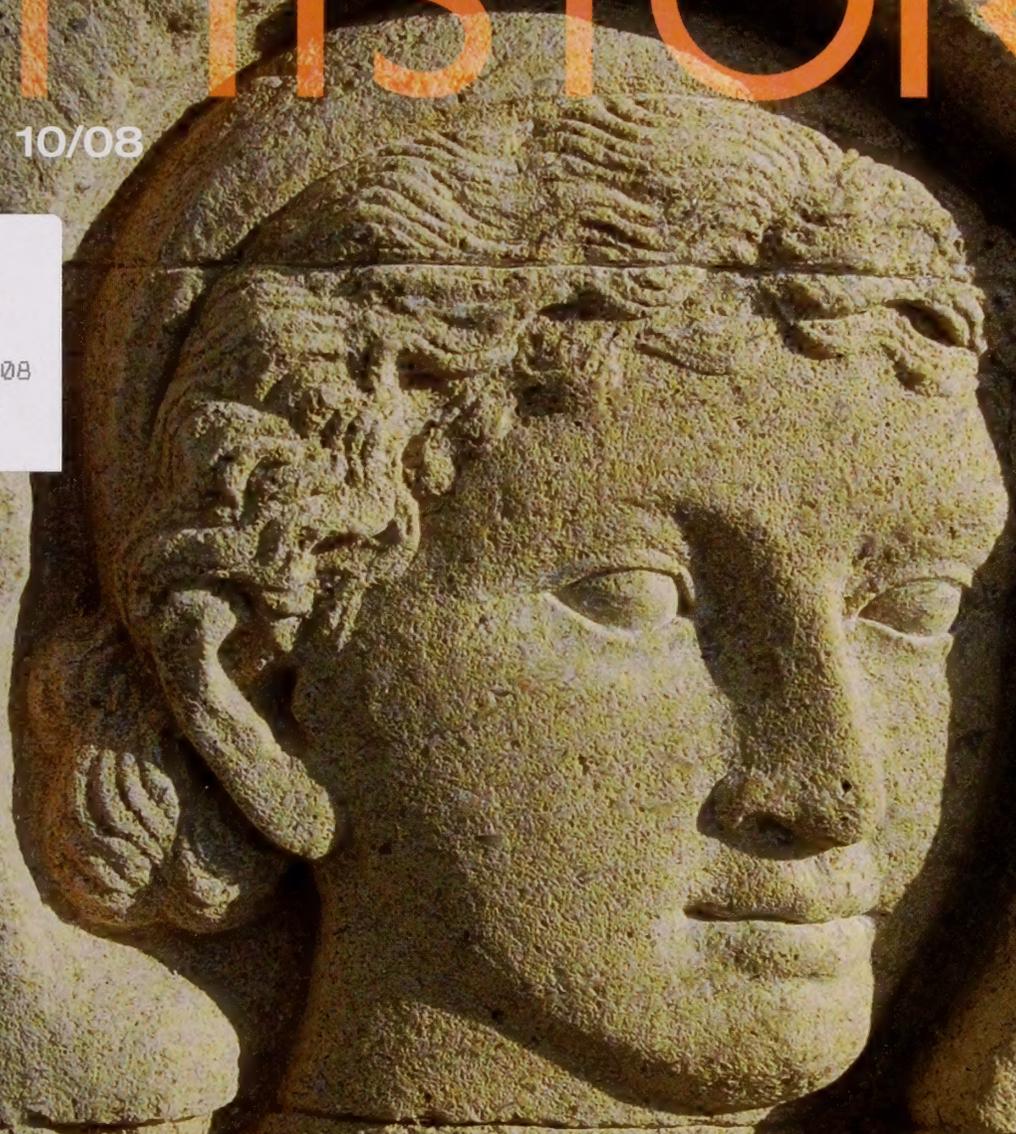


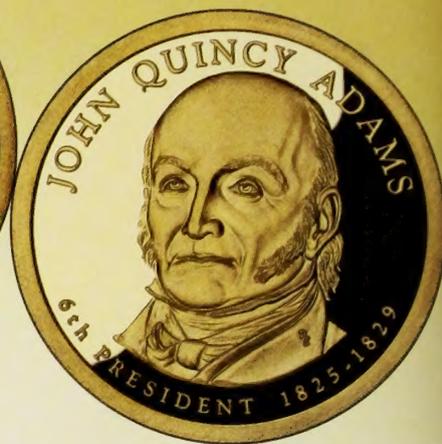
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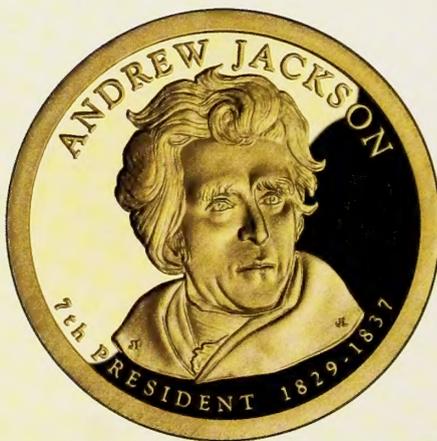
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OCTOBER 2008 VOLUME 117 NUMBER 8

## FEATURES

### 36 SHADES OF GLORY

*My whirlwind tour to the North Pole and back for 175 seconds of totality*

BY JOE RAO

#### COVER STORY

### 42 I, CLEOPATRA

*Egypt's legendary queen looks back on her tumultuous life.*

BY JOYCE TYLDESLEY

### 48 LUCKY DOGS

*By sniffing out scat, single-minded dogs trump traditional tracking methods.*

BY SAMUEL K. WASSER



#### 2 THE NATURAL MOMENT

Finger Lichen Good  
*Photograph by Patricia J. Hinds*

#### 6 nature.net

The Fungus Kingdom  
*Robert Anderson*

#### 6 WORD EXCHANGE

#### 12 SAMPLINGS

News from Nature



ON THE COVER: Cleopatra (69–30 B.C.) envisioned in a limestone carving by Balinese craftsman and artist Ongky Wijana.



#### 56 BOOKSHELF

*Laurence A. Marschall*

#### 63 SKYLOG

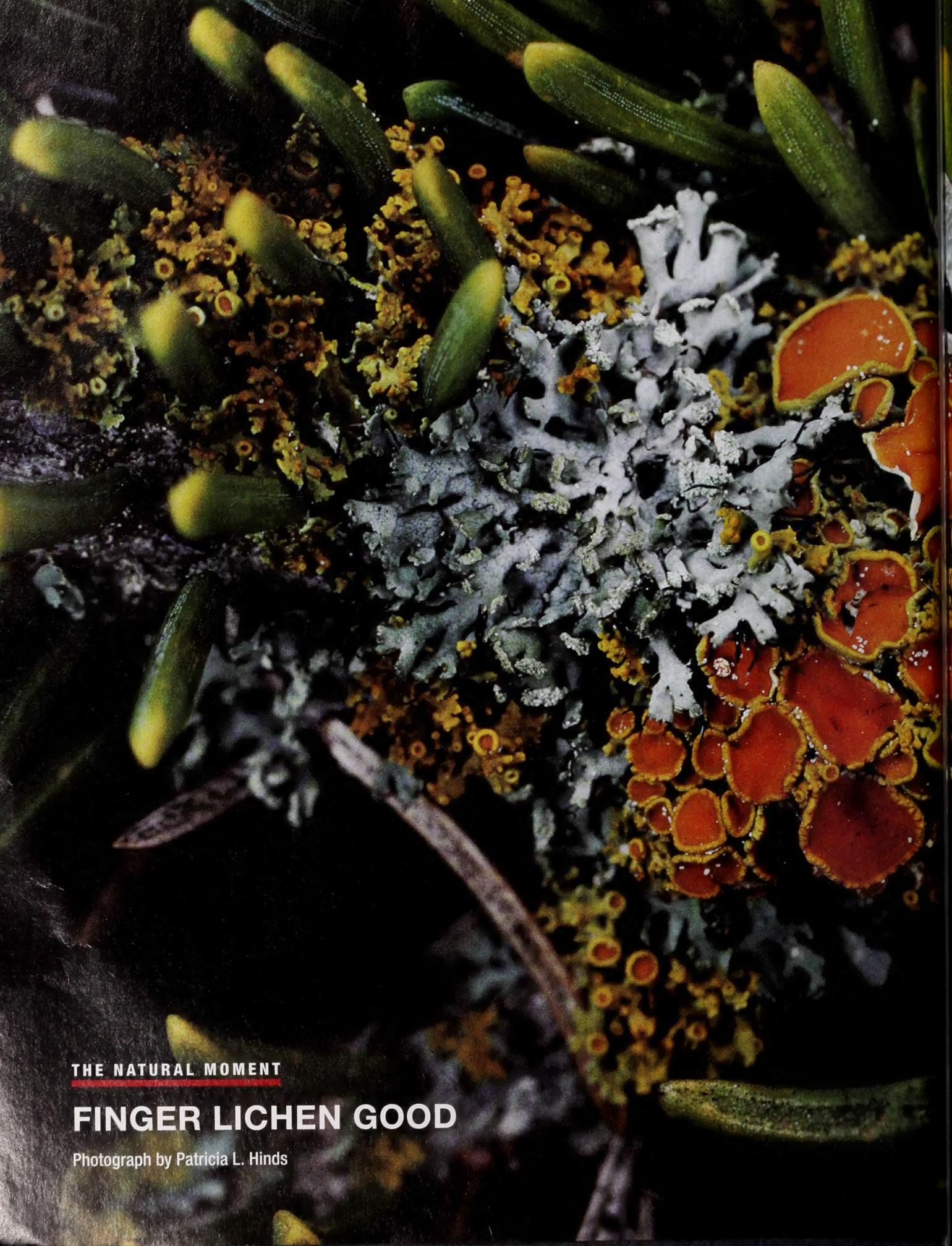
*Joe Rao*

#### 68 AT THE MUSEUM

#### 72 ENDPAPER

Time Portal  
*David A. Burney and Lida Pigott Burney*





**THE NATURAL MOMENT**

# FINGER LICHEN GOOD

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## THE NATURAL EXPLANATION BY ERIN ESPELIE

If you've been on a hike in New England in the last thirty-five years and have noticed a couple "hiking" on their hands and knees, you may have spied photographer Patricia Hinds and her husband James. "Crawling," explains James, "is a much better way to see soil lichens than walking."

Down on the ground is just one place to prospect for lichens. Those symbiotic organisms—fungi of algae—can pioneer a plethora of habitats, from deserts to old cars. They can even tolerate outer space, as shuttle experiments in 2005 proved. The Hinds were on their feet when they found the lichens pictured on the previous two pages. Thriving on a spruce branch above a rocky shore of Schoodic Point, Maine, were pin-cushion sunburst (orange), fringed coastal rosette (gray with black "hair"), and salted shield (gray with white marks). Those three lichens join 458 of their New England kin in a comprehensive new book coauthored by the Hinds.

Some people consider lichens to be a nuisance, unsightly and destructive. Witness the scrubbing given to Mount Rushmore a few years ago—an attempt to halt the supposed weathering effects of lichen. But when lichens were scraped off Cambodia's Angkor Wat twenty years ago, one lesson



Lichens, clockwise from top left: wall lichen, red-fruited pixie-cups, lungwort, pink earth

learned (too late) was that, at least to some extent, the lichens had protected the temple's stone carvings from heat and water damage.

In any case, lichens do provide clear benefits from a human point of view—antibiotic synthesis and dye making, to name just two. Caribou and reindeer depend on lichens for food, and many birds use lichens to build their nests. Recently, a land snail in the Canary Islands was discovered to camouflage itself by gluing thick coats of lichen on its shell.

As hardy and widespread as they are, though, lichens cannot tolerate one thing: air pollution. That might begin to explain why the Hinds deem 257 of the lichen species they have documented to be rare or in decline in New England. So add air-quality alarm as another reason why you might want to think twice before chipping those lichens off your garden gnome.



**Patricia L. Hinds** took all but three of the 400-plus photographs in *The Macrolichens of New England* (The New York Botanical Garden Press, 2007). **James W. Hinds** researched and wrote the book's text, having followed his wife's lead in the study of lichens. Earlier in their careers they were researchers in neuroanatomy. The couple have lived in Orono, Maine, since 1983.

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nature.net by robert anderson

## THE FUNGUS KINGDOM



**LIVING IN DRY** southern California, I rarely notice fungi, unless they are mushrooms on my plate or something mysterious growing in the fridge. But they are everywhere, breaking down what the other kingdoms of life create. In the far wetter Pacific Northwest, and those who study them really flourish. Recently I watched an online TED (Technology, Entertainment, Design) lecture by Paul Stamets, a mycologist who lives in Olympia, Washington, entitled "Six Ways Mushrooms Can Save the World" ([www.ted.com/index.php/talks/paul\\_stamets\\_on\\_6\\_ways\\_mushrooms\\_can\\_save\\_the\\_world.html](http://www.ted.com/index.php/talks/paul_stamets_on_6_ways_mushrooms_can_save_the_world.html)). Most impressive was his demonstration that oyster mushrooms could in a matter of weeks transform a toxic mound of oil-contaminated dirt into healthy soil. For my guide to this Web site and others exploring the hidden lives and talents of fungi, please visit the magazine online ([www.naturalhistorymag.com](http://www.naturalhistorymag.com)).

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

## WORD EXCHANGE



### Startle Reaction

I thoroughly enjoyed "Birds of a Different Feather" by Eben Goodale, Amila Salgado, and Sarath W. Kotagama [7-8/08]. Florida is a bit far from Sri Lanka, but my Tampa neighborhood also has some mimics in its midst. Red-shouldered hawks frequently hunt the area in pairs: one screeches to startle prey, and the other swoops down on the startled squirrels and small birds. A local band of blue jays mimics the hawks' cries—often with great success—when squirrels refuse to yield the best position on

*Continued on page 60*

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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](mailto: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 © 2008 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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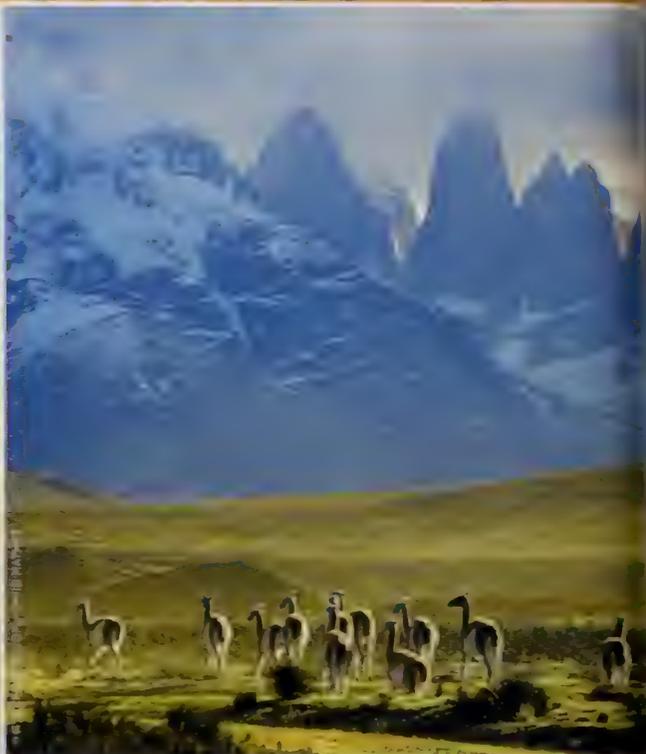
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## Pushy Pups, Passive "Parents"

Banded mongooses live in extended-family groups, with as many as ten females breeding at the same time. When they're about a month old, pups leave the communal den to forage with the adults. That's when a pup usually begins to associate exclusively with one particular adult—not necessarily a parent—that provides nourishment and protection. One might assume that the adult chooses the pup it wishes to assist.

Not so, says Jason S. Gilchrist of Napier University in Edinburgh, Scotland, who has long studied banded mongooses in Uganda. His latest research demonstrates that the pups do the picking, then establish and jealously defend a territorial zone of about a yard radius around their adult "escort." Other pups that venture too close are chased away.

In field experiments, Gilchrist separated pups from their escorts and held them captive for two days. During that time, the adults inter-

acted freely with other pups. When Gilchrist returned the detained pups to the group, however, they quickly reasserted exclusive rights to their escorts. The adults, it seems, are the passive partners in the relationship.



Banded mongoose pup sticks with its escort.

Generally, when pups reach three months of age, they no longer require their escorts' services and begin to fend for themselves. Gilchrist concludes that even in cooperatively breeding societies, "conflict can be as rife as cooperation." (*Proceedings of the Royal Society B*)

—Harvey Leifert



*Cerithidea decollata* snails cluster just above the tide line.

## Tide Travelers

Life is no beach for tidal creatures that must migrate in sync with the waterline. Imagine trying to gauge the tides that sweep through a Kenyan mangrove forest: how far the water rises up a given tree depends on the season, the phase of the moon, and the tree's position. Yet a pinkie-toe-size snail, *Cerithidea decollata*, seems to predict the height of the incoming tide. It ascends a trunk just high enough to escape inundation, then descends when it's safe to forage in the mud below.

To find out how, Marco Vannini of the University of Florence and colleagues observed the snails on plastic pipes—imitation mangrove trunks—that they stuck into the mud. The scientists tried obscuring any chemical markers left behind by the tide line or the snails themselves, and still, the snails climbed to the right height. Nor do the predictive gastropods seem to be using visual cues from overhead foliage. They aren't even counting the "steps" they must creep to beat the tide: when the scientists tilted the pipes, the snails readily climbed the extra length.

When lead weights were glued to the snails' shells, however, they adjusted their ascents; the heavier the weight, the shorter the climb. So it seems that the snails' are sensitive to their own energy output. Perhaps, Vannini suggests, they actually perceive the variations in gravity that drive the tides: before a low tide, the snails feel heavier and therefore don't climb very high. (*Animal Behaviour*) —Erin Espelie

Stone beads that may have symbolized health and fertility

## Green Bling

When agriculture arose about 11,000 years ago in the Middle East, fields weren't the only green things cropping up. People's accessories were growing greener too, according to a comprehensive study of stone beads—the bling of yestermillennia—unearthed at eight dig sites in Israel.

The sites are between 8,200 and 13,000 years old. Of the 221 beads found there, report Daniella E. Bar-Yosef Mayer of the University of Haifa and Naomi Porat of the Geological Survey of Israel in Jerusalem, 89 beads, or 40 percent, are made of green stone, including malachite, turquoise, and fluorapatite. The collections mark the first substantial appearance of stone beads, green ones in particular, anywhere in the archaeological record. In the hunter-gatherer societies that preceded the dawn of agriculture, beads—typically of antler, bone, tooth, ivory, or shell—were white, yellow, brown, red, or black, with only a few examples of green soapstone.

The minerals used to fashion the green beads discovered in Israel came from as far away as northern Syria and Saudi Arabia. Thus, people must have gone to great lengths to obtain stones of the latest color. Bar-Yosef Mayer and Porat propose that with the advent of agriculture, the color of young leaves came to symbolize fertility and good health. Green beads, they say, were probably used as fertility charms and amulets against the evil eye, just as they are today in many parts of the Middle East. (*PNAS*)

—Stéphan Reeb



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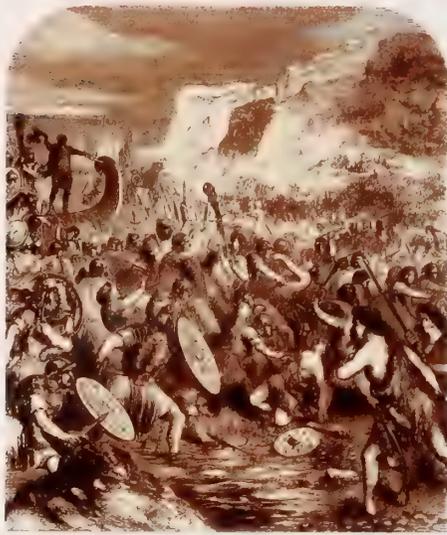
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## He Came, He Saw, He Sailed On



Caesar and his troops attack native Britons within sight of the white cliffs of Dover.

