of mud plaster, is pierced with beams that serve as scaffolding when renovations must be done. Much of the present construction dates to the nineteenth century, but the mosque was established in the late 1100s.

for scholars of Islam. The city's second and most significant golden age came several centuries later, under the rule of the kings of Gao.

Then as now, Timbuktu was made largely of mud. The mosques are still mainly mud, as are the tombs and shrines. The central town is a maze of narrow alleyways punctuated by secretive doorways, some providing a glimpse of courtyards, and glassless windows with intricately carved screens of wood. At intervals are ruined buildings and vacant lots

that look like bomb sites, but the only bomb that has dropped is time. A shrinking population has no money to repair a city made of mud, in which the buildings melt in the wet-season rains unless protected by fresh plaster.

We paid a visit to Abdel Kader Haïdara, whose home sprawls off one of the unnamed sandy alleys in the southeast quadrant of the city. The windowless main living room was sheltered from the sun, turquoise and cool, with carpets on the floor and red plush banquettes. The walls were lined with bookcases and cabinets and a hulking television set. After the first pleasantries, our conversation ranged from the legends about the founding of Timbuktu, through the golden age of the city, to its gradual decline after the Moroccan invasions some 400 years ago.

Eventually we fell to discussing Ahmed Baba, a scholar who died in the early 1600s but whose name is often still mentioned as though he were a favorite uncle who has just popped out for a quick prayer. Ahmed Baba's personal library included some 1,600 volumes when he died, but he had often remarked that his was one of the lesser collections. We knew that our host was himself the head of the family that owned the Mamma Haïdara Library, one of the largest extant collections of ancient manuscripts left in the region, a priceless link to the glorious past.

Could we see it?

We could, indeed. The building that housed it was undergoing much-needed and expensive renovations, so Haïdara had, well, brought a good deal of it home. Where better to keep an eye on it? It was his, after all. Our host led us back into the outer courtyard. In one wall was a battered corrugated-iron door, locked with an old-fashioned padlock. Haïdara fished a bunch of keys from his robe and opened the door, pushing it inward with a grinding sound. Inside the small room we saw tottering piles of ancient manuscripts, some in loose bundles, some in battered tin trunks or leather portfolios, others simply heaped on the dusty floor.

Buried in those floor-to-ceiling stacks were all the great themes of Timbuktu's history, the very

reasons it exerted such an hypnotic attraction on the Mediterranean world: its flowering, from a pasturing place for Tuareg nomads into a trading emporium that prospered on gold and salt and slaves; its reputation for wealth, which loomed so large it attracted the attention of the Venetian traders and then of the sultan of Morocco Ahmad al-Mansur, who wanted the gold traffic for himself to further his ambition to supplant the Caliphs of Baghdad; and its preeminence as a center of learning, of Islamic scholarship, luring the learned and the pious from Alexandria, Baghdad, Cordoba, Fez, Marrakech, Mecca, Tlemcen, Tripoli.

Intellectual wealth, religious piety, and commercial wealth are intertwined all through the city's history. Only political wealth is missing. Many powerful sovereigns wanted to control Timbuktu, and sometimes they did; but it never became the capital of anything. It was the outlying commercial emporium first of the Mali kings, governing from the southwest,

then the rulers of Songhai, governing from the east, then the sultans of Morocco, governing from the north, across the sand seas. In between it was governed, mostly ineptly and fiercely, by various occupiers—the Bambara, now Mali's majority ethnic group; the nomadic Fulani, a cattle-herding people; and the Tuareg themselves. But it never ran its own affairs.

Political power still eludes it. After fifty years of independence, the Malian state has yet to build a highway from the capital, Bamako, to Timbuktu. Timbuktu is a northern town, a Tuareg town, a frontier town. No one in the capital cares. □

*This article was adapted from the forthcoming book by Marq de Villiers and Sheila Hirtle, *Timbuktu: The Sahara's Fabled City of Gold*, which is being published in August by Walker & Co. Copyright © 2007 by Walker & Co.*

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Old manuscript recalls Timbuktu's reputation as a center of learning and Islamic scholarship, which at its height, from the 1300s until about 1600, attracted scholars from across North Africa and the Middle East.

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How Now, Little Cow?

The vaquita, the world's smallest porpoise, lives only in the northern Gulf of California. It often drowns in fishing nets as bycatch, and just 200 individuals remain. Can the species survive?

By Robert L. Pitman and Lorenzo Rojas-Bracho



Vaquita mother and her calf, as portrayed by an artist, embody whatever hope remains for the survival of the species. The population of the diminutive porpoises continues to fall, in part because they are slow to mature and have a low birthrate. Those factors merely compound the effect of their high mortality from entanglement in fishing gear—the main cause of their alarming decline.



Vaquita!"

Two on-duty and three dozing off-duty observers spring to attention on the flying bridge of our research vessel under the suffocating heat of the Mexican sun. The shouting observer checks the readings on her binoculars, but she can barely check her excitement: "Twenty-two degrees left of the bow, about 1,200 meters away. Looks like a mother and calf swimming together!"

Momentary mayhem breaks out on the flying bridge as members of the survey team tussle for binoculars and jockey for position. Everyone wants to see the world's most endangered marine mammal.

We have been looking for vaquitas for more than a week with little success, here in the northern reaches of the Gulf of California, Mexico. The gulf, also called the Sea of Cortez, is the thousand-mile-long spear of ocean wedged between the mainland of northwestern Mexico and Baja California. There is no wind: the ocean's surface looks like stretched Saran Wrap. The air temperature climbed above 100 degrees Fahrenheit just after sunrise this morning and hasn't looked back. Onshore, all we can see is desert. Towering cardon cactuses stand like sentinels flexing their biceps; the rest of the vegetation is mainly scrubby afterthought, sparsely sprinkled over scorching sand. This is the last place on Earth you would expect to see a porpoise, and our survey team is well aware that the vaquita, the desert porpoise, may not be here for anyone to see much longer.

But the austerity surrounding the gulf belies the productivity just beneath its surface. Seasonal winds and a thirty-foot tidal range dredge up cool, nutrient-rich waters that support an enormously productive marine food chain.

The gulf is home to large populations of blue whales, fin whales, and sperm whales; throngs of common dolphins charge about in schools that number in the thousands; multitudes of breeding seabirds crowd together on cactus-studded islets. The stark contrast between the relatively barren terrestrial landscape and the lush marine seascape is a defining paradox evident everywhere in the gulf.

Tucked away in the northernmost extremity of that abundant ecosystem lives the entire world population of the vaquita—a cetacean, as are whales, dolphins, and the five other living species of porpoise. (Porpoises are distinguished from dolphins in having teeth that are flat, like chisels, instead of round, like pegs.) The vaquita was first recognized as a new species in 1958, on the basis of three skulls found on beaches in the northern gulf. But a quarter century passed before a live animal was scientifically documented, and only in 1985 were its external features first described by biologists.

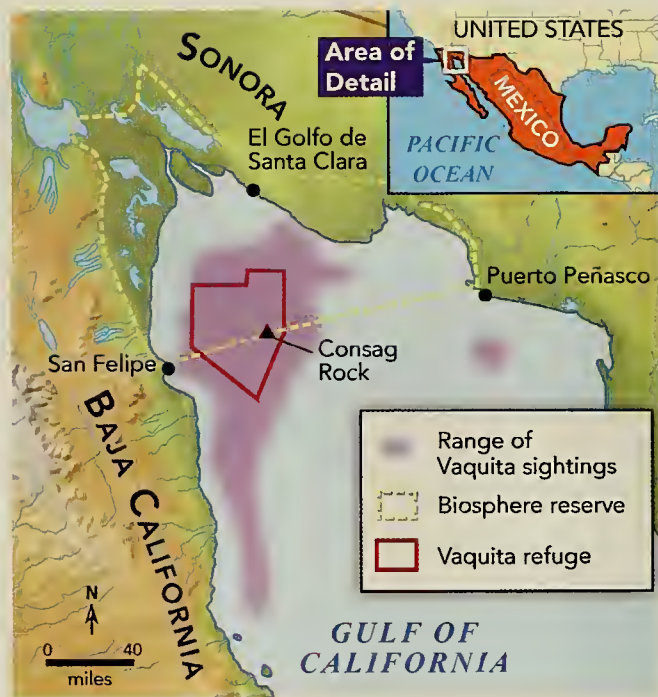
In addition to being the rarest of cetaceans, the vaquita is also the smallest. Its torpedo-shaped body measures less than five feet from snout to tail; calves are just twenty-eight inches long at birth, the size of a large loaf of bread. From a distance, the vaquita appears drab gray with a lighter belly, but at close range some intriguing details in the paint job emerge. A black stripe runs forward from each flipper to the middle of the lower lip, so the animal appears to be holding its own bridle. It has a black, circular patch around each eye. And its black lips set off a haunting little smile: Mona Lisa with black lipstick.

But the vaquita has no reason to smile. The world population of vaquitas is probably about 200 individuals—you can see more people

in a Wal-Mart on a busy weekend. And though Wal-Martians are definitely in no danger of extinction, the vaquita is losing market share. Gill nets—nearly invisible fishing nets set in the water like curtains and often left unattended—are the single greatest cause of vaquita mortality each year. Vaquitas become entangled and drown when they swim into the nets by accident; or they might be lured there by fish that are already

stuck. Vaquitas aren't the intended targets of any fishery; they're merely the bycatch of local fishermen trying to earn a living—collateral damage.

With the vaquita's population in steady decline, its distribution in the northern gulf has also contracted, so that its range is now the smallest of any marine mammal. Nearly the entire population lives in a region less than forty miles across. To put that into perspective, while on surveys throughout the gulf, we have seen a few dozen vaquitas over the years. But never have we seen one without being able to look up and see Consag Rock, a 300-foot-tall, guano-covered spire in the middle of the northern gulf.



Even the vaquita's scientific name, *Phocoena sinus*, acknowledges its claustrophobic range. *Phocoena* is derived from both the Greek and Latin words for "porpoise"; *sinus* is Latin for "bay" or "pocket," and refers to the animal's restricted home waters. (The common name, *vaquita*, means "little cow" in Spanish—a rather fitting name now that biologists know that all cetaceans are the product of a successful re-invasion of the ocean by terrestrial ungulates.)

At a recent forum convened in San Diego to address the fate of the vanishing vaquita, the organizers displayed a gallery of nearly every known photograph of the species. Most showed a dead animal swaddled in gill net in the bottom of a fishing boat, that innocent smile frozen on its face in death as in life. There were only a couple of photographs of live animals, and they were no more than blurred images of a head or a dorsal fin hastily rolling out of sight in the distance. We were struck that a large mammal living in our time could be driven off the planet forever, and leave behind such a scant record that it was ever here.



Snapshots of dead animals, such as this young vaquita brought to shore after drowning in a fishing net, comprise almost the entire photographic record of the species. Few living vaquitas have been captured with a camera.

The best estimate of the world's vaquita population to date comes from a 1997 shipboard survey of the vaquita's known range, which was conducted by the U.S. National Marine Fisheries Service in collaboration with Mexican investigators. From the survey data, Armando Jaramillo-Legorreta, a Ph.D. candidate in oceanography at the Autonomous University of Baja California in Ensenada, and several of his colleagues estimated the vaquita population at 567 individuals.