When Julius Caesar arrived off the coast of Britain with his hundred-ship force in August, 55 B.C., he was greeted by a host of defenders poised to hurl spears down on his invading army from the towering Dover cliffs. Seeking a better landing site, he sailed on a strong afternoon current and landed his troops at a beach seven miles away, according to his own account.

Caesar neglected to mention, however, whether he sailed southwest or northeast. The only shoreline within seven miles of Dover that matches Caesar's description lies to the

northeast, near present-day Deal. That would settle it, except that the current flowed southwest from Dover on the afternoons of August 26 and 27—four days before the full Moon, as Caesar obliquely reported the landing date. (It's unknown whether he counted the day of the full Moon itself.) For centuries, the paradox has provoked debate among historians and astronomers.

Enter forensic astronomer Donald W. Olson of Texas State University in San Marcos. With a colleague and two honors students, Olson traveled to Britain in August 2007, when astronomical conditions almost exactly duplicated those of 55 B.C. They confirmed that on August 26 and 27, the afternoon current ran southwestward. But on the 22nd and 23rd, it flowed strongly north-eastward, toward Deal. So that's where, and when, Caesar landed.

Could the great warrior have erred by four days? Probably not, says Olson, but his original manuscript is long vanished, and only copies of copies, made centuries later, survive. At some point, Caesar's handwritten VII or VIII—indicating August 22 or 23, seven or eight days before the full Moon—was likely mistranscribed as IIII. (Sky & Telescope) —H.L.

## Spun by the Sun

How does an asteroid pick up a satellite? Well, a big asteroid can capture a small passerby with its gravitational pull, but how a small one—less than six miles in diameter—gains any company has been a puzzle to astronomers. About 15 percent of the solar system's known small asteroids have satellites—they're "binary asteroids."

Kevin J. Walsh, now at the Observatory of the Côte d'Azur in Nice, France, and two colleagues conclude from a modeling study that the Sun powers the creation of most small binary asteroids, through the YORP effect (a previously described phenomenon named after the initials of its four discoverers). As irregularly shaped, so-called "rubble-pile" asteroids absorb and reradiate infrared solar energy, their rotation gradually speeds up or slows down—that's YORP, in a nutshell.

When YORP sufficiently accelerates a rubble-pile asteroid's rotation—a process that can take between tens of thousands and millions of years—rock moves from the poles toward the equator, from where it may launch into space. In some cases, the rock coalesces into a solid body orbiting the parent. Voilà! A little binary asteroid is born.

Walsh's team successfully tested its model against several of the solar system's small binaries, including a well-studied one named 1999 KW<sub>4</sub>, which has almost all the properties predicted by the model. (Nature) —H.L.

Animation stills show 1999 KW<sub>4</sub>—a binary asteroid.

## Immigrant Pathogen

Lyme disease entered American consciousness in 1975, when a cluster of cases turned up around Old Lyme, Connecticut. Thirty-plus years later, it's still on the rise in the United States. New research shows that the pathogen responsible for the ailment, which produces arthritis and neurological symptoms, originated overseas, millennia ago.

Lyme disease is caused by the spirochete bacteria *Borrelia burgdorferi*, which live in small and medium-size mammals and are transmitted to humans

via tick bites. Little known stateside is that it's the most common tick-borne disease in Europe, as it is in the U.S.; two other species of *Borrelia* are implicated there, though, along with *B. burgdorferi*.

To probe the U.S. pathogen's origins, Gabriele Margos of the University of Bath in England and sixteen colleagues compared DNA samples from *B. burgdorferi* collected across the U.S. and Europe. Contrary to earlier studies that located our *B. burgdorferi*'s origins in the New World, the research concluded that the pathogen originally came from Europe. The team studied eight "house-

keeping" genes, which are involved in cell maintenance and evolve slowly. As such, their variation is thought to yield more reliable insights than that of less conservative genes studied by others.

The team thinks the pathogen has resided quietly in North America for millions of years, only recently coming into sufficient contact with humans to warrant the medical community's attention. (PNAS) —S.R.

*Borrelia burgdorferi* bacteria viewed with fluorescence microscopy and magnified 400x

# What Is The *Real* Story behind Christianity's Formative Years?

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Illustration of Jesus

© Wood River Gallery

## About Your Professor

Dr. Bart D. Ehrman is the James A. Gray Professor and Chair of the Department of Religion at The University of North Carolina at Chapel Hill. The author or editor of 17 books, he has received many awards and prizes during his tenure at UNC including the Bowman and Gordon Gray Award for excellence in teaching.

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## SAMPLINGS

### Animal Party Line

A number of animals eavesdrop on warnings sounded by other species: if a predator is afoot, everyone wants to hear the news. Most prey species known to heed "second-language" alarm calls are social creatures with large vocal repertoires of their own—good indicators of intelligence.

But Günther's dik-diks don't fit that pattern. Mated pairs of the miniature antelopes live by themselves on multi-acre territories on the East African savanna, and they make only a few quiet little calls, including just one alarm: the breathy "zik-zik" behind their name. So when local lore that dik-diks heed the alarms of white-bellied go-away birds reached Amanda J. Lea, two fellow undergraduates at the University of California, Los Angeles, and their advisor, Daniel T. Blumstein, they pricked up their own ears.

Go-away birds announce incoming predators from their treetop perches for all to hear. When the researchers played recorded go-away-bird alarm calls, dik-diks usually assumed a vigilant stance or stopped foraging and headed for cover, whereas they all but ignored broadcasts of unalarming birdsong.

Dik-diks can't afford to miss out on a warning: more than twenty predators include dik-dik in their diets. Lea and Blumstein expect that interspecies eavesdropping is much more common than biologists now appreciate among vulnerable animals—regardless of how social, vocal, or intelligent they are. (*Behavioral Ecology*) —Rebecca Kessler



Günther's dik-dik

DANIEL BLUMSTEIN



White-bellied go-away bird

S. PETRA WILSON/PAUL WILSON



Fossil ichthyosaur

### Wet Suit

Predatory reptiles called ichthyosaurs cruised the oceans between 230 million and 90 million years ago. In a classic case of convergent evolution, their body and fin shapes resembled those of today's dolphins, tunas, and great white sharks—the fastest swimmers in the sea. A new study shows that the convergence even extended to the molecular composition of the animals' skin.

Soft tissues are seldom preserved, but a few rare ichthyosaur fossils still bear patches of skin that clearly display multiple layers of fiber bundles. Living dolphins, tunas, and sharks have similar strata, in which the fibers are made of collagen—a strong protein that, in layers, stiffens skin against flowing water. The ichthyosaur fibers were probably collagen, too, but proving it isn't easy: scientists usually identify fossilized

molecules chemically, a tricky, destructive procedure requiring large samples.

Fortunately, two biologists found a way around the problem. Knowing that collagen molecules pack themselves in bands separated by about three-millionths of an inch, Theagarten Lingham-Soliar and James Wesley-Smith of the University of KwaZulu-Natal in Durban, South Africa, examined a small sample of fossilized ichthyosaur skin with a scanning electron microscope. Sure enough, they found bands with just the right spacing.

The pair thinks electron microscopy could solve other questions about ancient soft tissue, such as the contentious nature of "proto-feathers" in some Chinese dinosaur fossils, which may turn out to be nothing more than degraded collagen fibers. (*Proceedings of the Royal Society B*) —S.R.



## THE WARMING EARTH

### Toot Spews Soot

Lovable Little Toot has come in for a scolding. An extensive survey of shipping lanes along the Gulf Coast of the United States concludes that tugboats emit far more soot than any other kind of vessel, and four times more than previously estimated. What's more, large cargo ships emit twice the soot attributed to them, with serious implications for global warming and air quality near major ports.

Daniel Lack and colleagues at the National Oceanic and Atmospheric Administration's Earth System Research Laboratory in Boulder, Colorado, measured sooty emissions from ninety-six vessels. Previous studies had observed only one or two ships. Lack lists several factors that make tugs the worst polluters: they burn low-grade fuel, their engines are inefficient because of frequent transitions between idle and full power, and many receive poor maintenance. Since tugs operate almost exclusively within ports, they substan-

tially degrade air quality in coastal cities.

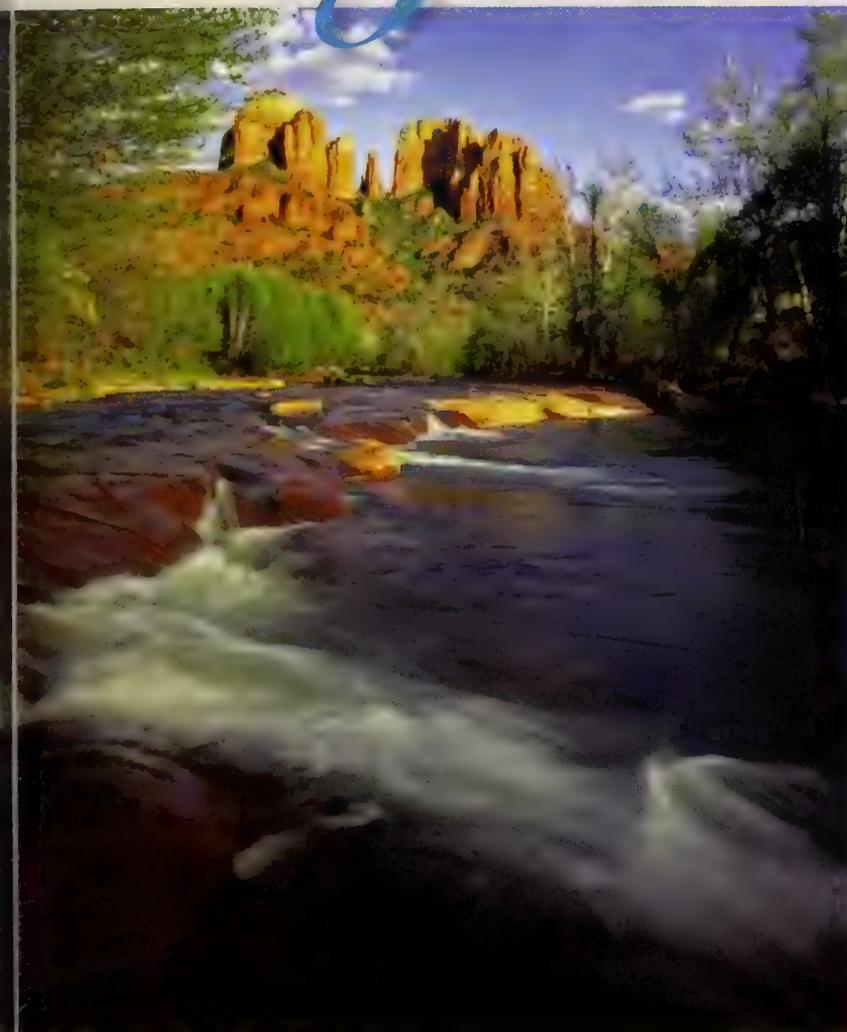
Ships now contribute less than 2 percent of all airborne soot—which warms the atmosphere—but global shipping is expected to increase by as much as 6 percent annually. That bodes ill for the climate, particularly in the Arctic. As rising temperatures shrink summer sea ice and open passage to shipping, additional settled soot will darken the remaining ice so it absorbs more solar radiation, thus accelerating the region's warming. (*Geophysical Research Letters*) —H.L.

Tugboat plies the Thames River in mid-twentieth century London.



© HULTON-DEUTSCH COLLECTION/CORBIS

# The Great GO Outdoors



Roads, trails and rivers beckon you to explore natural wonders, mysterious ruins, and well preserved history, from Montana's Big Sky Country and Arizona's Old West to the towns, wild retreats and shores of Maryland and Delaware and the ancient places of Peru and India.

Photo: Eduardo Cayo / PromPerú



Photo: Daniel Silva / PromPerú



Photo: Carlos Saiz / PromPerú

# Peru



Large image: the ciudadela, or large enclosure, at Machu Picchu. From left: exploring the Amazon at Tambopata National Reserve; Chan Chan, the largest Pre-Columbian archaeological site in South America; vibrant textiles crafted by the women of the Uros Islands, Lake Titicaca

**F**OR A TRIP TO PERU, YOU'LL NEED TO PACK your bags with plenty of room for adventure and prepare to encounter some of history's greatest legends and mysteries. You'll find portals there to some of the world's most astonishing natural and cultural wonders. Imagine exploring the lost world of the Incas in the Andean highlands and then venturing to a refuge deep in the Amazon jungle. Or walking the ancient cobbled streets of a colonial city, then traversing a fabled lake in the clouds.

Even Peru's place names evoke a sense of mystery and adventure. The glorious ruins of Machu Picchu, set high above the Urubamba River, seem to hold the clues to the secrets of the Inca empire. A center of worship as well as astronomic observation, Machu Picchu was the private retreat of the Inca ruler Pachacutec. Its perfectly fitted stones and layered terraces are still a marvel of engineering and craftsmanship. And you can get there the way the Incas did, hiking the Inca Trail. Or you can take in the breathtaking scenery by train, alighting at the entrance of the Machu Picchu Historical Sanctuary, also home to more than 300 bird species.

The city of Cusco, the ancient capital of the Inca, was already old when the Spanish conquistadors arrived there in 1533. The name of the city comes from the Inca word meaning "navel" or center, and Cusco makes an ideal center for exploring the lost Inca world as well as the beautiful colonial structures built over the ruins of the city's older civilizations. Cusco's Inca roots and colonial buildings landed it on UNESCO's World Cultural Heritage List more than two decades ago. Just yards from the main square is the Koricancha, the sacred Sun Temple built in honor of the sun god Inti.

**SOUTHEAST OF CUSCO IS LAKE TITICACA**, the world's highest navigable lake. The train ride to Puno, on the edge of the lake, traverses the Andes to an elevation of more than 14,000 feet. From Puno you can visit several islands in the lake, including the Floating Islands, actually enormous floating reed mats that support villages of reed huts. And for a completely different experience, you can travel northeast of Cusco to reach Manu National Park, which many travelers have found to be the most worthwhile jungle adventure in all of South America. The park is a World Natural Heritage Site and Biosphere Reserve of 445 acres of mostly virgin rain forest and native Indian villages lying within the largest protected tract (more than 8,500 square miles) of tropical rain forest in the world.

Adventurous souls may also want to try hiking, horseback riding or biking in the Cordillera Blanca, the highest tropical mountain chain in the world. Located in central Peru, the Cordillera are almost wholly contained within protected Huascarán National Park. There are opportunities for experienced and less experienced hikers alike to explore the scenery of snowcapped peaks, glaciers, lakes and rivers.

Visit [www.peru.info](http://www.peru.info) for more information.

# WHERE GODS BECOME MOUNTAINS

The Inca took giant blocks of stone and brought them to life, raising them high up to the heavens. There, he made his home with magnificent gardens and walls covered in gold.

At the Sun's Gate the clouds part to unveil a mystery that still today remains alive in the midst of one of the most majestic masterpieces created ever by man. This place exists. You can see it, feel it.

## PERU. LIVE THE LEGEND



Machu Picchu is located 130 km (80 Miles) from the city of Cusco. This city has all the amenities to make your visit comfortable, enjoyable and memorable. For information about hotels, restaurants and tourist transport, visit: [www.peru.info](http://www.peru.info)





Far left: viewing the **Amber Palace** near Jaipur by elephant; left: tigress spotted in **Bandhavgarh National Park**; below: Painted Stork, one of India's most colorful birds; a terraced highland tea plantation in **Darjeeling**

# India



**I**NDIA BECKONS TRAVELERS TO ADVENTURES IN a vast and timeless land, where culture, history and nature remain entwined in ways unlike anywhere else on earth. Almost everywhere you go, you're likely to discover something you've never seen before, or at least in such an unusual setting—whether it's the monkeys you spy capering alongside you on roads, trails and inside temples, the beautifully painted horns you'll notice on cows that wander serenely where they wish, or the ornate latticework on ancient storefronts. Or perhaps the tigers you spot from the back of an elephant in one of the country's remarkable wildlife refuges.

You can choose adventures that are as challenging, as exotic or as comfortable as you like, with accommodations that range from tent camps to former palaces of the Rajahs. Try camel trekking to the fairytale desert forts of Rajasthan, relaxing on the glorious beaches of Goa, trekking through the misty foothills of the Himalaya, exploring the hill stations of tea country, or rafting the roaring currents of the sacred Ganges as it flows down from the heights.

INDIA OFFERS SOME OF THE BEST BIRD and wildlife watching in the world in its many nature preserves. In the heart of Assam is Kaziranga, known as Asia's Serengeti, located on the south bank of the mighty Brahmaputra River where you can get a glimpse of what the wild lands of Asia were once like. From the safety of a perch atop your own elephant, you can spot tigers roaming through grasslands, and perhaps a one-horned rhinoceros lumbering near herds of wild Asian elephants splashing in the river.

Perhaps you'll be inspired to record your own impressions in Kanha National Park, considered the most game-rich region in India, where Rudyard Kipling wrote *The Jungle Book*. Or to be sure of a tiger sighting, travel to Bandhavgarh National Park, which is also home to leopards, sloth bears and various species of deer. You can't miss the ruins of the magnificent fort of the Maharaja of Rewa that overlook the park from a huge granite outcrop. And for passionate birders, there is the famed bird sanctuary of Bharatpur, home of such rarities as the Indian Spotted Eagle and the endangered Sociable Plover.



# TEA GREEN

Darjeeling is the champagne of teas, grown high in valleys where the world's smallest train does its rounds. Assam is known for its full-bodied flavour, as robust as the one-horned rhino that roams its plains. In Munnar, you could even get a taste of a planter's life in sprawling bungalows, British-era clubs with tennis, golf, bridge and, of course, high tea.

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## ARIZONA



Far left: wild burros—descendants of miner's burros—roam the streets of the former gold mining town of **Oatman**; center: the bustling restored mining town of **Bisbee**; far right: centuries-old Saguaro cacti stand vigil in the desert



**I**N ARIZONA, THE GREAT OPEN ROADS OF THE AMERICAN West vanish into a vast horizon, with glorious sunsets that defy any artist to duplicate. Those roads may lead you through a saguaro-dotted desert and forested mountains to breathtaking outlooks over seemingly bottomless canyons that have been inspiring travelers for centuries. Or they may beckon you off the beaten path to explore mining towns, mysterious ruins and ghost towns that speak of bygone eras.

No matter where in Arizona you go, you'll find charming small towns nearby, each with its own story, and each—without exception—set among spectacular landscapes. You can find plenty to do and great places to stay in old mining towns, like Bisbee and Jerome, that have preserved their heritage while carving out their own current cultural niche. First built on the hopes for riches of copper, silver, gold and turquoise, these towns have gotten new life with new generations of visitors who go there to travel back in time, tour the old mines, or to enjoy the arts and amenities that are springing up. Arizona's ghost towns have a lure of their own, especially when the ghosts mingle with legends and stories. The former gold mining town of Oatman, where Clark Gable and Carol Lombard honeymooned, is now home to 300 or so residents and a colony of wild burros (descendants of miners' burros) that roam the streets seeking handouts.

You'll find more stories and more mysteries in the ruins of vanished Native American settlements. There are a variety of notable sites, including Casa Malpais, near Springerville, and Besh-Ba-Gowah, near Globe, one of the most significant archaeological finds in the Southwest. Don't miss the Homolovi Ruins State Park in Winslow, which serves as a center of research. The Hopi people of today still consider Homolovi, as well as other pre-Columbian sites in the Southwest, to be part of their homeland. They continue to make pilgrimages to these sites, renewing the ties of the people with the land. The Hopi tell us that the broken pottery and stones are part of the trail that the Bahana, the visionary leader in their prophecies, will follow when he returns. You'll want to start planning your own pathway to explore Arizona's ghost towns, ruins and mystical landscapes.