To determine whether the population is growing, declining, or holding steady, one must know, among other things, its mortality from both natural and human causes. The latter is essentially the number of animals that die in nets every year, and that critical piece of information was supplied by Caterina D'Agrosa, now a postdoctoral fellow at Arizona State University in Tempe. Between January 1993 and January 1995, as part of her master's thesis, D'Agrosa had interviewed fishermen and

placed observers aboard fishing boats, primarily in El Golfo de Santa Clara, one of the three main fishing communities in the northern gulf. Extrapolating from her sample, she estimated that seventy-eight vaquitas were being killed annually, an overall population decline of about 10 percent per year. At that rate, a population of 567 individuals in 1997 would have plummeted to about 200 by now.

Beyond those population estimates, and despite numerous surveys to observe vaquitas in the wild, little is known about their biology or life history. Because the animal is shy as well as rare, it has not readily disclosed its secrets. But what little is known does not bode well for its future. The normal lifespan is probably twenty years or more. It reaches sexual maturity between three and six years of age, and females apparently give birth to a single calf every other year. It typically travels alone or in mother-and-calf pairs. A recent study determined that the species has little or no genetic diversity; it may have passed through a population bottleneck at some time in its past, or evolved from a small founder population. The combination of low numbers, late maturity, low birth rate, and low genetic diversity makes the vaquita vulnerable to extinction, even without such strong pressure from people.

In 1993, as a result of public and scientific outcry about its fate, the Mexican government created the Upper Gulf of California and Colorado River Delta Biosphere Reserve [see map on opposite page]. Within the reserve, gill nets are prohibited. At the time, the reserve was thought to include most of the vaquita's marine habitat, but after two shipboard surveys, in 1993 and 1997, it became clear that as much as half of the population was actually living south of the reserve boundary. Consequently, in December 2005 the Mexican government designated a vaquita refuge, which overlaps part of the biosphere reserve and includes an area where some 80 percent of recent vaquita sightings have been made.

In spite of the good intentions reflected by the creation of those protected areas, harmful fishing practices have continued virtually unchecked. A 2006 review concluded that there has been little or no change either inside or outside the biosphere reserve since its creation. When we visited the vaquita refuge in March 2006, we found unattended gill nets set right in the middle of it. One of us (Rojas-Bracho) recently launched a series of aerial surveys, which will provide a far better appraisal of fishing activity throughout the region than has so far been possible. But because the boundaries of the reserve and the refuge are not marked, and because there is little enforcement of the no-gill-netting rule, poor results

seem all but inevitable.

Fishermen, armed with nets, are the main reason for the vaquita's decline—just as they are for the mortality of marine mammals everywhere else in the world. Of the six porpoise species, for instance, the two that live in open oceans—and thus have the least exposure to gill nets—are faring much better than their shallow-water relatives. Populations of Dall's porpoise (*Phocoenoides dalli*) in the North Pacific and the spectacled porpoise (*Phocoena dioptrica*) in the Southern Ocean are in relatively good shape.

For the rest, the story is quite the contrary. On the Yangtze River in China, an endemic population of finless porpoise (*Neophocaena phocaenoides*), the world's only freshwater porpoise population, is in steep decline. The causes? Unmanaged fishing and rampant development on the river. The marine populations of finless porpoise are somewhat better off, depending on how much fishing is done in their home waters. The message is clear: if there's a net in the water, a porpoise will find it.

And then there's the baiji (*Lipotes vexillifer*), a dolphin that lived only in the Yangtze River. In the fall of 2006 one of us (Pitman) took part in a search for the last baiji. For the past twenty to thirty years the baiji had been recognized as the world's most critically endangered cetacean, because of its high rate of accidental drownings in fishing gear. In a six-week survey, the searchers failed to find a single individual—and in the end, were forced to conclude that the baiji, after more than 20 million years swimming in the Yangtze, was probably extinct.

There are troubling similarities between the



Consag Rock, in the northern Gulf of California, lies at the heart of the vaquita's range. In fact, the authors have never sighted a vaquita when they couldn't also see Consag Rock.

*For the vaquita the trend is clear, the threats are known,
and the answer is simple: the nets must come out of the water.*

baiji and the vaquita, the next cetacean in line for extinction. Historically, both species occupied small, insular ranges surrounded by fishing communities. They both faced the same threat to survival: nets. Both species, like all cetaceans, were slow to mature and had long intervals between births, so even if the threats to their survival had been removed, their reduced populations would have recovered very slowly. Both had been at risk of extinction for some time. "Protective measures" were put in place for both: reserves were created and laws were crafted that made harmful fishing practices illegal in protected areas. But the reserves existed largely in name only, and enforcement was unsuccessful.

All that remains of the baiji are lessons. Extinction is real. Unmanaged fishing practices have the potential not just to reduce populations of aquatic mammals, but to catch and kill every last member of a species. And extinction can happen quickly, right before our eyes. A scientific paper published a few months before the Yangtze River survey concluded that the baiji would be extinct in twenty years if protective measures were not stepped up. But the last baiji had probably already died before that article was written.

Vaquita conservation, of course, raises thorny ethical and sociological issues. The people who live along the desert shores eke out a tenuous living by fishing in the same waters as the vaquita. They simply want to keep their families fed and improve their lot. The tragedy is that their poverty and their struggles will continue long after the last vaquita loses its own final struggle in a ball of monofilament net.

It is all too easy to imagine the end of the vaquita: An exasperated fisherman wrestles with an entangled carcass under the blazing Mexican sun. He finally extricates it from the net and dumps it unceremoniously over the side of his *panga*—his small, open fishing boat. As the last vaquita sinks out of sight, the last human being ever to see one goes back to pulling his net.

We need to take care of this fisherman if we want to take care of the vaquita.