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**ARIZONA**  
GRAND CANYON STATE

# Tucson



**Mission San Xavier del Bac** on the Tohono O'odham Reservation—acclaimed as the finest example of mission design in the U.S.—is often referred to as the "Sistine Chapel of the Southwest".



Located on the University of Arizona campus and open daily, **Arizona State Museum** houses and displays the world's largest collection of Southwest Indian pottery.

**T**UCSON, KNOWN AFFECTIONATELY BY ITS residents as the Old Pueblo, is surrounded by the rugged beauty of five mountain ranges and a desert forested with giant cacti. Southern Arizona's Old West mystique still abides in this vibrant city along with its Saguaros and the region's deep roots in Native American, Spanish and Mexican cultures. The blending of cultures has made the Old Pueblo an ideal gateway for exploring some of the most fabled places in the Southwest as well as some important new museums that capture a diverse and complex past.

In the Santa Cruz Valley on the Tohono O'odham Reservation lies the Mission San Xavier del Bac, the "White Dove of the Desert," built between 1783 and 1797 by the followers of Father Eusebio Francisco Kino, the legendary Jesuit missionary and explorer. Listed on the National Register of Historic Places, San Xavier is considered by many to be the finest example of Spanish colonial architecture in the United States. It does indeed stand out on the horizon like a graceful, glistening white dove, combining Moorish, Byzantine and late Mexican Renaissance elements. The Mission is still an active parish, open every day of the year, and its colorful original interior artwork remains as fresh and vivid as ever.

**STEP EVEN FURTHER** back in time to the earliest days of Tucson's Native American tribes with a tour of the Arizona State Museum, an affiliate of the Smithsonian. The museum houses the world's largest Southwest Indian pottery collection, along with archaeological artifacts and prints and photo negatives that highlight the histories of the ancient O'odham, Hohokam and Mogollon cultures.

To learn even more about the Tohono O'odham, visit the new Tohono O'odham Nation Cultural Center and Museum near the town of Sells, a 90-minute drive southwest of Tucson. Built within sight of Baboquivari Peak, the O'odham nation's sacred mountain, the museum is designed to help a new generation appreciate the culture and tradition of the O'odham people and their contributions to our country's history.

For a taste of Tucson's pioneer past, stop by the Arizona Historical Society, which houses the world's largest collection of Arizona's historical artifacts, photos and documents. The museum has conserved more than a half-million relics relating to Arizona's mining, ranching and urban histories, and also operates two other important historical museums in the Old Pueblo—the Fort Lowell Museum and the Sosa-Carrillo Fremont House.

Visit [www.visitTucson.org](http://www.visitTucson.org) for more information on Tucson's world-renowned museums and historic landmarks. Tread the timeline of Tucson's tri-culture blend!

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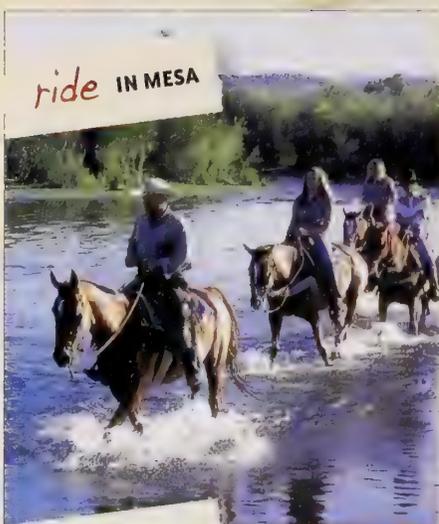


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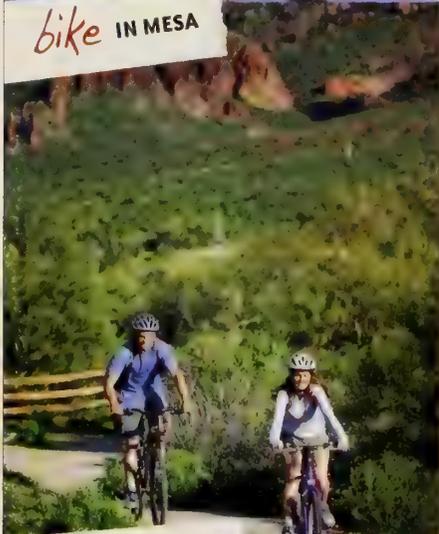
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# Mesa



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Photos: Mesa CVB

Above left: biking on a desert trail; above: Canyon Lake overlook; left: a visit to the Arizona Museum of Natural History

**M**ESA, LOCATED IN THE CENTER OF THE STATE, MAKES a great hub for day trips to explore Arizona's sweeping desert vistas, red rock monoliths, clear mountain lakes and whitewater river rapids. You can begin your journey in Mesa with a visit to the Arizona Museum of Natural History, which tells the history of the region from the creation of the earth to the present.

East of Mesa are the Superstition Mountains, the iconic backdrop of the city, and Tonto National Forest, which spans almost 3 million acres of rugged and beautiful Sonoran desert and mountains. You can take hiking and horse trails into ghostly Superstitions, which rise some 2,000 feet into the desert sky. You can also explore the scenic trails and paths of Arizona's rugged back country by taking off-road Jeep or Hummer desert tours.

Put on your explorer's or scientist's hat, and discover little known secrets about indigenous flora and fauna and how they thrive in the arid climate of this delicate desert eco-system. Early birds can catch a sunrise flight over the Sonoran desert via a hot-air balloon and capture a birdseye view of this timeless region.

Go a little further in your explorations to Park of the Canals, where you'll find evidence of Arizona's earliest canals, dug by hand by Hohokam Indians who lived in central Arizona until A.D. 1450. Discovered in 1878 by Mormon pioneers, the ruins at Park of the Canals are the only place accessible to the public where the size and scope of the canals can truly be appreciated. The park is also home to the Brinton Botanical Garden, with its variety of cacti and indigenous plants.

For more information go to [VisitMesa.com](http://VisitMesa.com).

# Yuma

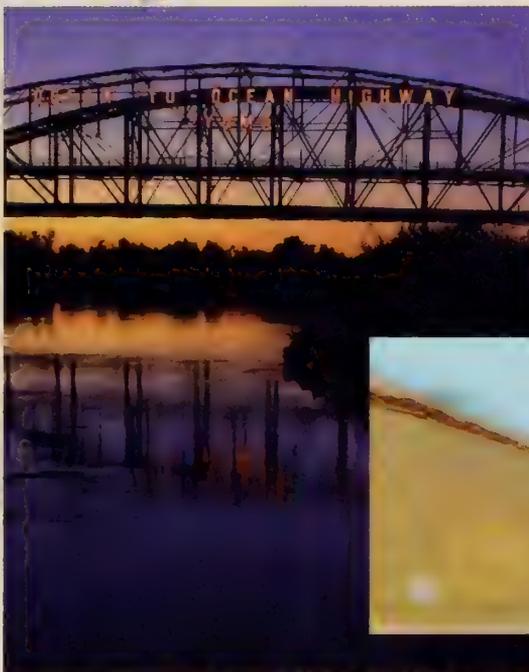
**A**DVENTURERS HAVE BEEN coming to Yuma's unique location in southwest Arizona, where the Colorado River meets the Sonoran Desert, ever since Spanish explorers arrived. Modern-day travelers are finding Yuma an ideal destination as well to enjoy its authentic history and explore thousands of acres of wilderness, desert dunes and wildlife refuges.

You might start your adventures right where those early explorers crossed the Colorado. Pivot Point at Gateway Park marks the riverfront site of the historic Yuma crossing and the first rail bridge, where the first train crossed from California into Arizona. Enjoy more history at the Yuma Territorial Prison State Historic Park, whose Old West prison was the bane of outlaws.

You can get a closer look at the river with narrated trips on a jet boat that include petroglyph sites. Take a cruise aboard a sternwheeler or rent a canoe to do your own exploring.

You might recognize some scenes from the Star Wars movies as you head west of town to the Imperial Sand dunes. Now popular with off-road enthusiasts and campers during the winter months, the exotic dunes also have served as a movie location since the days of Rudolph Valentino.

There are abundant opportunities for hiking, camping, and bird and wildlife watching in Imperial National Wildlife Refuge, Kofa National Wildlife Refuge, Cibola National Wildlife Refuge, or Picacho State Recreation Area (in California). Birders flock to the area in April for Yuma's annual birding festival. Yuma also offers a little taste of wilderness just steps from downtown. In the Yuma East Wetlands, about 500 acres have been restored as wildlife habitat with native trees, grasses and marsh plants.



Left: The 1915 **Ocean-to-Ocean Bridge** was the first highway crossing of the Colorado River. The historic structure was completely restored and reopened to vehicle traffic in 2002. Below: Yuma is the gateway to the **Imperial Sand Dunes**, which have attracted filmmakers since the silent-picture days and are now popular with off-roaders and campers.



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**C**USTER COUNTRY, IN SOUTHEASTERN Montana, is clean air, endless blue skies, and a beckoning progression of badlands, flatlands and highlands. The fabled badlands, capped by a strange and dramatic array of sandstone formations, provide a Wild West backdrop for photographers, nature lovers and those



who just want to breathe deeply and slip back through time. The vast prairies of the flatlands are shared by farmers, ranchers and their wild neighbors: antelope, deer and elk. Wildlife is plentiful, too, in Custer Country's highlands, which contain the Bull Mountains and the Pryors—home to about 120 wild mustangs.

The bright blue ribbon of



Below left: Makoshika State Park at Glendive; left: Tipis at Little Bighorn Battlefield National Monument

the Big Horn River and Big Horn Canyon Reservoir draw knowledgeable anglers from around the world to abundant trophy fish. Also winding through Custer Country is the Yellowstone River, one of the few places in the world where the prehistoric paddlefish can be found, and the Tongue River Reservoir, with its plentiful pike, trout, bass and pan fish.

Travel through Custer Country on Interstates 90 and 94, follow the Dinosaur Trail or take a take a scenic loop to explore some of the state's natural and cultural heritage, from a landmark saloon and a buffalo herd to the sandstone formation where Capt. Clark, of the Lewis & Clark Expedition, inscribed his name. Stop at a town along the way, enjoy the local sights and order a delicious steak. This is a place for recharging the spirit and filling your album of memories.

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# Delaware

JOIN IN DELAWARE'S AUTUMN HARVEST OF brilliant foliage and special activities to celebrate the season. The mild weather and vibrant fall colors offer a great getaway for nature lovers and leaf peepers. Scenic spots around the state treat travelers to colorful displays of sassafras, sycamores, sweet gums and their cousins.

Travel through the rolling hills of the Brandywine Valley, whose pastoral charms inspired artist Andrew Wyeth, and explore the legacy of the du Pont dynasty. Stop at the Hagley Museum and Library to savor the crisp autumn air and the setting of brilliantly hued leaves standing out among towering evergreens along the banks of the Brandywine River. Hagley, the site of the gunpowder works founded by E. I. du Pont in 1802, includes restored mills and the ancestral home and gardens of the du Pont family.

Head north across the Summit Bridge on Del. 896 in the evening for an unforgettable view of Iron Hill, about ten miles away, as the setting sun sets the foliage aglow.

For more ideas, visit [www.VisitDelaware.com](http://www.VisitDelaware.com) or call the Delaware Tourism Office toll-free at 1-800-284-7483.



The Birkenhead Mills, one of the most beautiful views along the Brandywine at Hagley Museum and Library

Further south, at Killens Pond State Park, autumn hayrides are available by reservation through mid-November. Corn mazes, straw bale and hay wagon rides throughout Delaware have become a great fall tradition for the whole family. Several farms have seasonal festivals, featuring haunted barns. Delaware's Apple-Scrapple Festival in Bridgeville and Frightland in Middletown are legendary fall events. And don't miss the Waterfowl Festival at Prime Hook Natural Wildlife Refuge in Milton.



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# Maryland

From seashore to mountains, from rolling farmland to historic cities, Maryland invites you to explore its great outdoors and beautifully preserved cultural heritage.



Photo: Nico Sarbanes

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*Captain John Smith  
1612*



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## DORCHESTER COUNTY The Heart of Chesapeake Country

**C**URVING OUT INTO THE Chesapeake from the Delmarva Peninsula, heart-shaped Dorchester County is known, appropriately, as the Heart of Chesapeake Country. With its pristine rivers, marshlands, working farms, fishing boats, and waterfront towns, this unique part of Maryland has retained much of the traditional way of life along the Chesapeake and has preserved much of the unspoiled Eastern Shore landscape associated with the history of this region.

The Blackwater National Wildlife Refuge, located south of historic downtown Cambridge, encompasses more than 250,000 acres of woodland, rich tidal marsh, freshwater ponds and managed cropland. Blackwater, home to a large year-round population of bald eagles, is also one of the chief wintering areas for migrating waterfowl making their way along the Atlantic Flyway. Osprey have been spotted here, and hummingbirds have been known to hover at the Butterfly Center near refuge headquarters. Adjacent to Blackwater

is the Fishing Bay Wildlife Management Area, the largest parcel of publicly owned tidal wetlands in the state. With its miles of meandering creeks, marsh grass habitats, secluded ponds and islands of loblolly pine, Fishing Bay has become known as Maryland's Everglades.

Among the county's historical attractions is the Harriet Tubman Museum and Education Center, part of the Underground Railroad Trail, a Maryland Scenic Byway.



Right: **Cunningham Falls State Park** is known for its history and scenic beauty, as well as its 78-foot cascading waterfall; far right: Lobster pots in **Rock Hall Harbor**



## KENT COUNTY

**K**ENT COUNTY'S SCENIC ROADWAYS AND waterways invite bicyclists and kayakers as well as drivers and boaters to explore its pastoral countryside, historic towns and important wildlife refuges. Many of the two-lane roads that wind through this tidewater county along the upper eastern neck of the Chesapeake Bay have been included in Maryland's first National Scenic Byway. Kent County's portion of the byway includes the routes from the Chester River Bridge to Georgetown and the Sassafras River, from Chestertown to Rock Hall, and from Rock Hall to the Eastern Neck National Wildlife Refuge. Stop in Chestertown to stroll and shop its historic downtown, just named a Maryland Main Street. The town's annual Heritage House Tour is October 4th.

## FREDERICK COUNTY

**F**REDERICK COUNTY, THE GATEWAY TO western Maryland, invites you to historic battlegrounds, scenic rivers and mountains, and fabled trails. At the heart of the county are the "clustered spires" of historic Frederick. To the west are the Blue Ridge Mountains and the Appalachian Trail; to the north lie the Catoctin Mountains; and to the southwest are roaring stretches of the Potomac.

Nestled in the Catoctin Mountains are Catoctin Mountain National Park and the adjacent Cunningham Falls State Park, where fall foliage is at its most dazzling in early to mid-October. Cunningham Falls cascade into the waters below from a height of 78 feet. The park trails range from a short wheelchair-accessible trail to the falls to the strenuous 27-mile Catoctin Trail.

A popular place to begin exploring the Appalachian Trail, as it winds over South Mountain, is at South Mountain State Park or at nearby Gathland State Park, where you can also absorb Civil War history at the South Mountain State Battlefield. Follow the trail southward, and you'll come to the Potomac and the scenic C&O Canal, whose towpath, now a national park, has become a favorite birding and biking trail.

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*Frederick* COUNTY

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Photo: Nico Sarbanes

## WORCESTER COUNTY

**L**OCATED ON THE EASTERN SHORE, Worcester County is Maryland's only coastal county, with lots of seaside beaches, bays and barrier islands along the Atlantic for exploring and birding. Assateague Island State Park and National Seashore is home to the state's famous wild pony herd as well as piping plovers and elusive sika deer. With the beautiful black-water Pocomoke River and its forests and cypress swamps as well, the county's varied habitats play host to more than 350 species of birds, the most in the state.

Worcester County has recorded more than 350 species of birds, resident and migratory.

The Delmarva Discovery Center on the Pocomoke River in downtown Pocomoke City is a great introduction to the history of the Pocomoke River, including shipbuilding, trading, fishing and local Native American historical culture. For exploring the river, the Nature Conservancy maintains a mile-long trail through the Pocomoke Forest and over the Nassawango Cypress Swamp, along Nassawango Creek, shaded by ancient bald cypress and black gum trees. The swamp is well known as a bald eagle roost, while you might catch a glimpse of such shy species as wild turkeys and an assortment of warblers.

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# AS HEARD ON PAUL HARVEY NEWS

# New advanced portable heater can cut your heating bill up to 50%

## Heats a large room in minutes with even heat wall to wall and floor to ceiling

## Does not get hot, cannot start a fire and will not reduce humidity or oxygen

### Never be cold again

A new advanced quartz infrared portable heater, the EdenPURE®, can cut your heating bills by up to 50%.

You have probably heard about the remarkable EdenPURE® as heard on Paul Harvey News and on television features across the nation.

The EdenPURE® can pay for itself in a matter of weeks and then start putting a great deal of extra money in your pocket after that.

A major cause of residential fires in the United States is portable heaters. But the EdenPURE® cannot cause a fire. That is because the quartz infrared heating element never gets to a temperature that can ignite anything.

The outside of the EdenPURE® only gets warm to the touch so that it will not burn children or pets. Pets can sleep on it when it is operating without harm.

The advanced space-age EdenPURE® Quartz Infrared Portable Heater also heats the room evenly, wall-to-wall and floor-to-ceiling. And, as you know, portable heaters only heat an area a few feet around the heater.

Unlike other heating sources, the EdenPURE® cannot put poisonous carbon monoxide into a room or any type of fumes or any type of harmful radiation.

**Q. What is the origin of this amazing heating element in the EdenPURE®?**

A. This advanced heating element was discovered accidentally by a man named John Jones.

**Q. What advantages does infrared quartz tube heating source have over other heating source products?**

A. John Jones designed his heating source around the three most important consumer benefits: economy, comfort, and safety.

In the EdenPURE® system, electricity is used to generate infrared light which, in turn, creates a very



Cannot start a fire; a child or animal can touch or sit on it without harm



safe heat.

After a great deal of research and development, very efficient infrared heat chambers were developed that utilize three unique patented solid copper heat exchangers in one EdenPURE® heater.

**Q. How can a person cut their heating bill by up to 50% with the EdenPURE®?**

A. The EdenPURE® will heat a room in minutes. Therefore, you can turn the heat down in your house to as low as 50 degrees, but the room you are occupying, which has the EdenPURE®, will be warm and comfortable. The EdenPURE® is portable. When you move to another room, it will quickly heat that room also. This can drastically cut heating bills, in some instances, by up to 50%.

The EdenPURE® comes in 2 models. GEN3 Model

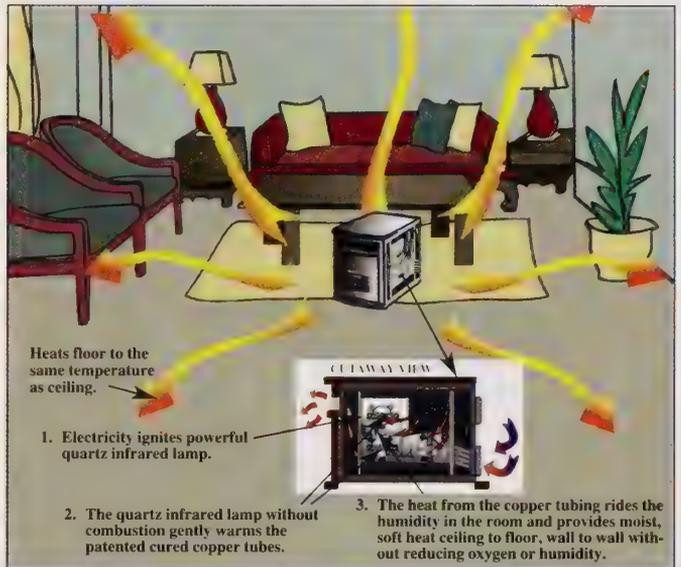
500 heats a room up to 300 square feet and GEN3 Model 1000 heats a room up to 1,000 square feet.

#### End of interview.

The EdenPURE® will pay for itself in weeks. It will put a great deal of extra money in a users pocket. Because of today's spiraling gas, oil, propane, and other energy costs, the EdenPURE® will provide even greater savings as the time goes by.

Readers who wish can obtain the EdenPURE® Quartz Infrared Portable Heater at a \$75 discount if they order in the next 10 days. Please see the Special Readers Discount Coupon on this page. For those readers ordering after 10 days from the date of this publication, we reserve the right to either accept or reject order requests at the discounted price

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2. The quartz infrared lamp without combustion gently warms the patented cured copper tubes.

3. The heat from the copper tubing rides the humidity in the room and provides moist, soft heat ceiling to floor, wall to wall without reducing oxygen or humidity.

### SPECIAL READER'S DISCOUNT COUPON

The price of the EdenPURE® GEN3 Model 500 is \$372 plus \$17 shipping for a total of \$389 delivered. The GEN3 Model 1000 is \$472 plus \$27 shipping and handling for a total of \$499 delivered. People reading this publication get a \$75 discount with this coupon and pay only \$297 delivered for the GEN3 Model 500 and \$397 delivered for the GEN3 Model 1000 if you order within 10 days. The EdenPURE® comes in the decorator color of black with burled wood accent which goes with any decor. There is a strict limit of 3 units at the discount price - no exceptions please.

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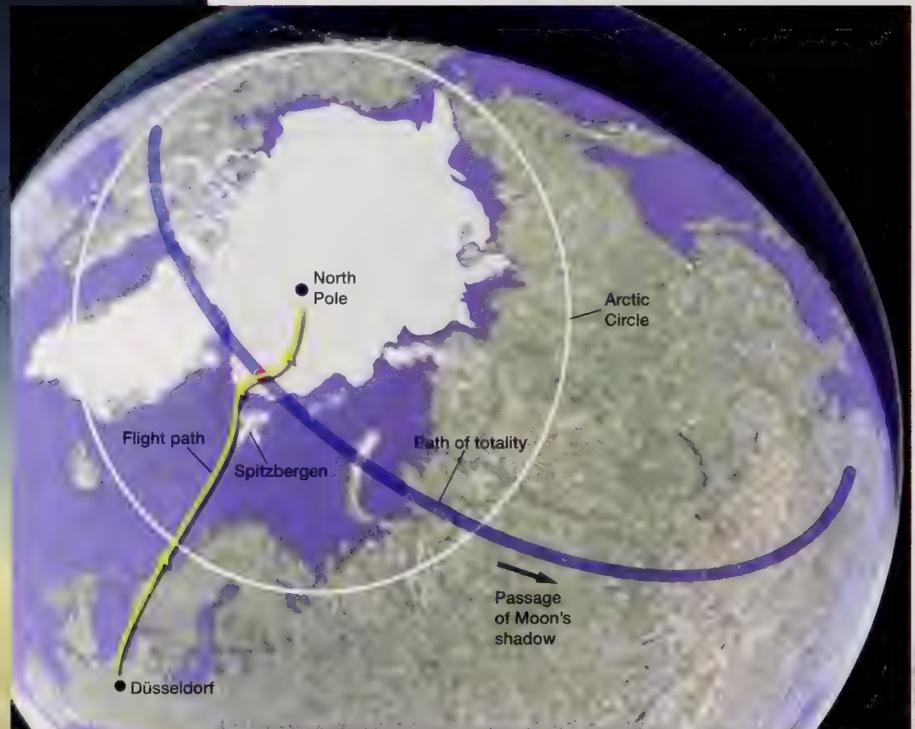
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# Shades of

## My whirlwind tour to the North Pole and back for 175 seconds of totality

As regular readers of my “Skylog” column are aware, a total solar eclipse was predicted for August 1, 2008, one whose track would stretch from northern Canada across the Arctic Circle and into Siberia and China. Although I had traveled to witness nine previous eclipses, I figured I would have to forego this one—hard to reach from my home base near New York City. Even a trip to Novosibirsk—a readily accessible major city in Siberia, directly in the path of the eclipse—didn’t seem worth the investment of time and money. The likelihood of clear skies there was little better than fifty-fifty, given the usual weather patterns at that time of year. But then, in late June, I was presented with an opportunity to observe the eclipse from a most unique vantage point.

Once or twice a year, a German tour company called



*Flight from Germany en route to the North Pole intercepted the Moon's shadow at 9:41:33 A.M. Greenwich Mean Time. During the brief "totality run" the aircraft flew northeastward, broadside to the Sun, to provide a view of the eclipse from the passenger windows on the right side (it being morning, the Sun was in the east).*

# Glory

By Joe Rao



Opposite page, far left: View through aircraft window of the August 1, 2008, solar eclipse shows the "diamond ring" effect created by the irregular edge of the Moon, just before the Moon completely covers the solar disk. Right: Total eclipse from 36,000 feet. Above: Passengers take in views prior to the eclipse.

Deutsche Polarflug runs a twelve-hour sightseeing flight to the North Pole and back. Their flight path scheduled for August 1 promised an unusual bonus: en route to the Pole, it would intercept the total eclipse, and the aircraft would be filled with scientists and inveterate eclipse chasers. When I was invited aboard to cover this event for *Natural History*, I readily accepted!

**Total solar eclipses are** a happy accident of nature. The Sun's 864,000-mile diameter is fully 400 times larger than that of our puny Moon, which is 2,160 miles. But the Moon also happens to be about 400 times closer to the Earth than the Sun (the ratio varies a bit, as both orbits are elliptical), and as a result, when the orbital planes intersect and the distances align favorably, the new Moon can appear to completely blot out the disk of the Sun. On such occasions, the Moon is casting its dark, slender cone of shadow (called the umbra) upon the Earth's surface; that shadow can sweep a third of the way around the Earth in just a few hours. Those who are positioned in the direct path of the umbra will see the Sun's disk diminish into a crescent, while beneath that spectacle, the Moon's shadow will be rushing toward them across the landscape. During the brief period of totality, when the Sun's disk is completely obscured, they will be engulfed in an eerie semidarkness, quite different from the onset of darkness at the end of a sunny day.

Self-evidently, the phenomenon differs from a total lunar eclipse. That is not only because in one case the Sun is obscured from our view, and in the other the Moon;

rather, they are obscured in different ways. Astronomically speaking, a solar eclipse can be called an *occultation*: a masking of a celestial body by another that passes in front of it. During a total lunar eclipse, in contrast, the full Moon passes completely into Earth's shadow. From another point of view—that of an observer on the Moon, for instance—a total solar eclipse amounts to a partial (very partial) eclipse of the Earth.

Contrary to popular belief, total solar eclipses are not particularly rare. Astronomers predict sixty-eight to take place during the twenty-first century—one about every eighteen months. That's not counting annular or "ring" eclipses (in which the Moon is too far from Earth to completely cover the Sun, and the tip of the umbra doesn't quite reach Earth's surface); hybrid eclipses (which are annular along one part of the path, total along the rest); and a goodly number of partial solar eclipses.

But if total solar eclipses aren't all that rare, seeing one is—mainly because (even assuming clear weather) you have to be at the right place at just the right time, and the Sun and Moon do not arrange their assignments for human convenience. The track traced by the Moon's umbra on Earth can run for many thousands of miles, but it's also very narrow, at most about 170 miles wide. It has been calculated that on average, a total eclipse of the Sun is visible from the same spot on Earth only once in about every 375 years. If you think back to a time when human societies were small and communications and transportation limited, not only were the chances of seeing a total solar eclipse slight, but the fact that anyone else had ever seen one would not be common knowledge. The phenomenon would have been regarded with awe and, likely, fear—as a sign that the gods were angry, an omen of impending disaster. Many people believed that the Sun disappeared because it was being eaten by a dragon. And, of course, as soon as the priests—the only astronomers (or rather, astrologers) of the earliest civilizations—were able to forecast such happenings, they could use their skills as a means to impress the multitudes.

**Old Chinese bone inscriptions** provide one of the earliest records of an eclipse—probably the one that, by our Western calendric reckoning, occurred October 22, 2134 B.C. Hsi and Ho, astronomers to the Emperor Chung K'ang, had failed to predict that eclipse, and as the Sun faded, pandemonium broke loose. The Son of Heaven had his court astronomers decapitated.

And there is at least one apparent reference to an eclipse in the Bible. In Amos 8:9, we read: "I will cause the Sun to go down at noon, and I will darken the Earth in the clear

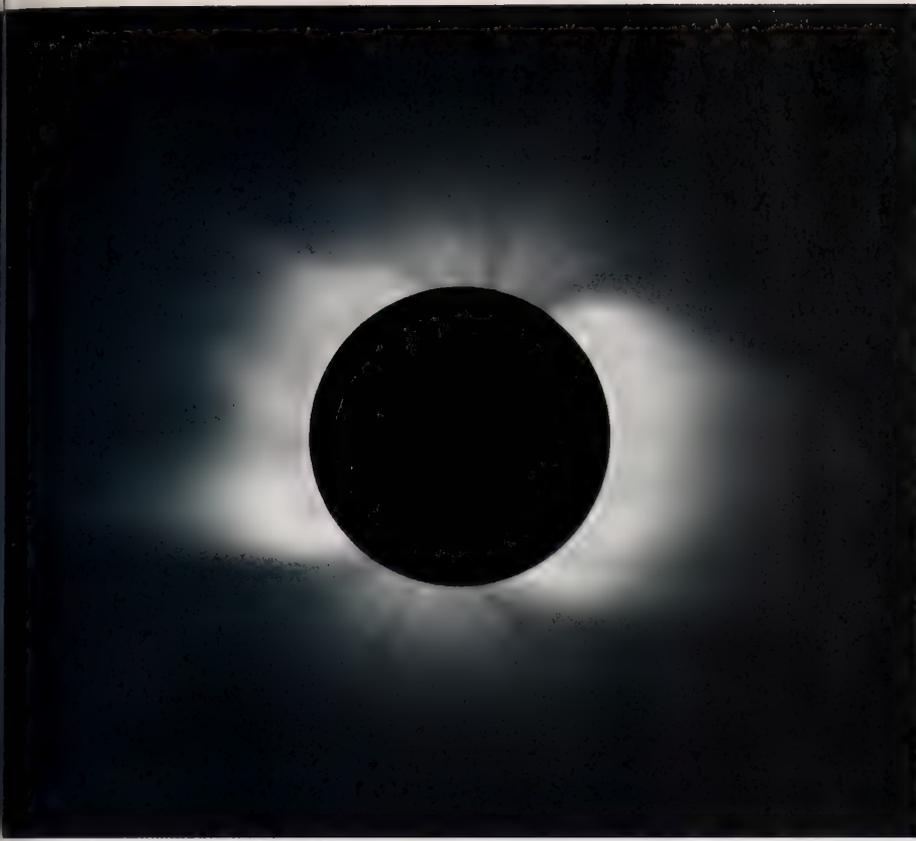


Above: Eclipse of September 10, 1923, as seen near Lompoc, California, shows the diamond ring effect. It was painted by Howard Russell Butler, based on his sketches and notes of the colors. Totality lasted 140 seconds. Opposite page: Composite of five digital camera images of the eclipse of August 1, 2008, processed to bring out detailed structure that cannot be revealed in a single photograph. The shape of the corona resembles that in Butler's painting; both eclipses occurred during quiescent years of the eleven-year sunspot cycle.

day." Most likely that was the Eclipse of Nineveh, which has been dated June 15, 763 B.C. An Assyrian tablet also attests to the event.

Modern-day astronomers have learned much by studying solar eclipses, such as determining the precise relative positions of the Sun, Moon, and Earth. Certain kinds of studies—especially measurements of the Sun's searing corona—can best be made during a total solar eclipse. The corona, or crown of the Sun, is a delicate halo of pearly white light that is always present but whose pale glow is normally overpowered by the Sun's brilliance. (Because it is only visible during totality, it wasn't until the eighteenth century that astronomers were certain that the corona surrounded the Sun and not the Moon!) It's composed of highly diffuse, superheated, ionized gases; most scientists believe those gases extend all the way to Earth as the solar wind. Thus, understanding the corona is relevant to understanding our own environment.

During a total solar eclipse, a few ruby-red spots may seem to hover around the jet-black disk of the Moon. Those are solar prominences, tongues of incandescent



BILL KRAMER/WWW.PHOTOHISERS.COM

hydrogen gas rising above the surface of the Sun. During the total eclipse of August 18, 1868, the French astronomer Pierre Janssen trained his spectroscope on the prominences and discovered a new chemical element. Two English astronomers, J. Norman Lockyer and Edward Frankland, later named it “helium,” from the Greek *helios* (the Sun). The gas was not identified on Earth until 1895.

And because sunlight is blocked during a total eclipse, some of the brighter stars and planets can be observed in the darkened sky. Under such conditions astronomers were able to test part of Einstein’s now-celebrated general theory of relativity. That theory predicted that light from stars beyond the Sun would bend from a straight path in a certain way as it passed the Sun. The positions of stars photographed near the Sun’s edge during a total eclipse on May 29, 1919, were compared with photographs of the same region of the sky taken at night; the results strongly supported Einstein’s theory.

**I’ve often been asked**, why bother traveling to an eclipse? My answer is always the same: “You must see one for yourself, and then you will understand.” Astronomy writer Guy Ottewell planned to create a painting of the 1983 eclipse visible from Borobudur in Java. He later wrote: “During the minutes of totality I was conscious of being in a different visual world; of trying to memorize colors for which I had no names, which would be as hard to recall or describe as a taste.”

Although—or perhaps because—totality lasts for a brief

time, there are some devoted eclipse chasers who organize their vacations, indeed much of their lives, and travel long distances so that they can witness as many eclipses as possible. It takes dedication, because the Moon’s shadow seems to have a perverse habit of passing over unpopulated and inhospitable parts of our planet. And for those who have made extensive plans, an overcast sky on eclipse day can be devastating. But there is something we can do about the weather besides talk about it: take to the air!

One of the earliest attempts at an airborne observation of an eclipse came over Russia on August 19, 1887, when Dmitri Mendeleev (better known for his work on the periodic table) carried out a solo balloon flight, ascending to 11,000 feet and landing two hours later after traveling 150 miles. And yes, he successfully observed the eclipse. The very first attempt to do so from an airplane took place June 8, 1918. The *Scientific American* later noted that while the flight was “not undertaken with any serious scientific objective in view, it was at least demonstrated that we may eventually look to the aviator for work of value in connection with eclipses.”

When the January 24, 1925, eclipse passed over New York City, twenty-five aircraft went aloft to observe it. Spread out from New Haven, Connecticut, to Greenport, Long Island, they flew at various altitudes from 5,000 to 15,000 feet above patchy clouds. In all, fifty men witnessed totality from those planes, which all took off from the army’s now long-deactivated Mitchel Field on Long Island. In addition, the U.S.S. *Los Angeles*, then the largest dirigible in the world, took up a position nearly nineteen miles off Long Island’s Montauk Point. There, from 3,000 feet, the forty-two observers aboard had a clear view of the sky, whereas clouds at 2,000 feet would have obscured the eclipse from a ship at sea.

Another milestone came on June 20, 1955, when a T-33 jet flying at 38,000 feet and 600 miles per hour followed the eclipse path over Southeast Asia and the Philippines. That was the first real “eclipse chase” by an aircraft, extending the duration of totality to more than twelve minutes, compared with just over seven minutes for ground-based observers. That feat was eclipsed on June 30, 1973, when scientists aboard a Concorde jet flew at more than twice the speed of sound across Africa and enjoyed seventy-four minutes of totality.

**Aircraft can also be useful** for viewing an eclipse in hard-to-access regions, such as near the poles (though if you actually lived year-round within the Arctic or Antarctic Circle, the experience of an eclipse during the summer,

when the sun never sets, would be extraordinary). The total solar eclipse of November 23, 2003, for example, was the very first in history to have been observed from the Antarctic.

So it was that on August 1, at 3:30 A.M. local time, I found myself at Düsseldorf International Airport, preparing to board an Airbus A330-200 long-range jet for a 2,189-mile airlift to a grandstand seat. The flight was arranged with LTU International Airlines by Deutsche Polarflug. There were 146 other participants, about half of them “umbraphiles” or “eclipsomaniacs”; the others were on board to take in the sights of the Arctic (of necessity, as only half the plane windows would be facing the solar spectacle). Most of us

means “jagged peaks,” and we found the name most fitting, for when we dropped from our cruising altitude of 36,000 feet down to 7,000 feet to have a closer look, we saw mountain formations, majestic fjords, and calving glaciers. Ascending again to 36,000 feet, we prepared for our special “totality run,” just 500 miles from the North Pole. Astronomer Glenn Schneider, from the University of Arizona’s Steward Observatory, had worked out the flight plan for Captain Wilhelm Heinz and his flight crew. This was to be Schneider’s twenty-seventh total eclipse, and he hoped to collect new corona data.

Flying nearly seven miles above the Earth’s surface, our jet provided an unobstructed view above more

than three-fourths of the atmosphere’s mass and almost all its water vapor. Several minutes before totality, the light inside the cabin gradually faded, signaling the start of a show much as the lights dim in a theater. Over the drone of the jet engines, passengers spoke excitedly in German and English as the Sun narrowed to a curved filament of light. As the last of its rays squeezed past the jagged lunar edge, they produced a beautiful and long-lasting “diamond ring” effect. The lunar shadow then swept in from the west and enveloped our plane in the eerie darkness of totality.

In the cobalt-blue sky the Sun’s corona now shone like a brilliant platinum ring on a dark velvet cushion. Several long streamers spilled out from the corona, a typical feature when the Sun is at sunspot minimum, as it has been for the past couple of years. On the edge of the Moon’s jet-black disk, a small prominence could also be glimpsed. Adding to the scene, to the left of the darkened star of the show, four planets seized their chance

to shine: Mercury, Venus, Saturn, and Mars. Although no match for the Moon’s shadow, which was moving at 2,740 miles per hour, our aircraft, with its 555-mile-per-hour speed, provided us with 175 seconds of total eclipse in which to take pictures and record other data. An observer on a stationary ship on the Arctic Ocean below us would have had 132 seconds.



*With temperatures hovering around freezing, gaps appear in the sea ice at the North Pole during the Arctic summer. The North Pole is significantly warmer than the South Pole because it lies at sea level in the middle of an ocean, which acts as a reservoir of heat; the South Pole falls within a continental land mass at an elevation of 9,300 feet.*

came already prepared, but special dark glasses were handed out, along with a warning against looking directly at the Sun during the partial stages of the eclipse.

We flew over the German North Sea coast and Denmark toward Norway. From there, we flew across the Barents Sea heading to Spitsbergen, the largest island of the Svalbard archipelago in the Arctic Ocean. The name Spitsbergen

Up front in the flight deck, Schneider had his camera equipment set up on a platform stabilized by two gyroscopes. His experiments dealt in part with the density of plasma in the solar corona and the question of how it is heated to millions of degrees Fahrenheit. He was collaborating with Jay Pasachoff of Williams College in Massachusetts, who was stationed within the totality path at Akademgorodok, Siberia. They had collaborated on a similar observation during the Antarctic eclipse of 2003.

**Those 175 seconds went fast:** a second diamond ring blazed forth, and the corona quickly faded away. There was a sensation of released tension as a cacophony of whoops and cheers greeted an eclipse flag that was paraded around the cabin. The owner of the flag was Craig Small, a colleague of mine at the Hayden Planetarium, who considers it his lucky charm. He has traveled to twenty-six eclipses and has never been clouded out!