As in the baiji's case, the future of the vaquita is no longer a scientific issue. The time for surveys is over. The trend is clear, the threats are known, and the answer is simple: the nets must come out of the water. A recent socioeconomic survey of the northern gulf suggested that for about \$25 million, all vaquita bycatch could be eliminated. The

money would be directed toward the 3,000 or so fishermen who make their living putting nets into those waters, either to buy out their fishing gear and help them get into another line of work, or to teach them sustainable fishing practices that don't threaten the vaquita. Economists from the U.S. and Mexico are now working to design such a program, but the money remains a stumbling block.

Maybe what the vaquita needs is a corporate sponsor. For the price of a couple of minutes of ad time during the Super Bowl, an underwriter could buy a future for the species. Corporate donations do not come free, of course—vaquitas might have to carry painted logos on their sides, like NASCAR race cars. Perhaps the species could be renamed, something like "The Home Depot 'You can do it, we can help' porpoise." Increasingly, people seem to be losing the ability to recognize the intrinsic value of Earth's wildlife; species will have to earn their way to justify their survival, a sad but honest appraisal of a world losing contact with its natural heritage and hewing only to market forces.

Just so, if this little porpoise goes extinct, many people will shrug off its passing as the disappearance of an obscure species from an out-of-the-way corner of the globe: "So what?" For others, however, the loss of any biological diversity on our planet is of grievous concern, particularly when what is lost is a relatively large, warm-blooded creature like the vaquita.

The vaquita has no value as a commodity: It is too shy and small ever to support an ecotourism venture. It is not a vital link in the marine food chain. There is no cure for any human disease lurking in its liver proteins. It is just a lowly beast trying to make its way, like the rest of us. Its loss would barely be noticed.

Yet it was part of the magnificent diversity of life on Earth that our generation inherited, and it is rapidly becoming part of the dwindling legacy we are leaving behind. We have a year or two now to decide whether we are going to let this species live, or whether, like the baiji, we vote it off the island and wipe that little black smile off the face of the Earth forever. □

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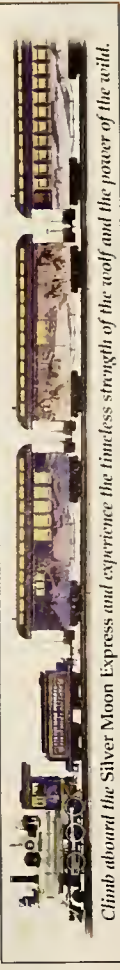
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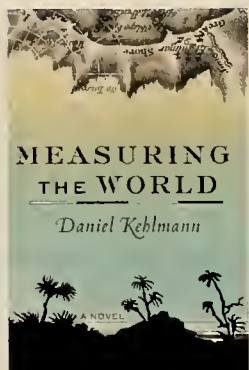
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And the Reading Is Easy

Summer has come around again (at least for readers north of the equator), and it's time to catch up on those books that have been piling up by the bedside. In anticipation of my vacation, I have relocated the accumulated pile to a spot near the patio door. As in past years, I've chosen titles that have characters, settings, or plots related to natural history or science. Enjoy!



Measuring the World by Daniel Kehlmann (Pantheon Books; \$23.00)

Daniel Kehlmann's droll confabulation, set in the age of Napoleon, features an unlikely pair of comic

heroes. Alexander von Humboldt, the very archetype of the intrepid explorer, has spent five years in the wildest parts of South America in the opening years of the nineteenth century, where he has climbed the Andes and canoed the Amazon.

Carl Friedrich Gauss, the pensive counterfoil to the Humboldt character's frenetic activism, has been a mathematical wunderkind. While staying close to his home in Prussia, Gauss has invented mathematical techniques that reveal the underlying unity of the cosmos. He has discovered how to predict the motions of asteroids and comets, and formalized the geometry of curved space that Einstein will borrow almost a century later to construct the general theory of relativity.

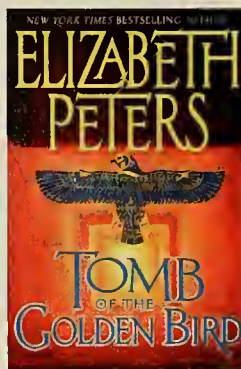
Kehlmann's protagonists meet at a scientific congress in 1828, each suffering a supposed midlife crisis, and in a series of interlocking flashbacks they replay scenes from the high points in their careers. Their stories are so familiar to historians of science that, stripped of the author's wry imaginings, the novel could almost serve as a straightfaced Wikipedia entry: Humboldt wrestles with electric eels along the Orinoco River, stupefied by the thrill of discovery—and by the

unforeseen amperage. Gauss astounds his schoolmaster by summing all the numbers from 1 to 100 in an eyeblink. But as with all good comedy, the humor is in the timing and phrasing. Re-animated by Kehlmann, Humboldt and Gauss sardonically observe life and the universe with two centuries' worth of hindsight. "So much civilization and so much horror," muses Humboldt, viewing the ruined pyramids of Mexico. "The exact opposite of everything that Germany stood for."

Tomb of the Golden Bird by Elizabeth Peters (Harper; paperback, \$9.99)

Egyptologist Amelia Peabody Emerson has appeared in nearly a score of books so far, and the body count keeps rising. Murder and mayhem, however, are not the main attractions of these mannered and chatty mysteries. Open to any page and you enter a vanished world, colonial Egypt of the early twentieth century, where wealthy amateur archaeologists putter around the ancient ruins along the Nile, looking for knowledge, fortune, and fame (not necessarily in that order)...while saving plenty of time for tea and gossip.

In this installment, Mrs. Emerson and her husband, Professor Radcliffe Emerson ("the greatest Egyptologist of this or any other century"), along with a large entourage, have just arrived for another season of digging in the Valley of the Kings. Soon



everyone is atwitter with news that Howard Carter, an archaeologist in the employ of Lord Carnarvon, has uncovered the steps of the tomb of the Pharaoh Tutankhamen. (Carter and Carnarvon, of course, like King Tut, are the names of real historical figures.)

The discovery attracts the usual bands of local grave robbers and envious rival scientists. But a greater mystery is: who is keeping the Emersons under surveillance? The appearance of Professor Emerson's brother Sethos, a sometime agent for British Intelligence, only adds to the sense of foreboding. What is the meaning of the coded message he has purloined?

Peters, who holds a Ph.D. in Egyptology from the University of Chicago, clearly is enchanted by the genteel life of bygone colonial days. What with frequent banquets, and so many family members, servants, and antagonists that you will find yourself flipping frequently to the four-page cast of characters at the front of the book, it's hard to keep track of who is chasing whom and why. Yet if the plot moves with the leisurely pace of the Nile, what's the hurry? Mrs. Emerson is appealingly engaging, the Professor appropriately eccentric, and the exotic setting sufficiently authentic to make one sad when it's time for the Emersons and their entourage to board the steamer back to England.

Mr. Thundermug by Cornelius Medvei (HarperCollins; \$14.95)

The idea of a talking animal is hardly a new one. Tale-spinners from Aesop to E.B. White have created memorable animal characters that endear and educate; serious satirists have often resorted to nonhuman commentators to cast the human condition into sharp relief. Mr. Thundermug, the eponymous baboon of Cornelius Medvei's smart novella, belongs in the latter category, I suppose, since his temperament is closer to Woody Woodpecker's than to Winnie the Pooh's. In spite of considerable facility with verbal expression, he can't help making himself an-



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


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BOOKSHELF: AT THE BEACH

noying to small-minded bureaucrats.

With his wife and two children, Mr. Thundermug has moved into a derelict apartment in a nameless city, where, as with so many immigrants, his very presence seems to irritate the authorities. The Housing Department wants him to register for assistance finding better lodgings, and frets that his illegal squat is infested with cockroaches (in fact, Mr. Thundermug and his family have already eaten them all). The City Council insists he send his children to public school (though, unlike their father, they can neither speak nor read). Eventually Mr. Thundermug is arrested on charges of indecent exposure, for walking around without clothes. He is also charged with cruelty to animals, since he is harboring a family of baboons in his apartment.

Cornelius Medvei's red-rumped hero is presented so matter-of-factly that it's tempting to think of his tale as a combination of magical realism and

shaggy-dog story. In structure, the short absurdist chapters resemble the *Ficciones* of Borges; and the juxtaposition of the mundane and the fantastic recalls passages from Gabriel García Márquez. But this is summer reading, and it would be unfair to ask too much of such a lightly drawn character. Eloquent as he is, Mr. Thundermug is as much buffoon as baboon, more like one of the befuddled eccentrics in James Thurber's "Fables for Our Time" than a symbol of the human condition.

ALSO WORTHY OF MENTION

Please, Mr. Einstein by Jean-Claude Carrière (Harcourt; \$22.00) and *A Madman Dreams of Turing Machines* by Janna Levin (Alfred A. Knopf; \$23.95)

Two books, the first by a writer, the second by a moonlighting astrophysicist, take us into the scientific mind. In Jean-Claude Carrière's book, as in the film *My Dinner with Andre*, the only action is an intense conversation. An anonymous twenty-first-century student meets Einstein in a nondescript office in Central Europe—and Einstein chats about the questions that concern him most: time, existence, the nature of space, and the meaning of life. It's all great fun, as long as you realize that the voice is that of the author as much as that of Einstein.

In contrast, Janna Levin strives for more historical verisimilitude, knitting together episodes from the troubled lives of the logician Kurt Gödel, who showed that there are true statements in mathematics and logic that can never be proved, and the mathematician Alan Turing, who pioneered the development of computing machines. Levin turns dry history into a literate and revealing examination of the power and the peril of creative genius.

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

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Mercury gradually emerges into view as a morning object in July. Beginning around the 14th, look for it with binoculars low in the east-northeast sky about thirty or forty minutes before sunrise. From the 15th through the 28th, the planet rises in the dawn's early light before 4:30 A.M. local daylight time. On the 20th Mercury reaches its greatest western elongation, or apparent angular separation from the Sun: twenty degrees. After that, it becomes easier to see: from magnitude +0.3 on the 20th, Mercury brightens threefold by August 1st.

You might still be able to catch the planet as late as August 4th, when it rises about an hour before the Sun. Thereafter, the twilight glow will likely hide it from view, as Mercury swings behind the Sun from our earthly perspective, arriving at superior conjunction on the 15th.

Venus, a prominent evening object since January, relinquishes the title of "evening star" by the beginning of August. Its departure is dramatic. On July 1st Venus is still well up in the west-northwest sky at sunset, closely accompanied by a much dimmer Saturn (the two planets are separated by just eight-tenths of a degree). On the 8th Venus attains its greatest brilliance in the evening sky, blazing at magnitude -4.5. But by then it is noticeably lower in the sky at sundown, and it sets just two hours later. By the end of July, Venus sets only forty-five minutes after sunset; you'll need a clear and unobstructed horizon to spot it.

A few days into August the planet is gone from the evening sky. It sweeps between Earth and the Sun (inferior conjunction) on the 18th; then, just a week later, it emerges as a morning object, rising about forty-five minutes before sunrise. By the end of August Venus rises around 5 A.M. local daylight time. Throughout much of July and again toward the end of August, Venus appears as a beautiful crescent in telescopes and even in steadily held 7× binoculars.