After the eclipse, the rest of our journey was spent “flightseeing” over fields of pack ice interspersed with gaps of water and enormous icebergs. We counted down to our impending arrival at 90 degrees north latitude, and soon we were on top of the world. After flying directly above the North Pole, we circled it first clockwise and then counterclockwise, each time flying across all 360 degrees of longitude in just two minutes. From that point, the distance to northern Canada was only 465 miles, put-

ting us closer to the American continent than to Europe.

As we headed back to Düsseldorf, many on the airplane were comparing digital images and videos of the darkened Sun, and some were already making plans to chase the next eclipse, set for July 22, 2009. Totality will sweep over parts of India, China, and the Ryukyu Islands of Japan; in some locations it will last more than six minutes, the longest that celestial mechanics will allow until the year 2132.

One passenger perhaps summed it up best: “No pictures or words can ever convey the experience of totality. It’s something you feel; you just get hooked. I came here to be awed—and I am.”



Chief Meteorologist at News 12 Westchester, serving New York’s Hudson Valley, **Joe Rao** has been an assiduous amateur astronomer for more than forty years. Since 1986 he has been an instructor and guest lecturer at New York’s Hayden Planetarium. He has also co- led two eclipse expeditions and has served as onboard meteorologist for three eclipse ocean cruises. Rao is a regular contributor to Space.com and the *Farmers’ Almanac* and writes a Sunday feature, “Sky Watch,” for the *New York Times*. His column for *Natural History* has been a regular feature since January 1995.

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UNIFI. *Compani*

# I, Cleopatra

*This was my Life.*

Twenty-one years have passed since I, Ptolemy's most loving daughter, closed his eyes and took his crown. Now my own end has come, and I must stand before the greatest of all judges. Divine Osiris, do you recognize the mortal woman who was once worshipped as Isis, your sister-wife? How will you weigh the choices I have made as queen of Egypt? Will you accept my confession, and grant me everlasting life?

My tale is one of triumph and disaster—of love, betrayal, and loss. It begins in Alexandria, at the western edge of the Nile Delta, the largest and most captivating city in the world. Where else would a visitor find straight, wide streets; a shining lighthouse; and a library holding every book ever written in Greek? Here, in my family's glittering palace beside the sea, I learned to read and write and calculate; to understand the laws, history, and traditions of the world; to mix potions and poisons; and to speak the languages of many peoples. It was here, in my father's temporary absence, that my sister Berenice seized Ptolemy's throne. Here she killed her husband, a coarse and vulgar man who stank of fish, and then married another. And here, after three years of rule, she was executed by my father. Ptolemy emerged from the bloodshed a poverty-stricken king, our family torn apart by treachery.

It is easy to underestimate my father, to simply see him as a corrupt king who ate, drank, and indulged in sexual debauchery, childishly blowing on his flute despite the growing shadow cast by Rome. His reign was one of undisciplined luxury and ostentatious display: the drunken god Dionysos inspired him. Yet for all his revels, he was wise enough to understand that his future was bound up with Rome. Egypt was a fertile, ill-

defended land ripe for plucking, Rome a greedy, ever-expanding state with a constant hunger for grain. Weak he may have been, but Ptolemy "the flute-player" managed against all odds to preserve his throne for me.

Granted, it was not for me alone. The women of my family were fated to rule alongside their brothers. And so I took the crown and throne with Ptolemy, the thirteenth to rule under that name, just ten years old to my eighteen. He was a golden boy: handsome, spoiled, arrogant, and naive. As long as young Ptolemy consented to be guided by me, all was well. But when he turned from me, seduced into believing he could rule alone, the gods sealed his destiny. I fled eastward to Syria, where I raised the army that would allow me to reclaim my throne. In a matter of months Egypt trembled on the brink of civil war—



Marble bust of Cleopatra, believed to have been created during her lifetime (69–30 B.C.)

By: Joyce Tyldesley

sister versus brother. Ptolemy camped at Pelusium, on the eastern edge of the Delta, hoping to intercept me. But external events overtook us both.

*In Greece, Julius Caesar and Pompey* had fought a great battle for control of Rome. Pompey wielded the advantage of numbers, but on his side Caesar had Mars, god of war, and Venus, his own divine ancestress—and no one can resist the gods. Beaten but still dangerous, Pompey fled to Pelusium, which sent Ptolemy into a panic. Should Pompey be welcomed as an honored guest, or was he a troublemaker who should be driven from the shore? Ptolemy's tutor argued persuasively that Pompey should be killed. After all, as everyone knows, a dead man does not bite. And so the deed was done.

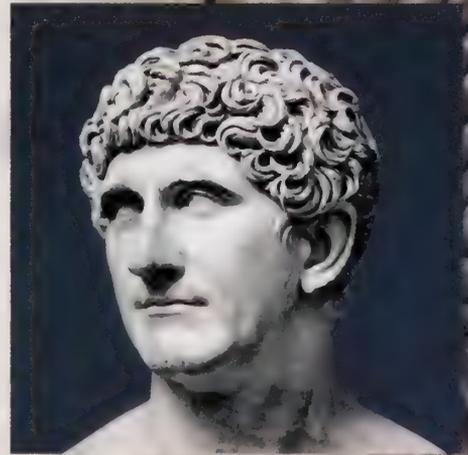
Four days later Caesar arrived in Alexandria. Shown Pompey's severed head and signet ring, he wept great tears for his rival. Then he donned a purple-edged toga and left his ship to march through the city. By nightfall he had commandeered my family's royal palace, at the cost of several lives.

Caesar ordered my brother and me to appear before him. Ptolemy did as he was bidden: leaving his troops at Pelusium, he arrived in Alexandria and moved into the royal palace. Abandoning all pomp and ceremony, I made my own journey there in a small boat. The landing was accomplished at nightfall, and I was smuggled into the palace. Striding straight to Caesar's apartments, I demanded and won his private audience to state my case.

Julius Caesar was the most powerful man in the world, yet I found him physically undistinguished. Thirty years older than me, he had dark eyes, a pale face, and thinning hair. But he was above all an intelligent man, a superb orator, good-humored and amusing. As we talked long into the night, it became clear that we had much in common. We were both ambitious; both prepared to take risks to achieve our goals. We both had reason to ensure that Egypt did not succumb to civil war. And, dare I say it, we were both lonely. Caesar had lost his only child and suffered from terrible nightmares. I, estranged from my younger brothers and sister, had lost my mother, my two older sisters, and my father. I knew that Caesar needed Egypt's wealth, while I needed Rome's protection to keep possession of my throne. Even if we had felt no other connection, a political alliance was an obvious step.

When he heard of my new alliance, Ptolemy flew into a tantrum, ripping off his diadem and flinging it to the ground. The people of Alexandria—shortsighted fools that they were—gave Ptolemy their support. But Caesar made it clear that he expected my brother and me to rule Egypt together, under his guidance. This Ptolemy could not accept, and he summoned his troops. They started the five-day march from Pelusium, and the atmosphere grew tense. Securing the palace, Caesar hastily sent for reinforcements.

Four months of vicious land and sea battles followed, bringing devastation to my beloved city. Trapped in the royal place, I kept my own counsel. My



Mark Antony, Cleopatra's Roman ally. Background image across these pages: Fanciful Roman view of an Egyptian scene, in terra-cotta relief from the first century A.D.

Below: Egyptian-style statue identified as Cleopatra from details of her head ornamentation; until recently it was thought to be of Arsinoë II (316–270 B.C.). At right: Silver denarius coin portraying Cleopatra, issued in the eastern Roman domain in 32 B.C. Antony is shown on the other side.



younger sister Arsinoë was not so wise. She fled the palace, and the populace proclaimed her queen of Egypt. With her encouragement, the people then demanded the release of Ptolemy, who had been imprisoned at the palace. Caesar, thinking that would bring peace, agreed. But once he was free, Ptolemy, foolish boy, turned on Caesar and rallied his followers. Soon after, Caesar's allies captured Pelusium and marched on Alexandria.

The battle was short and decisive. Alexandria surrendered, Arsinoë was captured (and later exiled), and Ptolemy drowned as he tried to escape in a disastrously overcrowded boat. The heavy golden armor that had made it impossible for him to swim was displayed to the people as proof of their king's death. Caesar restored me to my throne, now to rule alongside my next brother in line, also called Ptolemy, a boy of twelve at the time.

Worn out with campaigning, Caesar dallied in Alexandria. Thus he was present when my first son was born. I had fulfilled every queen's duty and provided Egypt with an heir. It still makes me smile to remember how much gossip the birth provoked. Was the child, Ptolemy Caesar, the son of Julius Caesar? Was he the son of my dead brother Ptolemy? Or fathered by someone else? I never spoke on this matter.

My son's father was irrelevant. As his mother, however, I had been transformed into the new incarnation of Isis—the single mother of the divine child Horus, the mother of all of Egypt's living kings. Now I wore the ceremonial garments of Isis: a crown of a moon disk held in place by twin snakes, and a multicolored robe with an embroidered hem of fruit and flowers, covered with a black cloak. Priests and scholars spoke of a new Savior who was to come from the east—for a time I believed that my son and I would fulfill that prophecy. Meanwhile, I had a new purpose in life: the preservation of my throne for my child.

I paid two visits to Rome—an unpleasant, overcrowded city with none of the grandeur of Alexandria. Thus I was in Rome on that fateful day in March when Caesar's friends betrayed him. Within a month I had returned to Alexandria. Soon after, my brother Ptolemy died—I cannot deny I wished it so—enabling my son to take his place as king. Three years of low Nile levels, failing crops, and hunger and plague followed. Persistent inflation forced me to lower the silver content of my coins, making them compatible with the Roman denarius. Nevertheless, I felt secure: with my brothers dead, my surviving sister in exile, and their supporters removed, I had absolute power.



*Outside Egypt things were far from peaceful.* Mark Antony, a friend of the late Caesar, had united with Caesar's young heir, Octavian, and Caesar's supporter Marcus Aemilius Lepidus to capture Brutus and Cassius, the principal assassins. They expected my Egypt, still a relatively prosperous nation, to help. Meanwhile, Brutus and Cassius also looked to Egypt for aid. I delayed as long as I could, but was eventually forced to take sides.

Raising a fleet, I sailed to join Octavian and Antony in Greece. Unfortunately, a mighty storm blew up, and my ships sustained serious damage. While I waited for a second fleet to be made ready, news came that Brutus and Cassius had committed suicide.

Two men, Octavian and Antony, now held power in Rome. I needed a protector, and Antony seemed my natural ally. Not only was he the controller



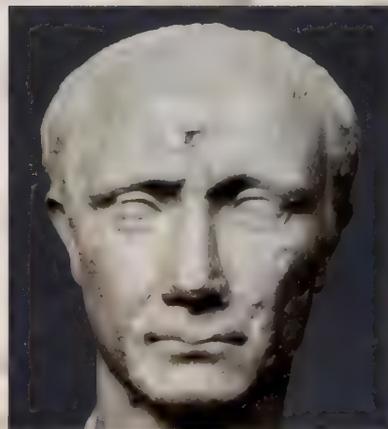
of Rome's eastern empire, he was also older and more experienced, more popular and robust. Antony, in turn, needed money to pay his veterans. He summoned me to meet him in Tarsus, on the Cydnus River in Cilicia, southeastern Anatolia. I planned my approach carefully. Antony had styled himself, or so I had heard, as an incarnation of Dionysos. I, then, would dazzle him as Isis! I sailed along the river in a gilded ship with silver oars and a splendid purple sail. Flutes, pipes, and lutes played on deck, and potent incense perfumed the air. Dressed in my divine robes, I reclined beneath a gold-spangled canopy, attended by beautiful boys dressed as cupids. The people of Tarsus flocked to watch the spectacle, leaving Antony alone and disconcerted in the marketplace.

When Antony sent an invitation to dine, I declined, declaring that he should be my guest. We ate that night in a room decorated regally, where I served delicious food on gold plates inlaid with precious stones. I feasted with Antony, as I had feasted with Caesar, but I bargained with him too. I offered him the money that he so desperately needed, if he, in return, agreed to protect my crown. That protection included murder of my last living sibling, Arsinoë.

Satisfied, I returned home. Antony followed a month later, and we enjoyed a carefree winter in Alexandria. Together we formed a society we called The Ones with Matchless Lives, which met nightly to drink, feast, play dice, hunt, and wander the streets in disguise, playing tricks on the citizens. In the fullness of time I gave birth to twins, Alexander Helios and Cleopatra Selene. Antony had already left Alexandria, and did not make any effort to see his children for three and a half years—an arrangement that suited me well.

Ruling an increasingly prosperous Egypt, my days filled with administrative tasks, I knew little of Antony's life at that time. He still believed he had a future working alongside Octavian. Only when Antony realized that could never be did he enter my life again. Then he told me of

**Julius Caesar, who sought to have Cleopatra rule alongside her brother Ptolemy XIII**



his wife's and brother's imprudent conspiracy against Octavian; of his wife's death, his hasty marriage to Octavian's sister, Octavia, and their two daughters together; and of his disastrous Parthian campaign.

Antony had designs to build a base of power in the East and then to challenge Octavian in Italy. I traveled to meet him at Antioch, and new negotiations commenced. I could provide the fleet and provisions that he needed, but in exchange I asked for the ultimate prize: the return of the lost eastern Mediterranean empire that my ancestor Ptolemy Philadelphos, the second Ptolemy, had controlled two centuries before. Antony had little choice but to agree. And so, without spilling a drop of Egyptian blood, I regained control of the land to the west of Egypt called Cyrenaica; to our east, Nabataea, Phoenicia, and southern Syria; and to the north, Cilicia and the islands of Cyprus and Crete. When, the following year, I bore Antony another son, I named him Ptolemy Philadelphos in honor of my triumph.



Roman warships  
in a fresco from  
Pompeii

Antony's campaigning resumed with a long march through Syria and Armenia. That quickly turned into a humiliating disaster, and he was forced to make a weary winter retreat to Syria—his dreams of Italy in abeyance. In the meantime, I was once again summoned from Egypt. This time I hesitated. The balance of power had shifted, and Octavian was beginning to pose a serious challenge to Antony's authority. Eventually I met Antony in Phoenicia. I brought supplies of warm clothing and food, but not enough money to pay the troops. A few weeks later the two of us retired to Alexandria for the winter.

*Spring renewed us and brought action:* I traveled with Antony as far as the Euphrates, then made my way home through my new territories. Later that year, our fortunes seemed to have changed for the better when Antony captured the king of Armenia, his family, and his treasure. Crowned with ivy leaves and dressed in the golden robe of Dionysos, Antony entered Alexandria in triumph. Later we appeared before our people. I, splendid in the robes of Isis, sat on a golden throne, while Antony sat on a silver throne beside me. I was now officially recognized as the "Queen of Kings and of Sons Who Are Kings," and my son Ptolemy Caesar took his rightful place as "King of Kings." (None of this was well received in Rome, where Octavian retaliated by spreading laughable rumors: Antony was a drunkard; he was completely under my thumb; he reclined on a golden couch and even urinated in a golden chamber pot!)

We spent the next winter assembling a fleet in Ephesus, on the west coast

of Anatolia. I know that Antony's friends resented my presence; they liked to fool themselves into believing they were supporting Antony against Octavian rather than Egypt against Rome. But Antony knew who was paying the bills, and he would not risk sending me away. From Ephesus we moved to Greece, mooring our fleet in harbors along the west coast from Actium in the north to Methone in the south. Had we invaded Italy at that time we might well have triumphed. But we hesitated, waiting for Octavian's forces to leave Italy so that we might fight on neutral territory.

The fateful moment finally arrived: Octavian declared war on me. Our omens were bad—a city swallowed by an earthquake, statues oozing blood, the rampage of a two-headed serpent—and Antony was filled with dread. With unexpected swiftness, Agrippa, Octavian's admiral, took Methone. Octavian's ships were now able to work their way along the coast, attacking our supply ships and targeting the dispersed fleet. With the campaign all but lost, my sixty ships hoisted their sails, broke through Octavian's line, and sailed away at full speed. As we had planned, Antony abandoned his flagship and chased after me.

The people of Alexandria do not take kindly to defeat. Aware of that, I entered the harbor in triumph, with garlands draped over the front of my boat and musicians playing victory songs. I determined to flee by way of the Red Sea to India, hoping my beloved Ptolemy Caesar could rejoin me there. To that end I ordered a small fleet to be transported overland. That plan had to be abandoned, when my first boats were seized and burned by the hostile Nabataean king. It was at this desperate time that I formed The Partners in Death, a close-knit group of friends who chose to face the inevitable by partying harder than ever.

*Summer saw Egypt under double attack.* Roman forces to the west launched land and sea assaults, while Octavian marched across the Delta from the east to camp outside Alexandria. Antony challenged Octavian to man-to-man combat, but Octavian refused to be lured. Finally, Antony resolved to meet Octavian in battle. On the eve before the encounter, Antony's god Dionysos left him, passing with his entourage out of the city to join Octavian.

At daybreak, Antony led his troops through the city gate while his fleet sailed eastward to meet the Roman ships. To Antony's horror, his fleet surrendered immediately, and his cavalry deserted. Although his infantry remained loyal, it was a one-sided battle, and, defeated, Antony retreated into Alexandria. Almost immediately, he heard a rumor that I had killed myself. Devastated, he unbuckled his breastplate and asked his faithful slave Eros to help him die. Eros drew his sword, but stabbed himself to death instead. Antony then seized the sword and stabbed himself in the stomach.

As he lay fatally wounded, my secretary brought him the news that I lived after all. Weak from loss of blood, Antony was carried to my mausoleum, where I had barricaded myself with my treasure. He was dragged up through a window and died soon after, in my arms, just as Octavian entered the city.

I have sent him messages, but Octavian will not hear me out. He is a cold and calculating man who refuses to guarantee the lives of my children. My spies tell me that I am soon to be taken to Rome, to be exhibited in the streets in a public triumph, then throttled in a dark and stinking cell. That I cannot allow. I shall seal a last letter to Octavian, asking only to be buried with Antony. I will bathe, and enjoy my last dinner. My message will be delivered. Doubtless, Octavian will try to stop me. But he will be too late. With your blessing, incorruptible Osiris, I will have started on my longest journey.



Octavian, Julius Caesar's heir, who defeated Cleopatra and Antony and became Rome's first emperor, Augustus



**Joyce Tyldesley** is an Egyptologist with a long-standing interest in the women, and in particular the queens, of ancient Egypt. She has written many books on ancient Egypt both for adults and children; her most recent is *Cleopatra: Last Queen of Egypt* (Basic Books, 2008). Tyldesley has worked on archaeological excavations in Britain, Europe, and Egypt. She is currently a lecturer in Egyptology at the University of Manchester, where she teaches the online Certificate Course in Egyptology; a fellow of the Manchester Museum; and an honorary research fellow of the University of Liverpool.

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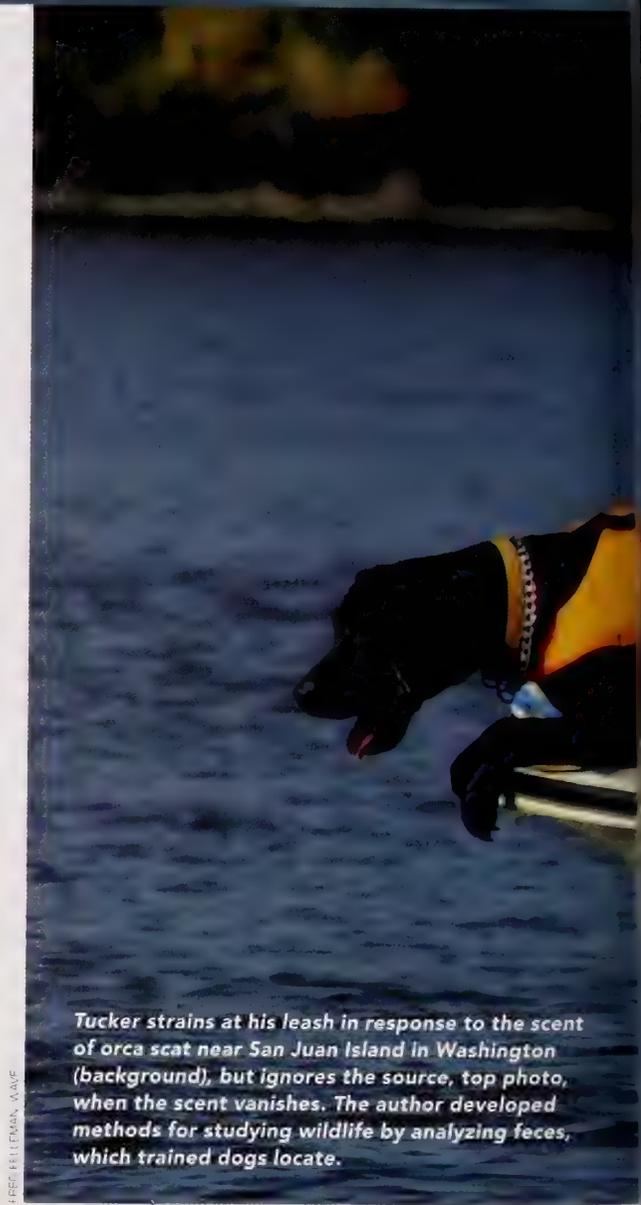


**F**rehley was emaciated and frenetic when we found him at the local animal shelter. His former owner, unable to handle his boundless energy, had kept him locked in a crate in a tiny apartment—no place for a border collie. With no outlet for his insatiable urge to play, Frehley would chase his own paws in circles to the point of exhaustion. It took Heath Smith, the lead dog trainer in my program, half an hour to get Frehley to stop whirling long enough to even notice the ball he'd brought. Such neurotic behavior puts off most would-be pet owners, and the dog might well have wound up euthanized like so many others of his kind. Fortunately for Frehley, we recognized in him the single-minded drive of a born conservation canine.

Once Frehley was in our care at the Center for Conservation Biology (CCB) at the University of Washington in Seattle, it didn't take long to redirect his obsession with his paws into an obsession with playing fetch. A few months of training, confidence building, and gentle encouragement transformed him into a top-notch detection dog with a remarkable new skill: the ability to locate scat from a variety of endangered species over vast wilderness areas. And all for the simple reward of a favorite ball. Frehley and our team of dogs like him—professional poop chasers—have entirely changed my program's approach to studying endangered species, from orcas in Puget Sound to giant anteaters in Brazil.

**HUMANKIND'S UNBRIDLED DEMAND** for resources is putting immense and complex pressures on wildlife. It is urgent to understand those pressures, their scale, and how best to mitigate them. Central to that work is the study of the affected animal populations, and the most common sampling methods include traps, camera traps, hair snags, and radio-telemetry tags. But those methods all suffer from collection bias: samples are more readily collected from some individuals than others, so the data they provide is incomplete at best. Trapping and tagging can also be expensive, and disruptive or even dangerous to the very animals the studies intend to help.

In the mid-1980s, my program, the CCB, began developing methods for studying wildlife populations in a safe and noninvasive



*Tucker strains at his leash in response to the scent of orca scat near San Juan Island in Washington (background), but ignores the source, top photo, when the scent vanishes. The author developed methods for studying wildlife by analyzing feces, which trained dogs locate.*

FRANK FELLEMAN, WAVE

Rescued from the pound, single-minded dogs sniff out the scat of endangered animals, trumping more technical tracking methods.

BY SAMUEL K. WASSER

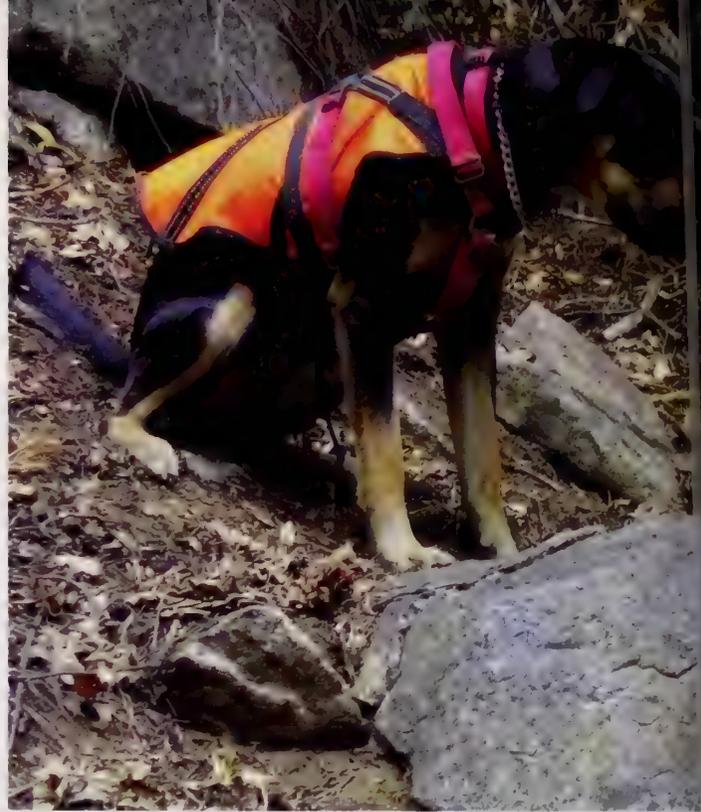


manner—by examining their scat. We pioneered ways to measure hormones in feces that indicate reproductive health, as well as emotional and nutritional stress. We also developed methods for confirming the species, sex, and individual identity of the animals based on DNA in the scat. Over time we've refined our techniques, and now, from scat alone, we can acquire a fairly comprehensive picture of the distribution, health, and well-being of many species without even having to see the animals. But how best to find the scat?

While attending a talk, in 1997, on the use of hounds for hunting, I was struck by the idea that detection dogs might provide a solution. I approached Sergeant Barbara Davenport, the lead narcotics-dog trainer at the Washington State Department of Corrections, for help developing a method to train dogs to find grizzly-bear scat. She readily agreed, and before long my team of biologists was training alongside police officers and prison guards who were learning to handle drug-sniffing dogs. Soon thereafter, Davenport and I had developed methods that would form the basis of the CCB's training program for scat-detection dogs.

Selecting the right dogs is critical. They must have an extraordinarily strong love of toys, ignoring all distractions—cats, other dogs, wild animals, even food—just to play fetch. As with Frehley, we rescue most of our dogs from the pound, where they often wind up thanks to their obsessive personalities. We commonly screen more than 250 dogs just to find one with the right qualifications. That's the lucky dog that gets the dream job: tromping through the woods, sniffing poop, and playing ball.

A new dog quickly learns that it gets the coveted ball whenever it detects scat from the correct species. Next, it learns to sit by the scat, as a visual cue for its handlers. Finally, it masters finding scat hidden outdoors. Properly trained dogs, working with human handlers, can detect scat from as far as one-third of a mile away, and can simultaneously



detect scats from several target species while ignoring scats from all nontarget species. The handler must keep the dog in view as they move through the environment and must recognize the dog's split-second behavior change when it first detects a target scent: excited by the prospect of a ball, the dog shifts direction and speeds up, wagging its tail (if it has one). Those behaviors evaporate if the dog loses the scent. The handler must quickly assess why—a shift in the wind, an obstacle—and help the dog find the scent again.

When a dog and handler work well as a team, they can find a great many scats from numerous individuals of one or more target species, distributed over huge areas. The samples provide a rapid snapshot of the animals' numbers, density, habitat and dietary preferences, ranging patterns, physiological health, and more. All of that information can be correlated with environmental disturbances.

Unlike inanimate sampling devices, scat-detection dogs learn and improve over time, and they can cover an area more thoroughly. They also have far less collection bias. Stationary devices typically use lures, which can alter animal movement or selectively draw animals based on gender or dominance rank. Dogs, on the other hand, locate scat where the animals left it naturally. Compared with radio tracking devices, the dogs provide data on a broader spectrum of individuals at a fraction of the cost—and without the disturbance of capturing and immobilizing wild animals.

**IN 1999, MY PROGRAM BEGAN** its first major study using scat-detection dogs, which served as a trial of our methods. We examined the effects of human land use on grizzlies and black bears in a 2,000-square-mile area of the Yellowhead Ecosystem in western Alberta, Canada.



Gator, an Australian cattle dog, leaps for his favorite toy, a reward for finding a scat.

JAY MYERS FOR WASHINGTON STATE DEPARTMENT OF CORRECTIONS



KATHERYN PURCELL/USFWS

After finding a scat of a Pacific fisher (an endangered relative of weasels), Mocha watches her handler check its freshness. The author's team collected some 700 Pacific-fisher scats in northern California after a decline in live-trap catches suggested the population might be crashing; back in the laboratory, trained dogs will help determine the number of individuals represented in the collection.

My team compared results from the dogs with data from hair-snag stations and radio-collared bears, gathered independently by other researchers. Many biologists were skeptical that the dogs would measure up, but we proved otherwise.

DNA testing of scat samples showed that the dogs detected four times more individual grizzly bears per square mile than the hair-snag stations did. Statistical tests confirmed that sampling by the dogs was unbiased—all bears in the population had an equal probability of being detected. Radio telemetry provided massive amounts of data on the movements of nineteen collared bears during each of the study's three years. In the end it showed the same bear distributions as the scat, but at more than thirty-three times the cost (about \$1 million for telemetry versus \$30,000 for the dog sampling). Moreover, two grizzly bears died and one was seriously injured as a result of the trapping—high stakes for a population of only a hundred threatened animals.

Today—many projects later—my program is studying numerous species across the United States, Canada, and Brazil. Perhaps the most challenging of those projects is in northeastern Alberta. The province has tremendous oil reserves trapped in tar sands, which require a special, expensive extraction process. The resulting environmental disturbance is hard to exaggerate. Even before extraction begins, during exploration for tar-sands deposits, new roads carve up pristine wilderness, small trailer cities spring

up to accommodate hundreds of workers, and immense equipment appears, some airlifted in by helicopter [see photograph on next page]. Machines that produce enormous vibrations search out ideal spots for oil wells.

One of the first corporations to begin working in the area, in collaboration with the native Chipewyan Dene tribe, asked us to monitor the long-term effects of its activities on caribou, moose, and wolves; caribou are threatened in all of Canada and are declining even more dramatically in Alberta. In 2006, the company began exploring—the prelude to a decade of planned extraction—at its 430-square-mile lease site, and we began monitoring a 1,000-square-mile area that includes that site and others.

Both the exploration activities and our surveys are restricted to winter, when the spongy, boglike habitat, called “muskeg,” freezes; come spring, everyone disappears, and all is quiet until the following winter. Mason, a lanky three-year-old black Labrador retriever, is one of four dogs that have so far braved two Alberta winters on the project. Each winter morning before dawn, Mason's handler would suit him up in a fleece safety vest and boots, and they'd head out into the cold. Mason and the other dogs found more than 2,500 scats throughout the huge study site during the winters of 2006 and 2007. They had no trouble finding scat that was hidden beneath two or more feet of snow, and sometimes so frozen the handlers had to chisel it free.

Judging by the fluctuations of hormones in the scat over time, tar-sands exploration seems to be having physiological effects on all three species. In general, the hormone cortisol increases (reflecting mounting emotional or nutritional stress, or both) and thyroid hormone decreases (reflecting mounting nutritional stress) in scat as exploration activity gears up and peaks. Intriguingly, the moose and caribou appear to recover as soon as the work crews start packing up to go home, but still well before spring arrives—so it's not the renewal of food supplies that alleviate the animals' stresses. Not so for the wolves: their nutritional and emotional stress levels increase right through the end of the season, suggesting that the disturbance makes it progressively more difficult for them to catch prey.

Development also seems to be changing the animals' habitat use. The scat's location shows that wolves and caribou have developed a preference for the new artificial linear features crisscrossing their habitat: roads, “cutlines” cleared for seismic mapping of tar-sands deposits, and paths above underground pipelines. Wolves had the strongest preference, followed by caribou—raising concern that attraction to the exposed areas could be making caribou more vulnerable to predation by wolves. Moose, by contrast, preferred good feeding grounds over linear features, a strategy that served them well: hormones in their scat showed smaller nutritional deficits than in the other two species.

Since 2006, the number of oil leases issued in the area has skyrocketed. Only time will tell how the animals will bear the mounting disturbance, particularly once year-round

tar-sands extraction begins, but we hope our findings can guide efforts to soften the blow of development.

**FAR FROM THE CHILLY ALBERTA** muskeg, the Cerrado of Brazil, a tropical savanna, is a biodiversity hotspot that is home to thousands of endemic species. It's also among the world's most threatened biomes. As with Alberta's tar sands, the destruction is partly driven by humanity's unquenchable thirst for fuel: vast fields of soybeans and sugarcane, grown for biodiesel production, are replacing natural savanna at a staggering pace. Landowners near Emas National Park, a large preserve in the Cerrado, are required to set aside 20 or 30 percent of their land (depending on the location) as reserves of natural habitat. But my graduate student Carly Vynne and I suspected that the park and the private reserves might be insufficient to sustain wildlife populations, particularly if the private reserves are located outside huge cultivated fields, rather than within them to provide stepping stones between patches of natural savanna.

So Vynne and I have been using the dogs to monitor how maned wolves move within the patchy landscape of

gives us a pretty clear picture of where the animals spend their time. Although the species differ in their behavior, they all live both inside and outside the park in virtually every type of natural habitat, but shy away from extensive cultivated fields. With very few exceptions, the samples discovered outside the park were in or near patches of natural habitat, showing the importance of locating the private reserves within farmland. We are currently analyzing hormones indicating emotional, reproductive, and nutritional stress in the maned-wolf scat to see whether the wolves' health is better inside or outside the park and whether it's compromised when reserves are small and far apart, as we predict.

**WITHOUT QUESTION, OUR DOGS'** most surprising feat is their successful tracking of whale poop. In our first whale project, Rosalind M. Rolland, a marine scientist at the New England Aquarium in Boston, Barbara Davenport, and I used dogs to find the conspicuous scat of North American right whales in Nova Scotia's Bay of Fundy. The scat is orange, stinky, and floats. Soon enough, dogs were locating it at more than four times the rate achieved by multiple human observers. They even detected a few samples from farther than one nautical mile away.

Then, two years ago, my graduate student Katherine Ayres and I began a pilot study to investigate why an endangered population of orcas, or killer whales, in Puget Sound had declined by 20 percent in the late 1990s and had since recovered only slowly. We planned to examine scat for toxins and for hormones indicating emotional, reproductive, and nutritional stress, to determine the relative importance of three possible culprits: inadvertent harassment by commercial and private whale-watching boats, a decline in the whales' main food of Chinook salmon, and PCB contamination. But orca scat is much harder to find and collect than right-whale scat. It's similar in color to seawater, sinks quickly, and, being slimy and fish-laden, is hard to remove from the water. A dog, we hoped, would help us get to the poop before it sank.

We chose Tucker for the job, a happy-go-lucky black Lab who hates to swim. Tucker rides calmly on the boat's bow, sniffing air currents wafting across the water. In spite of his fear of the deep, he practically pulls his handler off the bow as soon as he catches a whiff of orca scat. We steer into the wind, toward the airborne cone of scent emanating from the scat. If the boat exits the scent cone, Tucker loses interest immediately. So we turn the boat perpendicular to the wind until Tucker again tries to leap into the water; then we steer back into the wind. And so we snake our



Exploration for tar sands, a source of oil, mars a forest in northeastern Alberta, Canada. If developers discover sufficient deposits in an area, pipelines, extraction facilities, and additional roads soon follow. Scat-detection dogs are helping to determine the effects of such exploration on caribou, moose, and wolves.

the Cerrado, with the secondary goal of studying distributions of puma, jaguar, giant anteater, and giant armadillo. All five species have large home ranges and are reclusive, so they're difficult to study; scientists know little about whether and how each lives outside the park, and almost nothing at all about the endangered giant armadillo.

Over vast stretches of park and farmland, Vynne and Mason, along with five other dog teams, have located an impressive amount of scat from all five species, which



*Dog and handler search for the scat of caribou, moose, and wolves in an area of northeastern Alberta disturbed by tar-sands exploration. Boglike habitat permits exploration and research activities only during winter, when the ground freezes.*

way to the whale poop. We can't play fetch on the boat, so we reward Tucker with a bout of tug-of-war with his beloved Kong toy—a rubber and rope thingamabob—as soon as we retrieve the scat.

Our pilot study gave us the green light: DNA confirmed that all the samples we collected were indeed from orcas. We found that stress hormones were higher on weekends, when whale-watching peaks, than on weekdays—the first solid evidence that boats are indeed affecting the whales. Thyroid hormone in the scat also tracked the availability of salmon, providing the first measure of nutritional status in orcas. Scat collection continues, providing a data trove that should allow us to sort out how whale watching, food, and toxins—probably in combination—are affecting orcas.

**A NUMBER OF SCIENTISTS** have expressed an interest in using scat-detection dogs for their own research, and my colleagues and I have been happy to instruct them in our methods or provide trained dog teams. But to disseminate our techniques widely and to make sure they're done right, the CCB needed to expand. This past spring we completed construction of a state-of-the-art facility with indoor-outdoor kennels for thirty dogs. Housing is available on-site for handlers in training. The facility is ideally situated, on the University of Washington's 4,300-acre Center for Sustainable Forestry in the foothills of Mount Rainier.

The next frontier is to use dogs to sort out how many individual animals are represented in a given collection of scat. That will reduce the need for DNA analysis—an expensive, lengthy, and occasionally error-prone task. (DNA is often degraded in scat, and related individuals' DNA is quite similar, particularly in endangered, low-diversity wildlife populations.) After two years, we've worked out a technique that engages the collaborative sniffing power of three dogs to identify and match scat from the same individual. Impressively, the dogs beat DNA analysis for precision, paws down. With the new facility complete, we'll soon begin using the technique experimentally.

Teasing apart the tangle of pressures people are placing on wildlife is a daunting task that grows more urgent with each passing year. By combining the ancient tool of canine olfaction, perfected through millions of years of evolution, with modern genetic and endocrine technologies, my team and I aim to help address some of the world's most critical conservation problems.

**Samuel K. Wasser** is Director of the Center for Conservation Biology at the University of Washington in Seattle. In addition to pioneering methods for extracting hormones and DNA from scat and for using dogs to locate scat samples, he has also developed techniques to acquire DNA from elephant ivory and genetic tools to track the burgeoning illegal ivory trade across Africa.



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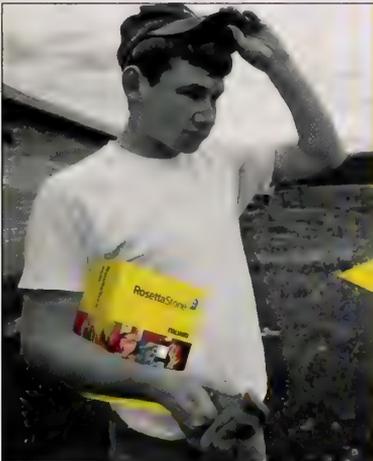
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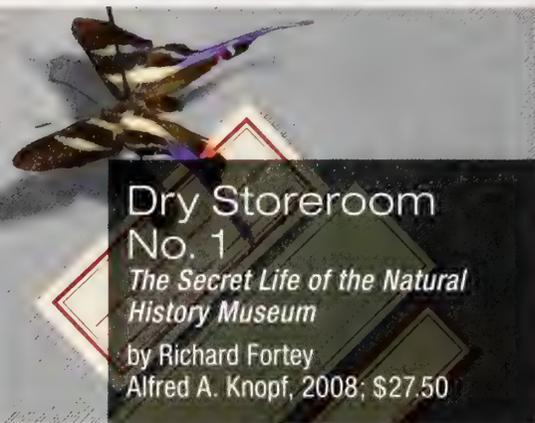
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Whether or not you have ever visited the Natural History Museum in London, this tell-all by a longtime senior paleontologist is a highly entertaining way to learn what makes Dry Storeroom No. 1—and the entire museum—so special. As in virtually all museums of international stature, most of the archives, storerooms, and laboratories in the London museum complex are off-limits to the public. The main work of the institution happens away from the exhibit galleries, behind locked doors, where squadrons of specialists tend a vast warehouse of animal, vegetable, and mineral specimens numbering, by current estimates, about 80 million objects.