Mars continues to approach the Earth slowly during July and August, and so becomes increasingly obvious in the late night and early morning sky. On July 1st the planet rises with the constellation Aries, the ram, in the east-northeast before 2 A.M. local daylight time, shining like a yellow-hued "star" of magnitude +0.7. By August 1st Mars moves into the constellation Taurus, the bull, rising around 12:45 A.M. and shining about 20 percent more brightly, at magnitude +0.5. The planet passes above the V-shaped Hyades star cluster on the 19th. By the end of August Mars rises just before midnight and has brightened to magnitude +0.3. By dawn, Mars is high in the southeast.

Jupiter is almost due south as darkness falls at the start of July, and sets in the southwest as dawn breaks, about five hours later. By the beginning of August, Jupiter emerges from the twilight in the south-southwest at dusk and sets before 1:30 A.M. local daylight time. By the end of August it is even lower in the southwest after sunset and sets at around 11:30 P.M.

Saturn begins July hovering just above dazzling Venus and follows Venus's plunge into the sunset fires as the month progresses. But you'll probably lose sight of it before Venus sets, particularly in the last week of July, because at magnitude +0.6 it is only about a hundredth as bright as Venus. Saturn becomes lost in the glare of the Sun throughout August, arriving at solar conjunction on the 21st.

The **Moon** is at last quarter on July 7th at 12:54 P.M. It wanes to new on the 14th at 8:04 A.M. and waxes to first quarter on the 22nd at 2:29 A.M. The full Moon takes place on the 29th at 8:48 P.M. In August, the Moon wanes to last quarter on the 5th at 5:20 P.M. and to new on the 12th at 7:02 P.M. Our satellite waxes to first quarter on the 20th at 7:54 P.M. and to full on the 28th at 6:35 A.M.

A total eclipse of the Moon is visible throughout much of the region encompassing the Pacific Ocean basin on August 28th. Alaska and particularly Hawai'i are excellent viewing spots, because there the entire eclipse plays out in the middle of the night. In New Zealand and eastern Australia the eclipse gets under way right after moonrise, and there, too, the view is not interrupted by the Sun. On the west coasts of Canada and the United States the eclipse ends just before moonset, shortly after the Sun rises. In the eastern third of the U.S. and in east-central Canada the Moon sets during totality; this past March in that same region the Moon was rising during totality. The Moon enters the Earth's umbra at 4:51 A.M. EDT/1:51 A.M. Pacific daylight time (PDT). Totality begins at 5:52 A.M. EDT/2:52 A.M. PDT and lasts ninety-one minutes. The Moon leaves the umbra at 5:24 A.M. PDT.

Because the Moon is new and out of the picture, conditions are excellent this year for observing the maximum activity of the Perseid meteor shower. The shower is predicted to peak this year during the late night and early morning hours of August 12–13. The best time to watch that night is between 11 P.M. and 5 A.M.; with a dark, unobstructed view of the sky, you might see between fifty and a hundred meteors per hour. The paths of the Perseids, if extended backward across the sky, appear to diverge from a spot in the constellation Perseus: hence the name "Perseids." In the early evening hours you won't see many meteors because Perseus is low in the sky. But as Perseus rises, the numbers should gradually increase until morning twilight interferes. The Perseids usually remain above a quarter of their peak intensity for one or two mornings before and a day after the maximum. You might even see an occasional member of the shower earlier or later than that.

Unless otherwise noted, all times are eastern daylight time.

Continued from page 19

they come from someone genetically identical to you, have all the hallmarks of an intruder. And the greater the genetic differences between donor and recipient, the more rapid and violent the immune response. That is why the few attempts to transplant animal organs, such as hearts, into people have been disastrous: the human immune system attacks the organ, quickly killing the alien tissue.

The fetal sheep doesn't reject the human stem cells, however, because the animal hasn't yet developed an immune system of its own. By the time its immune system does develop, it treats the implanted human cells as belonging there, recognizing that they were there to begin with. In principle, then, stem cells from your own bone marrow could be harvested and injected into a fetal sheep. Once inside the sheep, your stem cells would grow and develop into the organ you needed. The new organ could then be transplanted into you. And because it would be genetically identical to your own tissue, your immune system should not reject it.

As a place to start, the liver is of particular interest, because it can regenerate its own tissue. So if you needed a liver transplant, you wouldn't have to grow an entire human liver inside a sheep; it would be enough to have a human chunk.

At least, that's the idea. But my bet is that the human-organs-from-sheep scenario will never make it to the clinic. For one thing, there are questions of safety. New infectious diseases regularly jump into people from animals. HIV came from chimpanzees; SARS, from bats or civets. A transplant is an intimate contact, and animal cells may harbor viruses that, though harmless to their animal hosts, could be dangerous to people. Before transplants from animal tissues could go ahead, that risk would have to be assessed.

Continued on page 42

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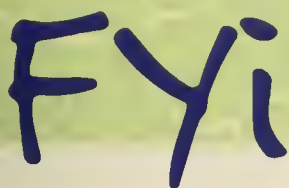
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LIFE ZONE

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In any case, I think tissue engineers will be able to grow human organs in vats long before surgeons are ready to collect them from sheep. Tissue engineering, which involves coaxing stem cells to become various kinds of tissue, is advancing fast. Already, biologists at the University of Newcastle, in England, have grown a small cube of human liver tissue from stem cells collected from an umbilical cord; another group of investigators has just grown a heart valve. And in the United States, several people have received transplants of new bladders, grown from small pieces of their old ones.

But even if no organ is ever transplanted to a person from a sheep, the sheep that carry the human cells are fascinating in themselves. There are two reasons why.

First, despite the fact that people and sheep are not particularly closely related, the human cells do what they are told to do by the signals they receive from the surrounding sheep cells. They become liver cells, or muscle cells, and so on. That is remarkable: it shows that the signals have remained more or less unchanged since the ancestors of humans and sheep began evolving along their separate paths more than 75 million years ago. It leads one to ask, How far apart do organisms have to be on the evolutionary tree of life before cells from one species cannot respond to signals from cells of another species? Bets, anyone?