Richard Fortey, who has been at the museum since 1970, rambles around its network of corridors and cubbyholes like an enthusiastic docent. The Natural History Museum, you quickly learn, is not just a haphazard assemblage of curiosities, but a sort of international bureau of standards, the repository of the exemplary specimens that scientists use to impart order to the diversity of nature. There are file cabinets crammed with pressed leaves and flowers, ranks upon ranks of drawers holding neatly pinned beetles, and cupboards filled with jars holding fish, newts, frogs, and jellyfish pickled in formalin or alcohol. All are kept, not just because someone fancied them, but because scientists need to study them to find out how apparent differences conceal

underlying connections, and to discover how they fit into the history of our planet.

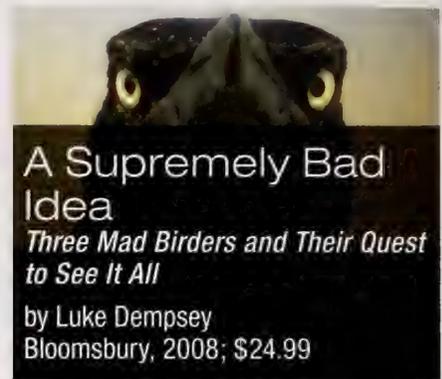
Even more fascinating than the curious collection of animals, vegetables, and minerals, however, is the museum's curious collection of people, especially the curatorial staff, each of whom claims an almost monomaniacal expertise in one small area of the institution's holdings. Fortey is an expert in trilobites, for instance, and may know more about those crablike fossils than anyone else in the world. But it appears that he knows at least as much about the strange habits of the inhabitants of the museum's turrets, laboratories, and offices.

Miriam Rothschild, for instance, was the world authority on fleas, following in the footsteps of her father, Charles, who donated his large collection of the little creatures to the museum in the 1920s. She labored for two decades on the insects, producing a five-volume illustrated catalogue of fleas, while maintaining an active public life as a conservationist. As a member of one of the richest families in Europe, she was known to her colleagues as the "Queen Bee," and came to work every day in a chauffeur-driven Rolls-Royce.

At the other end of the spectrum of legitimacy was Colonel Richard Meinertzhagen, a sort of Indiana Jones figure, whose autobiographical accounts of his exploits as a soldier, spy, and big-game hunter earned him a minor public reputation. He donated some 20,000 bird skins to the museum in the 1950s, as well as a collection of a half million lice. Not until almost two decades after his death was it discovered that many of the bird specimens had been stolen from various museums—including the London museum itself!

Although the size and variety of the museum's collection continue to grow, Fortey recognizes that the days of aristocratic collectors and ob-

sessive catalogers may be numbered, as computerized databases make it less essential to house everything in creation under one roof. But there's little doubt that the Natural History Museum will continue to be a mecca for both tourists and scientists, and that Fortey's lively book is a great way to get to know it.



Reading this book took a bit longer than expected. Not because the writing dragged—Luke Dempsey's narrative, as witty and intelligent as vintage Bill Bryson, moves along at a brisk and sometimes breathless pace. No, what slowed me down was that I so frequently found myself setting the book aside and reaching for a previously uncracked copy of the *Smithsonian Field Guide to the Birds of North America*. My life list of bird sightings, you see, consists of the Canada goose, the pigeon, the crow, and the robin—and I'm not too sure about the robin. Dempsey, on the other hand, *really* knows his birds and his birding, which makes him something of an avian name-dropper. So when he exults over a crested caracara, a Hudsonian godwit, or an elegant trogon, I'm off to the *Field Guide* to see what all the fuss is about.

Yet when I arrived at the last chapter, after many digressions, the book seemed all too short. It's a supposedly true story of three New Yorkers—Dempsey and two friends, Don and Donna Graffiti—who spend lunch hours gawking at migratory birds in Central Park and

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## BOOKSHELF

long weekends traveling to out-of-the-way corners of the United States in search of the perfect birding experience. Recounting those birding holidays, Dempsey's self-effacing humor turns what might otherwise be humdrum lists of birds missed and birds spotted into tales of both misadventure and epiphany.

There's a trip to Silsbee, Texas, for instance, where Don's insistence on booking non-generic lodging lands them in a dingy motel room whose smell is "enough to make a horse gag," and whose sheets seem to bear the insignia of the local Ku Klux Klan. To make matters worse, when the bleary-eyed trio makes it out to the nearby Piney Woods and Big Thicket National Preserve early the next morning, they find the place as devoid of birds as the planet Mars. A few days later, things are looking

much more promising, as the trio snaps telephotos of ringed kingfishers along the Rio Grande. Until . . . oops . . . a band of marijuana smugglers in a cigarette boat zooms ashore nearby. The smugglers, you can be sure, don't know or care much about kingfishers, and, to quote one tattooed and glassy-eyed member of the group, they "don't like cameras." Needless to say, Dempsey and his friends walk away from that encounter intact, and most of the other people they meet are far more congenial.

In truth, not much happens to our stalwarts most of the time, though their obsessive inattention to virtually everything that doesn't have feathers lands them in occasional hot water. But Dempsey's gift for embellishment, along with his enthusiastic appreciation of the beauty of the moment, makes for compelling reading.

## The Universe in a Mirror

*The Saga of the Hubble Space Telescope and the Visionaries Who Built It*

by Robert Zimmerman  
Princeton University Press,  
2008; \$29.95

Everyone has heard of the Hubble Space Telescope. Scarcely a month goes by without a spectacular new color image in the press of a remote galaxy, a cluster of newborn stars, or a storm on Jupiter, taken by Hubble. The telescope's unique visual acuity, made possible by an orbit high above the Earth's atmosphere, has made it humanity's eye on the universe.

Of course, there was a time, shortly after its launch in 1990, when everyone thought of the Hubble Space Telescope as an overpriced failure. After two months of fruitless adjustment by ground controllers, Hubble scientists were forced to conclude that the telescope was defective. A slip-up in the exquisite calibration of mirror grinding had produced a main mirror of perfect but improper shape—its curve was slightly flatter than designed, making it impossible to focus the telescope. Editorials labeled the snafu "the inglorious result of NASA's laxity and ineptitude."

But unlike most space missions, Hubble was designed to be serviced on the fly by shuttle astronauts. Three and a half years later, the ailing telescope got a set of corrective lenses, restoring it, as it were, "to specs," and the dazzling pictures and scientific breakthroughs began to flood in. On occasional servicing missions since then, the original instruments, designed in the 1970s, have been replaced by improved detectors, keeping Hubble not only alive, but at the cutting edge of astronomical research. During its fifteen years of operation, astronomers have published more than 6,000 scientific papers using

*Continued on page 60*

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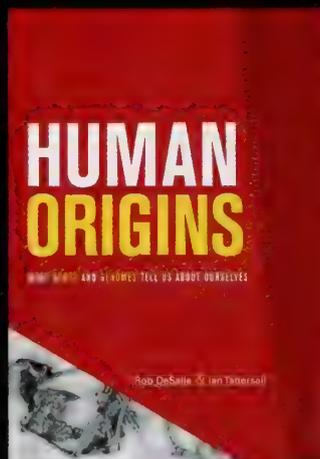
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## BOOKSHELF

*Continued from page 58*

Hubble. Its youthful myopia has virtually been forgotten.

Space historian Robert Zimmerman's crisp and balanced account of Hubble (based on many oral interviews as well as documents) reminds us not only of Hubble's battle with adversity, but also of the many scientists and engineers who shepherded the project through good times and bad. Prime among them was Princeton professor Lyman Spitzer, who proposed an orbiting telescope in 1946, and who promoted the project actively as the U.S. space program ramped up in the post-Sputnik era. When the funding for a Large Space Telescope (as it was originally titled) came through in the early 1970s, Spitzer passed the torch to a young C. Robert O'Dell, who, as chief project scientist, coordinated the first decade of planning and construction. Zimmerman regards O'Dell—who was a young man on the rise when he left academia for NASA—as one of the unsung heroes of the Hubble saga, sacrificing a decade of his own research to the thankless administrative demands of a politically and technically delicate mission.

And though the Hubble story is ultimately one of great triumph, it is also a story of continuing tribulation, through the cancellation of a last scheduled shuttle servicing mission in early 2004 to its reinstatement after a maelstrom of public protest nearly three years later.

Within the next decade, even in the most optimistic scenarios, Hubble's mission will end, leaving behind an indelible legacy. Zimmerman's book is a fitting testimonial to a remarkable instrument and the remarkable people who built it, operated it, and saw it through its darkest hours.

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

## WORD EXCHANGE

*Continued from page 6*

the peanut feeder. The jays had us fooled for a while, but when we figured out the mimics' game, we could only be amazed at their ingenuity.

*M. Angela Strain  
Tampa, Florida*

### Untidy Explanation

In "Skylog" [6/08], Joe Rao gives a misleading explanation for the fact that high tide occurs not only "under" the Moon but also on the opposite side of the Earth. It's not that the "underlying ocean basin is being deepened by the Moon's pull," but rather that the Moon is pulling more strongly on the solid earth than on the water on the far side, just as on the near side, the ocean—being closer to the Moon—is pulled away from the earth.

*C. Goebel  
Madison, Wisconsin*

JOE RAO REPLIES: Indeed, we had a lively discussion here as to exactly how to explain the so-called tidal bulges. To be really accurate, it is a matter of both gravity and inertia, acting in opposition on the Earth's oceans. On the "near" side of the Earth (the side facing the Moon), the gravitational force of the Moon pulls the ocean's waters toward it, creating one bulge. On the far side of the Earth, inertia (specifically, centrifugal force) dominates, creating a second bulge. Why inertia? The Earth and Moon are in fact revolving around each other (the axis of revolution being within the Earth, but not at the Earth's center). If you imagine the two bodies spinning around that axis really fast, material on their far sides would not only bulge but be thrown off into space. (For a detailed explanation see [co-ops.nos.noaa.gov/restles3.html](http://co-ops.nos.noaa.gov/restles3.html).)

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SKYLOG BY JOE RAO

In October we have good views of four of the five brightest planets: Venus and Jupiter in the evening sky, Mercury and Saturn in the morning sky. (The fifth, Mars, has disappeared into the evening twilight.)

The relative brightness of celestial objects from our earthly viewpoint is expressed in terms of “magnitudes,” a scale whose roots go back to Hipparchus of Nicaea, a second-century B.C. mathematician, philosopher, and astronomer. Based upon his naked-eye observations, Hipparchus categorized stars into six levels of brightness, with the brightest as first magnitude and the faintest as sixth magnitude.

By the nineteenth century, astronomers could measure a star’s apparent brightness objectively, but they retained the magnitude system, refining and quantifying it. If, for example, two stars are one magnitude apart, the brighter star is 2.512 times brighter than the dimmer star. The difference between a first-magnitude and a sixth-magnitude star thus works out to be  $2.512^5$ , or a hundred times difference in intensity. Today, we also measure brilliant objects with zero or even negative magnitudes. The full Moon is rated  $-12.6$ , and the Sun  $-26.7$ . At the other extreme, telescopes enable us to see objects much fainter than magnitude 6, and we can detect even fainter ones by using long photographic exposures.

At its brightest, Venus reaches  $-4.7$ ; this month it shines at magnitude  $-4$ . Look for the planet thirty or forty minutes after sundown, quite

### OCTOBER NIGHTS OUT

7 The Moon waxes to first quarter at 5:04 A.M. eastern daylight time (EDT).

14 The Moon becomes full at 4:02 P.M. EDT. Coming after the Harvest Moon, which in the Northern Hemisphere is the full Moon nearest the autumnal equinox, this one is known as the “Hunter’s Moon.”

21 The Moon wanes to last quarter at 7:55 A.M. EDT, but is still bright enough to



Hipparchus (ca. 190–120 B.C.) maps stars over Alexandria, in a nineteenth-century woodcut.

low in the southwest. Jupiter stands watch at magnitude  $-2.2$  in the southwest at nightfall.

Mercury passes inferior conjunction (sweeping between the Sun and Earth in its orbit) on October 6, and soon after becomes a feature of the morning sky. By the 14th, shining at magnitude 1, the planet will rise close to due east, more than an hour before the Sun. On October 22, having brightened to magnitude  $-0.6$ , Mercury reaches its greatest western elongation, or apparent distance to the west of the Sun, and rises a minute or two before the first glimmer of morning twilight.

Saturn rises north of due east two hours before sunrise on October 1, and more than four hours before sunrise by the end of the month. At magnitude 1, the planet is faint, mainly because its ring system is turning almost edge-on toward Earth.

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

reduce the effect of the Orionid meteor shower, which peaks this morning before sunrise. The “shooting stars” appear to radiate from a source in the constellation Orion, the Hunter; they are generated as the Earth passes through debris left behind by Halley’s Comet.

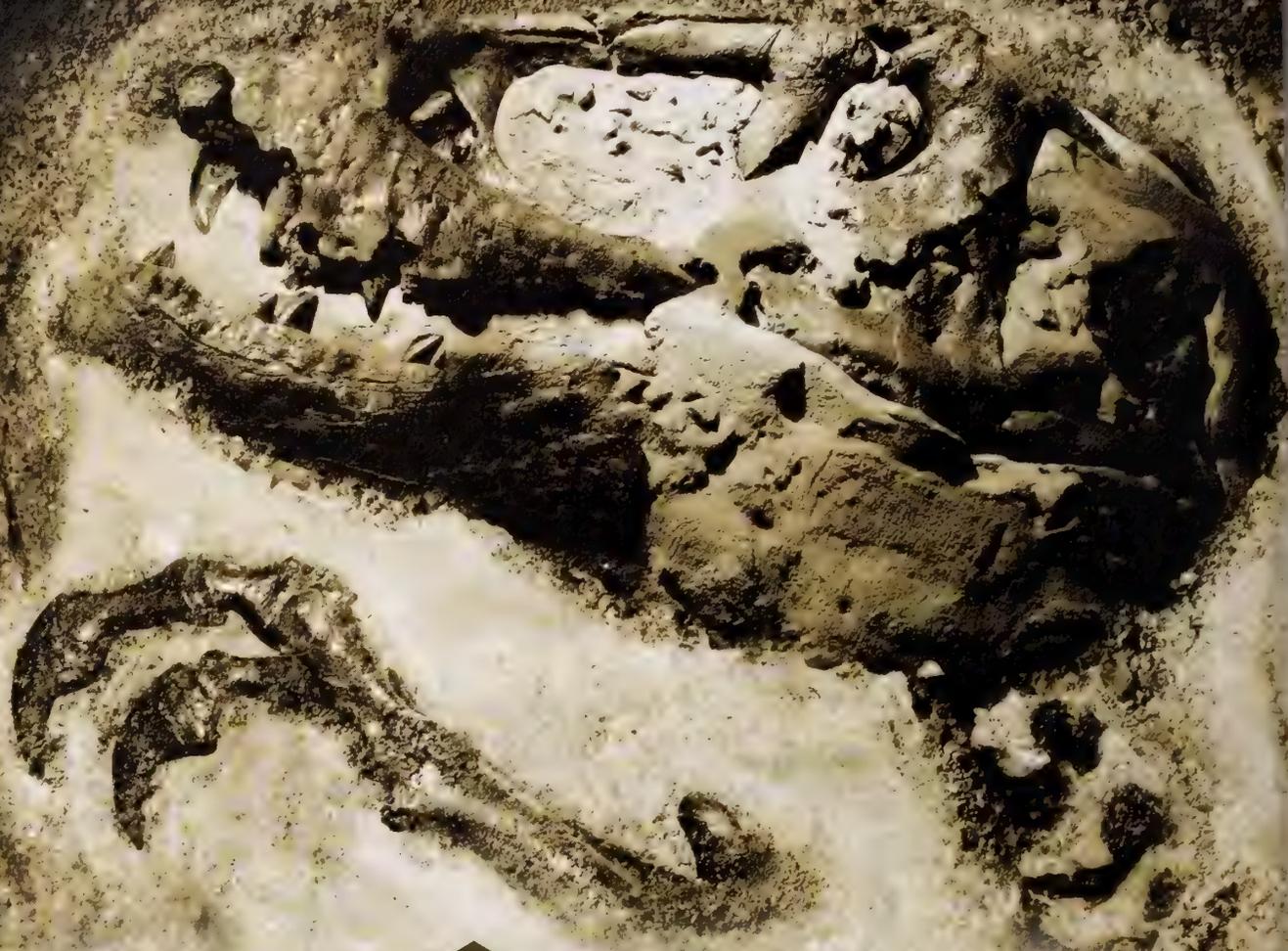
22 Mercury reaches its greatest western elongation (see story above).

28 The Moon is new at 7:14 P.M. EDT.

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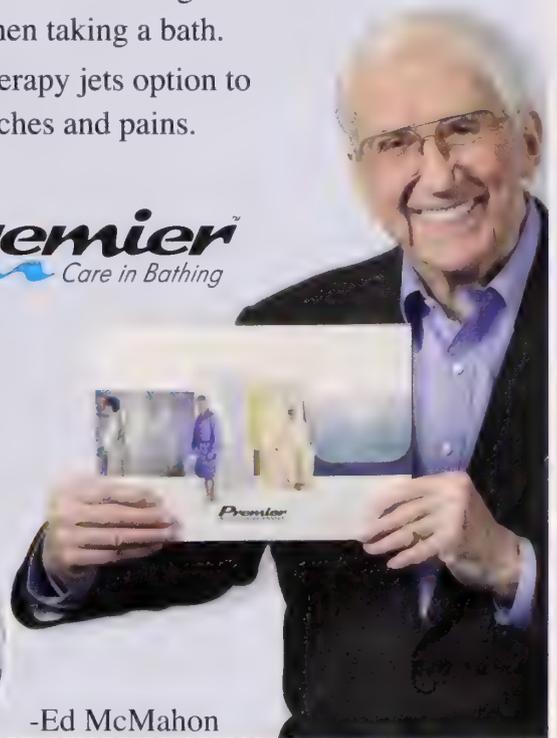


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## Earth on the Edge

Anyone who has seen *The Twilight Zone* episode “The Midnight Sun” won’t soon forget the mercury exploding from the top of a thermometer as Earth moves inexorably toward the Sun. In a chilling twist, the story ends with humans facing the opposite circumstance, the Earth is moving *away* from the Sun, an equally terrifying prospect over which they also have no control—and hence, no hope.

Of course, that is fantasy, science fiction. Today, the very real, human-induced warming of the Earth provides our own looming doomsday scenarios—possible droughts, rising sea levels, more intense storms, and other events with potentially harmful effects on the health of society and the natural world. But the very fact of human responsibility raises the possibility for creative solutions to the problem, and that is an important and hopeful message of the timely new exhibition *Climate Change: The Threat to Life and A New Energy Future*, which opens October 18.

“Evidence has been accumulating for some time that Earth is warming due to human activity,” said Museum President Ellen V. Futter, “but we are only just beginning to come to terms with the breadth of the consequences of this phenomenon, and to learn what we can do to mitigate them. The fact is,” Ms. Futter continued, “we do have options; but implementing solutions will require individual, communal, and global action. *Climate Change* will examine both the consequences of global warming and possible solutions to this critical problem.”