It turns out that cell transplants can also work between mice and chickens. Here, astoundingly, the animals in question have been diverging for more than 300 million years. Experimentally implanting the mouse cells

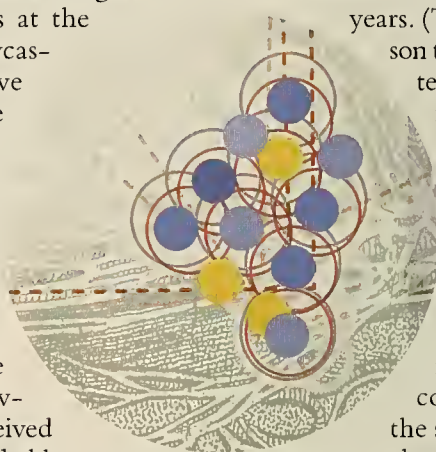
that are in charge of tooth development into crucial positions in early chicken embryos has led to chickens with teeth. The mouse cells send out signals that say, "Become teeth! Become teeth!"—and the chicken cells respond, even though birds haven't

had teeth for about 80 million years. (The most likely reason the genes for making teeth have remained intact and functional in birds is that the genes are useful in some other way.) And here's my second source of amazement at these chimeric, or genetically composite, beings. As the surgeon told me, as much as 15 percent of the

cells throughout the bodies of the sheep are human cells, not sheep cells. Yet the animals have no evident human characteristics. That makes me wonder how high a percentage of human cells a sheep could have and still be a sheep. Would you still have a sheep if half its cells were human? When would the system start to break down?

We've pretty much gotten used to the idea that the differences between species, or even individuals, can be comfortably defined in terms of DNA. But as developmental biologists learn how embryonic cells are transformed and guided, it is becoming increasingly apparent that an important part of what makes sheep sheep—and humans human—is how their bodies are laid out in early life. Will it prove possible, using mostly human cells, to build what to all appearances is a sheep . . . or vice versa?

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).



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New Jewel in Our Crown

One can only imagine the state of mind of the antimony miners in the Jiangxi Province of southeastern China as they carefully unearthed the spectacular stibnite now on view in the Museum's Grand Gallery, sparing it from destruction. The specimen's dramatic structure and brilliance, even against the bright white walls of the recently renovated first-floor Grand Gallery, cannot be overstated. As one youngster, training his camera on it, said, "I don't think I need the flash for this one!"

This rare and beautiful specimen is the largest on public display anywhere, unusual both for its size and for having so many freestanding crystals intact. Weighing one thousand pounds with hundreds of sword-like, metallic blue-gray crystals sprouting from a rocky base, it is sure to be as popular a

draw as the Star of India, the world's largest and most famous star sapphire, and the Patricia Emerald, one of the few large, gem-quality emeralds preserved uncut, both of which are housed in the Museum's Morgan Memorial Hall of Gems.

Stibnite (Sb_2S_3) is a compound of the elements antimony and sulfur, and this specimen is believed to have formed some 130 million years ago when water heated by volcanic activity dissolved those elements from surrounding rocks and then flowed between layers of limestone. It was donated to the Museum by mineral collector Marc Weill, founder and CEO of City Light Capital.

Stibnite today is mined for the antimony, which is used in matches, semiconductors, flame retardants, engine bearings, pottery enamel, and even some medications.



A close-up of the stunning stibnite specimen on display in the Grand Gallery

One Step Beyond

This is definitely not your parents'—or even your grandparents'—*American Bandstand*! One Step Beyond is a spectacular new multimedia program, teeming with live performances and world-class DJs and VJs spinning the latest music and projecting dynamic visuals while thousands of young professionals enjoy dancing and cocktails under the stars (and planets) in the Rose Center for Earth and Space. Held on select Fridays over the coming months, including July 27, September 14, October 19, and November 30, these out-of-this-world evenings are organized by the Museum in conjunction with *Flavorpill*, the cultural events email magazine.



See and be seen at One Step Beyond, the Museum's new monthly party in the Rose Center.

PEOPLE AT THE AMNH

Beverly Heimberg
Assistant Director
Volunteer Services Department



Beverly Heimberg oversees the more than 1,000 volunteers who contribute some 120,000 hours of invaluable service to the Museum every year, entering data, doing library searches for curators, staffing information desks, serving as tour guides and exhibition explainers, and more.

"We work with every department here," says Beverly, who selects the volunteers from "hundreds and hundreds of applications" that pour in, trains them, places them, and then makes sure they, as well as their supervisors, are happy. "These volunteers are extremely dedicated," she says, noting that in the case of tour guides and explainers, two of the most-sought-after positions, 30 hours of on-site training is required, followed by exacting tests of the volunteer's knowledge of the exhibition halls.

Volunteers range in age from high school students to retirees; there's even a 100-year-old volunteer emeritus, who assisted in the library for 30 years. Beverly herself was once a volunteer, then a paid assistant in the Department of Invertebrates, putting her bachelor's in biology to work in the field in Antarctica, Panama, and Florida. In 1997, armed with an M.A. in Museum Studies, she moved into her current position. She says she's able to keep her hand in science when training volunteers for new exhibitions. "I still learn," she says with obvious delight, "which is why they all still like being here too."

FROG SPOTTING

WWW.AMNH.ORG

Frogs may be elusive in the wild, but that's part of why they've thrived for more than 200 million years. The return of the delightful exhibition *Frogs: A Chorus of Colors*, with more than 200 frogs of more than 20 species spending their summer in re-created habitats, attests to the continuing popularity of these amazing amphibians. Now through September 9, the *Frogs* Web site, www.amnh.org/frogs, features the FrogCam, focused every day on as many as 9 different species and 75 living frogs in the popular centerpiece of the exhibition, the dart poison frog vivarium. Be sure to tune in each morning between 9:00 and 10:00 (Eastern Daylight Time) for mealtime!



Try to catch a glimpse of the blue dart poison frog at www.amnh.org/frogs.

Museum Events

AMERICAN MUSEUM OF NATURAL HISTORY 

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EXHIBITIONS

Mythic Creatures: Dragons, Unicorns, and Mermaids
Through January 6, 2008
Mythic Creatures traces the origins of legendary beings of land, sea, and air. Cultural artifacts bring to light surprising similarities—and differences—in the ways peoples around the world have depicted these beings, and fossil specimens suggest a physical basis for the many forms they have taken.

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



D. FINNIN/AMNH

This Tibetan piece in *Mythic Creatures* represents Garuda, a minor Hindu deity, fighting with the snakelike Naga.

Frogs: A Chorus of Colors
Through September 9, 2007
This delightful live-animal exhibition introduces visitors to the colorful and richly diverse world of frogs, exploring their biology, ecology, and conservation.

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

Gold

Through August 19, 2007
This glittering exhibition explores the captivating story of the world's most desired metal. Extraordinary geological specimens, cultural objects, and interactive exhibits explore and illuminate gold's timeless allure.

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

Undersea Oasis: Coral Reef Communities

Through January 13, 2008
Brilliant color photographs capture the dazzling invertebrate life that flourishes on coral reefs.

Beyond

Through April 6, 2008
Exquisite images from unmanned space probes take visitors on a journey through the alien and varied terrain of our planetary neighbors.

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

Exoplanets and the Search for Life

Two striking astronomical instruments demonstrate the need for extremely specialized tools in the search for planets around stars other than our own Sun.

This exhibit, part of the education and public outreach efforts of NASA's Navigator Program, was made possible through a grant from NASA's Michelson Science Center at the California Institute of Technology.



D. FINNIN/AMNH

Watercolor of a Canadian lynx, John James Audubon, 1842

Unknown Audubons: Mammals of North America

The stately Audubon Gallery showcases gorgeously detailed depictions of North American mammals by John James Audubon, best known for his bird paintings.

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



Golden mantella frog

LECTURE



LESLIE WAN STEIN

Yamada with Klingon killer worm and prehistoric horseshoe crab

Art/Sci Collision: Taxidermy Curiosities

Tuesday, 7/10, 7:00 p.m.
Artist Takeshi Yamada carries on the 19th-century tradition of "gaffs"—man-made objects passed off as real natural wonders or oddities, such as the chupacabra, fossilized fairies, and Fiji mermaids.

This program is made possible, in part, by the Allaire Family and Ruth A. Unterberg.

FIELD TRIP

Evening Bat Walk in Central Park
Friday, 7/20, 8:30 p.m.
Join the New York Bat Group for a bat walk through Central Park.



ROSE CENTER FOR EARTH AND SPACE

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

Friday, July 6
Friday, August 3

Visit www.amnh.org for lineup.

The 7:30 performance on August 3 will be broadcast live on WBCO Jazz 88.3 FM.

FAMILY AND CHILDREN'S PROGRAMS

NEW! Field Trip to the Moon
Every Wednesday, 10:30 a.m.
Guided by a live presenter,
this new program flies visitors
to the Moon in the Hayden
Planetarium.

AMNH ADVENTURES SUMMER CAMPS



Neanderthal skeleton in the
Spitzer Hall of Human Origins

Fossils and DNA

Monday–Friday, 7/23–27,
9:00 a.m.–4:00 p.m.
(For children entering
grades 4 or 5)

AMNH Sampler Camp
Monday and Tuesday,
7/2 and 3, 9:00 a.m.–1:00 p.m.
(For children entering grade 1)

Mythic Creatures

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children entering grades 4 or 5)
Monday–Friday, 7/23–27,
9:00 a.m.–4:00 p.m. (For
children entering grades 2 or 3)

Robotics

Monday–Friday, 7/9–13,
9:00 a.m.–4:00 p.m. (For
children entering grades 6 or 7)

Destination Space:

Astrophysics

Monday–Friday, 7/16–20,
9:00 a.m.–4:00 p.m. (For
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Monday–Friday, 7/30–8/3,
9:00 a.m.–4:00 p.m. (For
children entering grades 4 or 5)

Frogs

Monday–Friday, 7/16–20,
9:00 a.m.–4:00 p.m. (For

children entering grades 4 or 5)
Monday–Friday, 7/30–8/3,
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HAYDEN PLANETARIUM PROGRAMS

TUESDAYS IN THE DOME

Virtual Universe

Fly Me to the Moon
Tuesday, 7/3, 6:30–7:30 p.m.

The Dark Side

Tuesday, 8/7, 6:30–7:30 p.m.

Celestial Highlights

Sizzling Summer Skies

Tuesday, 7/31, 6:30–7:30 p.m.

Welcome Autumn

Tuesday, 8/28, 6:30–7:30 p.m.

HAYDEN PLANETARIUM SHOWS

Cosmic Collisions

Journey into deep space
to explore the hypersonic
impacts that drive the
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Cosmic Collisions was developed in
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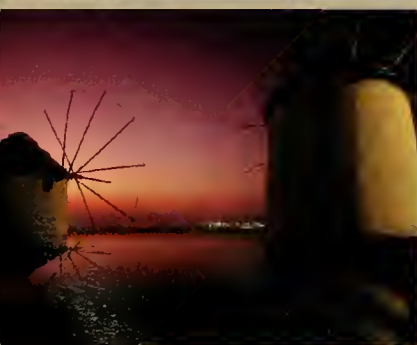
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