Scientists have documented a dramatic increase in greenhouse gases in the atmosphere over the past 150 years—especially carbon dioxide—caused primarily by the burning of fossil fuels, deforestation, and other changes in land use. *Climate Change* uses realistic dioramas, interactive stations, dynamic animations, compelling wall text, and more to provide context for today’s urgent headlines, while empowering and encouraging visitors of all ages to take an active part in our planet’s future.

“We have strength in numbers,” said the curator of the exhibition, Edmond A. Mathez, Curator, Earth and Planetary Sciences, AMNH Division of Physical Sciences, adding, “We’re a rich, highly educated country, and we have a responsibility to lead.”

A central part of the exhibition explores the effects of climate change on several separate but interrelated areas: Earth’s atmosphere, polar ice sheets, ocean, and land. A mini-diorama in the land section illustrates the local impact of climate change on land animals in the tropics and the importance of ongoing field work by Museum scientists. The scene tells the story of a chameleon that could go extinct between 2050 and 2100 if it migrates higher and higher up the mountains of Madagascar to compensate for warming temperatures at its



©KENN W. KISER

current altitude, according to a paper published recently in *Global Change Biology* by Christopher Raxworthy, AMNH Associate Dean of Science for Education and Exhibition, Richard G. Pearson, a biodiversity specialist with the Museum’s Center for Biodiversity and Conservation, and a team of others from the U.S. and around the world. Similarly, a ghostly coral reef—a victim of “coral bleaching”—shows how higher water temperatures and increased carbon dioxide in the oceans are killing corals and the communities that they anchor. A startling, visual reminder of the human impact is a model representing one ton of coal; scientists estimate that every year the equivalent of three tons of coal is burned, one way or another, for every person in the world.

Throughout the exhibition, the movements of clouds, ocean currents, and seasonal ice are displayed on digital video globes to reveal how climate works. One dramatic feature depicts rising sea levels on a scale model of lower Manhattan, graphically demonstrating the flooding that would be caused by the melting of ice sheets and ocean warming.

Finally, *Climate Change* explores the possibilities for reducing energy consumption in our daily lives, from buying energy-efficient appliances to making better use of mass transit, and outlines various options for future energy sources, including nuclear energy; solar, wind, hydroelectric, and geothermal power; and carbon dioxide capture and sequestration technology for coal-burning power plants. In essence, the exhibition is a powerful call to action. We are not, after all, in the Twilight Zone.

The exhibition, which runs through August 16, 2009, before traveling to Europe, Asia, the Middle East, Mexico, and South America, is guest co-curated by Michael Oppenheimer, Albert G. Milbank Professor of Geosciences and International Affairs, Woodrow Wilson School and the Department of Geosciences, Princeton University, New Jersey.

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

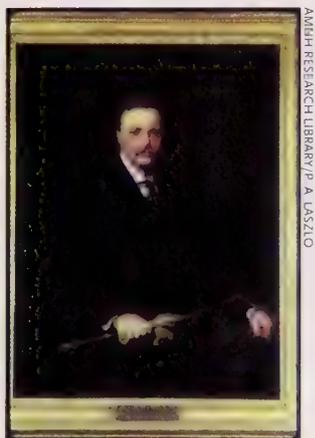
*Climate Change* is proudly presented by **Bank of America**.

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

# A Monumental Man

Two halls, three murals, four dioramas, a massive bronze statue on horseback at the main entrance—these are a few of the ways in which the American Museum of Natural History pays public homage to Theodore Roosevelt, 26th President of the United States and great friend of the Museum who was born 150 years ago this month, on October 27, 1858.

Roosevelt was ten years old when, in 1869, a group of private citizens, including his father, Theodore Sr., approved the Museum's original charter in the parlor of his boyhood home in Manhattan. In 1871, a teenage "Teedie," as his family called him, donated to the fledgling Museum one bat, 12 mice, a turtle, the skull of a red squirrel, and four bird eggs. It was the beginning of a lifelong relationship during which numerous Roosevelt specimens would make their way to the Museum, and the incomparable TR—soldier, statesman, author, civil rights advocate, explorer, naturalist, conservationist, and more—would become the embodi-



Portrait of Theodore Roosevelt

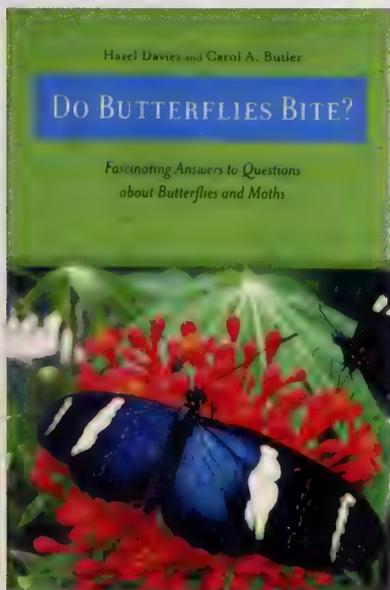
ment of the spirit of the Museum.

So it is fitting that tributes abound. A dozen tiles from "Ranchman" to "Patriot" are carved into the stone parapet above the plaza at the entrance to the Museum, conveying the remarkable breadth of his interests. Inside, beneath the soaring vaulted ceiling of the Roosevelt Rotunda, quotations from his prolific writings are carved into four walls while three

large painted murals depict important episodes in his life: the building of the Panama Canal; the mediating of a peace treaty between Russia and Japan in 1905 for which he won the Nobel Peace Prize; and an African expedition in which he joined Museum explorer Carl Akeley in search of elephants. It was then, in 1909, that he collected the cow elephant still visible just to the right as you enter the Akeley Hall of African Mammals beyond the Rotunda, along with her calf, collected by his son Kermit.

One floor below, in the Roosevelt Memorial Hall, visitors will find an inscribed catalog of his accomplishments, cases filled with personal memorabilia, and four dioramas about his life, including a tranquil scene in the Theodore Roosevelt Sanctuary, the oldest Audubon songbird sanctuary in the nation. It was not far from there, at Sagamore Hill, his home in Oyster Bay, Long Island, that TR died on January 6, 1919. One of his sons would cable the others: "The old lion is dead."

## Butterflies by the Book



As visitors mingle among the hundreds of live butterflies and moths in *The Butterfly Conservatory: Tropical Butterflies Alive in Winter*, which opens this month, eager educators will be on hand to offer lessons in lepidoptery, including life cycles, camouflage, evolution, conservation, and more. Now, the curious can also turn to a comprehensive new guide: *Do Butterflies Bite? Fascinating Answers to Questions about Butterflies and Moths*.

Co-authored by Hazel Davies, Manager of Living Exhibits at the American Museum of Natural History, and Carol A. Butler, an AMNH volunteer, *Do Butterflies Bite?* was published this summer by Rutgers University Press. Packed with information and illustrated with photos by both authors and drawings by William H. Howe, the book is organized in a user-friendly Q-and-A format. The aim is to fill a void, the authors write, "to answer all the questions we have been asked over the years and even those questions that

we've asked ourselves." Among them, do butterflies sleep? Do they have ears? How fast do they fly? How long do they live? And, of course, do they bite? (For every squeamish child or adult who wonders about that before entering the exhibition, the answer is no.)

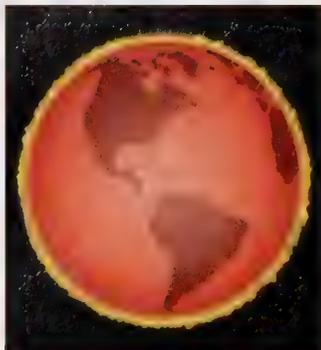
*The Butterfly Conservatory* has been an annual favorite since it first opened in 1998, and features up to 500 live, free-flying butterflies from Central, South, and North America, Africa, and Asia. It is housed in the Museum's Whitney Memorial Hall of Oceanic Birds in a lush tropical vivarium that approximates their natural habitat. Davies, for all her familiarity with it, thrills to this live experience. "After ten years," she says, "it's still exciting to see a butterfly emerge and unfurl its wings."

*The Butterfly Conservatory* opens October 11, and runs through May 25, 2009. Visit [www.amnh.org](http://www.amnh.org) for more information and to purchase tickets.

# At the Museum

AMERICAN MUSEUM OF NATURAL HISTORY 

[www.amnh.org](http://www.amnh.org)



## **The Butterfly Conservatory** *Opens October 11, 2008*

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

## **The Horse**

*Through January 4, 2009*

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

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

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

## **Lizards & Snakes: Alive!**

*Through January 5, 2009*

Meet over 60 live lizards and snakes, and discover some of their remarkable adaptations.

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

## **Saturn: Images from the Cassini-Huygens Mission**

*Through March 29, 2009*

This stunning exhibition reveals details of Saturn's rings, moons, and atmosphere with images sent over half a billion miles by the Cassini spacecraft.

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

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

## **On Feathered Wings**

*Through May 25, 2009*

This exhibition brings together the work of renowned wildlife photographers whose artistry showcases the majesty of birds in flight.

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

## **Unknown Audubons:**

### **Mammals of North America**

*Through January 18, 2009*

The stately Audubon Gallery showcases the last great works of John James Audubon.

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

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

## **LECTURES**

### **FROM THE FIELD**

#### **Roger Tory Peterson**

*Tuesday, 10/14, 6:30 pm*

To honor the centennial of Roger Tory Peterson's birth, his son, naturalist Lee Allen Peterson, and AMNH Curator Joel Cracraft, Ornithology, will discuss Peterson's legacy and its impact on birding and the study of ornithology.

### **GLOBAL KITCHEN**

#### **Wine and Climate Change**

*Tuesday, 10/28, 6:30 pm*

With Climatologist Gregory V. Jones, Southern Oregon University; author and blogger Tyler Coleman, DrVino.com;

and David Bowler, wine importer and distributor. Includes a wine tasting.



## **Zoarchaeology: From the Mundane to the Sacred**

*Three Wednesdays,*

*10/8–22, 7–9 pm*

*Enrollment is limited.*

Examine animal bones from Viking sites in Greenland and Iceland with Sophia Perdikaris, Professor of Anthropology and Archaeology at CUNY.



Rob Mies and Kamilah, a Malayan flying fox

## **FAMILY PROGRAMS**

### **Wild, Wild World: Bats**

*Saturday, 10/25, 11 am–12 noon and 1–2 pm*

A live animal presentation with Rob Mies of the Organization for Bat Conservation.

## **HAYDEN PLANETARIUM PROGRAMS**

**TUESDAYS IN THE DOME**  
*Virtual Universe*

**Moons, Moons, Moons**

*Tuesday, 10/14, 6:30 pm*

## **EXHIBITIONS**

### **Climate Change: The Threat to Life and A New Energy Future**

*Opens October 18, 2008*

This timely new exhibition explores the science, history, and impact of climate change on a global scale. Realistic dioramas, dynamic animations, and interactive stations allow visitors to witness potential effects, such as the flooding of lower Manhattan as a result of melting ice sheets and ocean warming. The exhibition lays the groundwork for potential solutions, empowering and inspiring visitors of all ages.

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

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@USGS

*Cosmic Collisions* was developed in collaboration with the Denver Museum of Nature & Science; GOTO, Inc., Tokyo, Japan; and the Shanghai Science and Technology Museum. Made possible through the generous support of CIT.

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

**Celestial Highlights**

**Celestial Royalty**

Tuesday, 10/28, 6:30 pm

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

**LECTURES**

**Beyond UFOs**

Monday, 10/20, 7:30 pm

Author and scientist Jeffrey Bennett takes you on a whirlwind tour of the scientific search for life in the universe.



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**AND DON'T MISS...**

**Halloween Party**

Friday, 10/31, 4-7 pm

Trick or treat among the "dangerous" dinosaurs

**Cosmic Collisions**

Journey into deep space to explore the hypersonic impacts that drive the formation of our universe.

**INFORMATION**

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

**TICKETS AND REGISTRATION**

Call 212-769-5200, Monday-Friday, 9 am-5 pm, or visit [www.amnh.org](http://www.amnh.org). A service charge may apply. All programs are subject to change.

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

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For further information, call 212-769-5606 or visit [www.amnh.org/join](http://www.amnh.org/join).



Children greet a special guest at the Family Party.

and in an "other-worldly" universe. Kids' favorite characters wander the halls; "spooky" arts and crafts keep little hands busy; and live performances punctuate the proceedings.

**15th Annual Family Party**

Tuesday, 10/21, 5-7:30 pm

The Family Party is one of the Museum's best-loved annual traditions. Children and parents can meet live animals, dig for dinosaur fossils, conduct fascinating experiments, simulate space

travel, and more.

For more information and to purchase ticket packages, visit [www.amnh.org/familyparty](http://www.amnh.org/familyparty) or call 212-496-3495.

**IMAX MOVIES**

**Sea Monsters:**

**A Prehistoric Adventure**

Travel back 82 million years to a time when strange creatures filled the seas that once covered what is now the middle of North America.

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

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# Time Portal

By David A. Burney and Lida Pigott Burney

From the moment we saw it, we knew the place held many great secrets. We had been looking for new fossil sites on the south side of the Hawaiian island of Kauai in 1992 with our colleagues, Helen F. James and Storrs L. Olson of the Smithsonian Institution in Washington, D.C., along with their children, Travis and Sydney, and our own, Mara and Alec. And what we found was a cave—once a Pleistocene dune field, and later a sinkhole with pickling-jar powers—that may be the richest fossil site in the Hawaiian Islands, perhaps in the entire Pacific Island region.

Sixteen years after our discovery, we have excavated seeds, pollen, Polynesian artifacts, thousands of bird and fish bones, and more from this half-acre pile of sediments spanning many millennia. The site (pictured below) has yielded up some of the island's long-kept secrets, telling of a time when the largest land animals here were flightless waterfowl, such as the turtle-jawed moa nalo (*Chelychelynechen quassus*). Moreover, it documented the great changes that occurred when first Polynesians, and later Europeans, Americans, and Asians, arrived with boatloads of invasive alien species.

The first boats began arriving roughly a thousand years ago, kicking off the first of three stages of extinction on Kauai. In the first stage, Polynesians prob-

ably overhunted the large flightless birds, while introduced rats, chickens, and small pigs disrupted their remaining nests. Later, but before Captain Cook arrived in 1778, the agriculture of a growing Hawaiian population wiped out more species. Finally, Europeans arrived and brought goats and other livestock that finished the job.

In 2000 we learned the long-lost nineteenth-century name of the cave, Makauwahi, thanks to a local archaeologist, William K. "Pila" Kikuchi, who recovered the name from an essay written by a high school student more than a century ago. It means something like "smoke eye." That may have been in reference to Keahikuni, a mid-nineteenth-century native diviner who read the future in spirals of smoke rising from the sinkhole.

The story struck a resonant chord, as we had begun thinking about Makauwahi Cave as a preserver of the future at least as much as the past. In 2004, we were granted a lease on the cave property, including the surrounding seventeen acres of dunes, wetlands, and abandoned farmland, by the owners, Grove Farm Company. Using the fossils as a guide, we set out to suppress plants introduced in the last two centuries and to favor



Maiapilo (*Capparis sandwichiana*)

those that evolved here or were brought from other Pacific islands by the first human inhabitants.

The most unusual patch of land is on several acres of weedy thicket formerly used for cane and corn farming. After only three years of rehabilitation, nearly a hundred species of native and Polynesian trees, shrubs, and ground covers are now thriving. Planted by volunteers, including some of the same folks who helped us sift the fossils from the cave sediments, and the eager assistance of hundreds of schoolchildren from all over Kauai, the new forest has flourished beyond all expectations. Thousands of acres of abandoned farmland throughout the Hawaiian Islands could grow native plants just as well as this!

Unfortunately, many of the animals that disappeared from Kauai were unique to the island. But even if we can't have giant, flightless waterfowl, we can make the area more attractive to the surviving species of birds, animals, and insects that are indigenous to the island. In this way and others, we'd like to think we can be a little like old Keahikuni the Diviner in telling the future. Here at Makauwahi, which has given us such a powerful sense of the past, we can find a better future for an island world that was nearly lost.

DAVID A. BURNEY AND LIDA PIGOTT BURNEY live on Kauai. David is Director of Conservation at the National Tropical Botanical Garden, and Lida manages the Makauwahi Cave Reserve.



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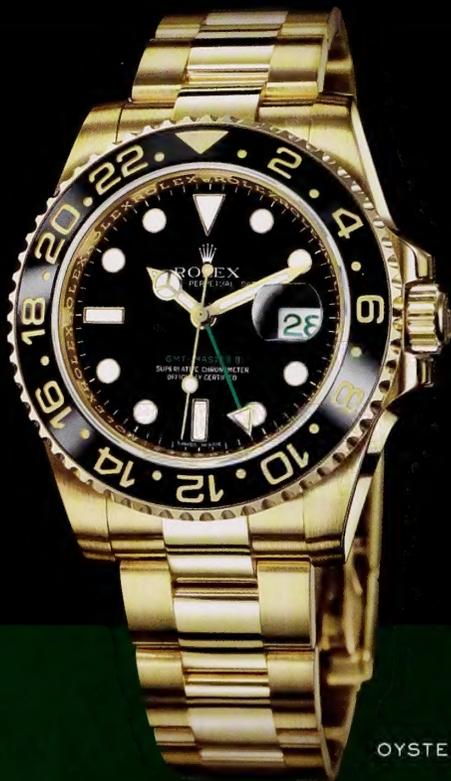
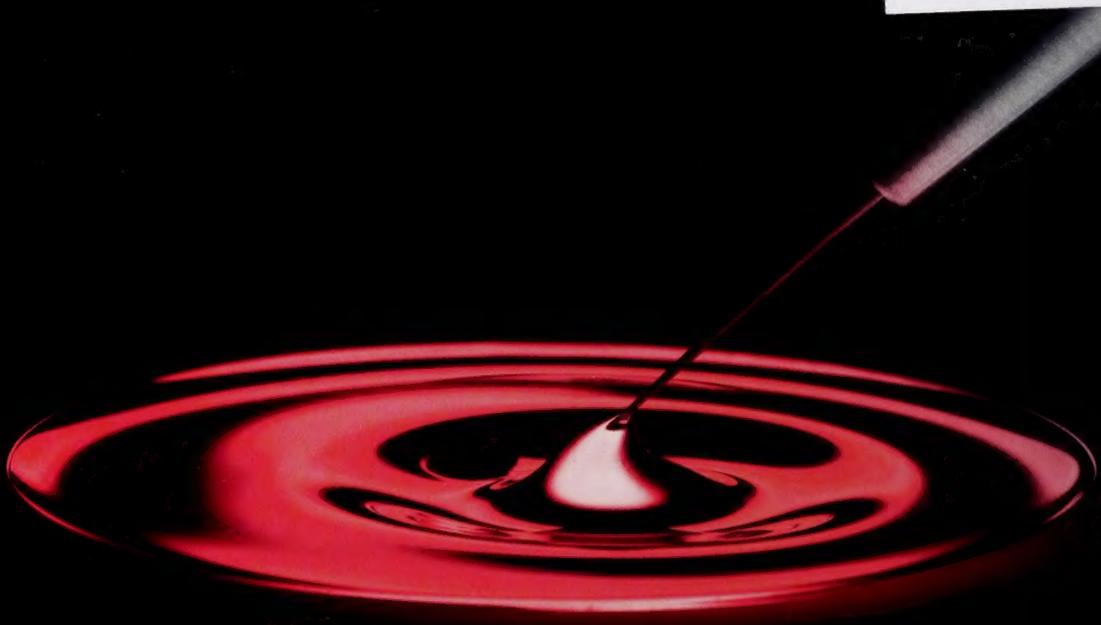
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